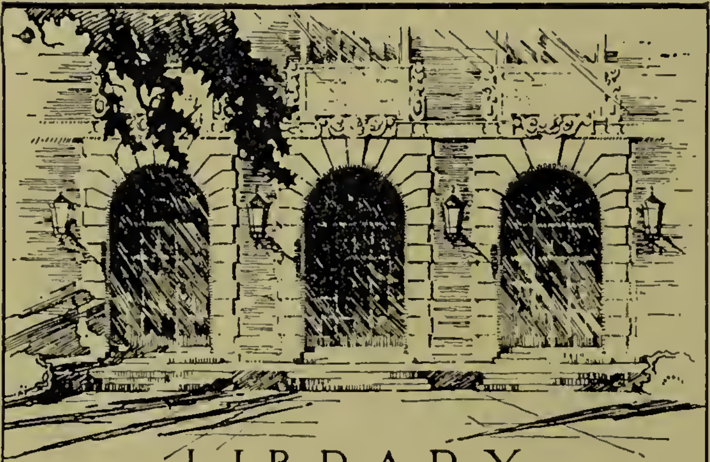

THE

State Agricultural College

The Agricultural Experiment Station.

BULLETIN No. 20.

I. The Best Milk Tester for the Practical Use of the Farmer and Dairyman.

II. The Influence of Food Upon the Pure Fat Present in Milk.

Approved by the Station Council.

ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

AUGUST, 1892.

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I.

The Best Milk Tester for the Practical Use of the Farmer and Dairyman.

WALTER J. QUICK.

That time is the present when intelligent farmers and dairymen, like other business men, have discovered the noteworthy fact, that those who make the greatest success, do so by means of that enterprise which introduces or adopts and manipulates into practical utility the most approved methods. Being ever ready for the many and rapid modifications of this advanced age, enables one to place the balance on the right side, perpetuate his business and crown it a success. Those men who lead are ever on the alert for the new, at the same time, the tried and the best, and do not wait until every one has acquired it and reaped the benefit accruing from its adoption. Just now, during the rapid progress of the present century, a simple and practical method for the reliable valuation of milk should be in general use.

Numerous methods have been introduced, and are being employed for ascertaining the amount of butter fat in milk. The poorest is better than none. Churning each cows milk separate will detect unprofitable animals. It is certainly quite as important for the dairyman to know what quality of milk he buys, as for the owners of a beet sugar factory, or a smelter, to ascertain by analysis or assay the quality of the product they purchase. The farmer, too, wants to know the quality of the milk he sells, that he may receive the proper recompense, and not too little, while perhaps his neighbor for poorer milk receives too much. Both the farmer and the dairyman, by the employment of a milk tester, find the cows it is the part of wisdom to retain, and as readily those which, reducing the profits of the better animals, should be speedily discarded.

The farmer with but a few cows is now ready for such a machine or apparatus, provided it is not too expensive, and he can successfully manipulate it. Does such a method for testing cows exist?

COMPARING METHODS.

As we have said, there are a number of methods that are well known, accurate and approved, but the question arises, Which is the most practical for the farmer and the dairyman?

It is our purpose, then, to compare three methods for determining the fat present in milk, viz., Babcock's, Cochran's, and Shorts', observing the economy of handling the different apparatus, the rapidity of work, simplicity of structure, accuracy, and the cost of the outfit. To do this, we have made from 16 to 32 fat determinations with each apparatus; from each, whole, skim milk and cream, always drawing from the same general sample and source. Our conclusions are summarized below:

Economy of Handling.—Regardless of time, we find the Babcock tester to be much more cheaply manipulated, from the fact that but one reagent is required, commercial sulphuric acid, or oil of vitriol, having a specific gravity of 1.82, or about 90 per cent. pure acid. In addition to this, hot water is always required. The cost is about one-fifth cent per test when the sulphuric acid can be secured wholesale. With each of the other methods the same required for the Babcock is necessary, and, in addition, for the Cochran examination acetic acid of a specific gravity difficult to procure, and ether, which is highly explosive and must be handled with care. For the Shorts method, besides that necessary for the Babcock, caustic soda, caustic potash and acetic acid must be used.

The apparatus of the last-mentioned is not more breakable than the Babcock, but that of the Cochran is much more delicate, the most careful manipulators often breaking testing flasks.

Rapidity.—With Shorts' method, about five hours are necessary for the analyzing of one set of twelve flasks. This condemns it for the farmer's use.

The Cochran requires, for heating water, transferring from bottles to fat indicators, cleansing, etc., from three-quarters to an hour for a set of nine samples.

With the Babcock, and without assistance, I analyzed ten samples in thirty-nine minutes, being about four minutes to the sample, and, with assistance, in thirty-three minutes, cleansing the entire apparatus in the time. Alone I tested two samples in duplicate in eighteen minutes, and thirty samples—three sets—in one hour and twenty-two minutes, only cleansing such of the apparatus as was necessary between sets. It is claimed that analyzing can be done in half the time with the new Curtis' Babcock tester.

Simplicity of Structure.—All are simple enough, so that the ordinary farmer will experience very little difficulty in handling them. He may break more, perhaps, than the trained chemist. The glassware of the Cochran is the most complicated and easily broken. There is very little, if any, difference in the other two methods in this respect. The Babcock is a centrifugal machine, and requires no heating, and less hot water than either of the others.

Accuracy.—The accuracy of the Babcock was tested by the gravimetric method—it is true by samples taken from ten to twelve hours apart, but under the most favorable conditions of the milk possible, with that consideration. The variations below, though small, would not likely be as much if the samples where taken at the same time.

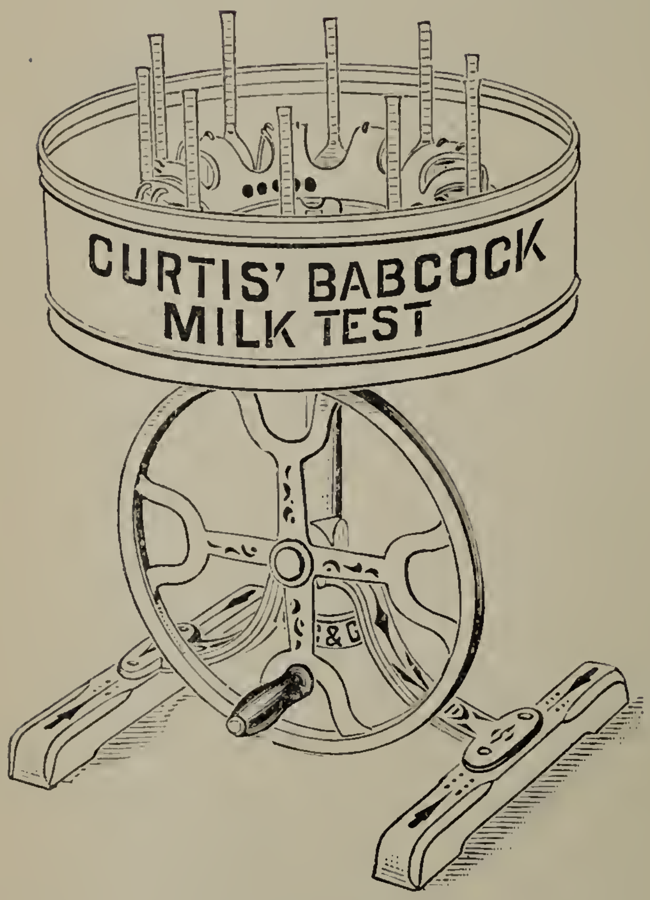
Source of Sample.	Averages of	Per Cent. Butter Fat.		
		Gravimetric.	Babcock.	Difference.
Shorthorn cow........	7 samples in Feb.	4.14	3.86	.28
Shorthorn cow........	7 samples in Feb.	3.98	3.28	.70
Jersey cow...........	7 samples in Feb.	3.07	2.94	.13
Jersey cow...........	7 samples in Feb.	4.00	4.04	—.04
Shorthorn cow........	8 samples in March.	4.01	3.83	.18
Shorthorn cow........	8 samples in March.	3.60	3.30	.30
Jersey cow...........	8 samples in March.	3.10	2.82	.28
Jersey cow...........	8 samples in March.	4.05	4.17	—.12

Accuracy depends mainly on the careful sampling of the milk, using reagents of the proper strength, and in following directions closely. It is seldom, if ever, that the graduated scales on the test bottles are wrong. By several trials with all in duplicate an error can easily be discovered.

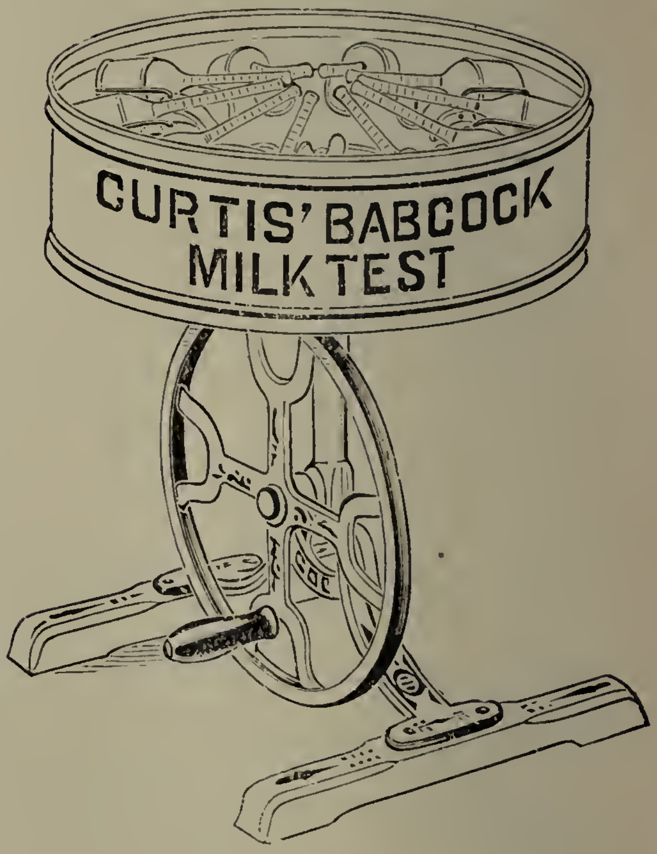
After testing the Babcock with the gravimetric, we then tested the Cochran, Shorts and Babcock together, with the following results, which can be said to be very little better for one than another :

SOURCE OF MILK.	Per Cent. of Fat.		
	Babcock.	Cochran.	Shorts.
Whole milk, Bonnie Louan, Shorthorn, ... averages,	4.56	4.32	4.22
" " Orchard Lark, " .... "	2.65	2.76	2.86
" " Lizzie Lesley, " .... "	3.80	3.80	3.74
" " Kirk. Duchess 29 " .... "	2.70	2.93	2.95
Separated milk, from Shorthorn cow, ...	1.80	1.81	1.83
" " " " "	1.70	1.65	1.83
" " " " "	1.80	1.78	1.83
" " " " "	1.60	1.38	2.01
Milk, separated very close, from College herd, ...	.20	.15	Trace.
" " " " " " "	.15+	.15 —	Trace.
" " " " " " "	.10 —	.10 —	Trace.
" " " " " " "	.10+	.10+	Trace.
Cream, separated, from College herd, ...	14.35	14.06	13.86
" " " " "	19.70	19.68	19.23

Cost of Outfit.—The Babcock method for the use of the ordinary farmer or small dairyman, or creamery, is manufactured in very convenient size, with ten test bottles, at a cost of $15.00. It is also made larger for testing more samples simultaneously. It is not patented, and can this year be procured of almost any dairy supply house. We believe it to be the best milk tester on the market for practical use. On the following page we give a cut of the Babcock apparatus, as improved recently by Mr. Curtis:

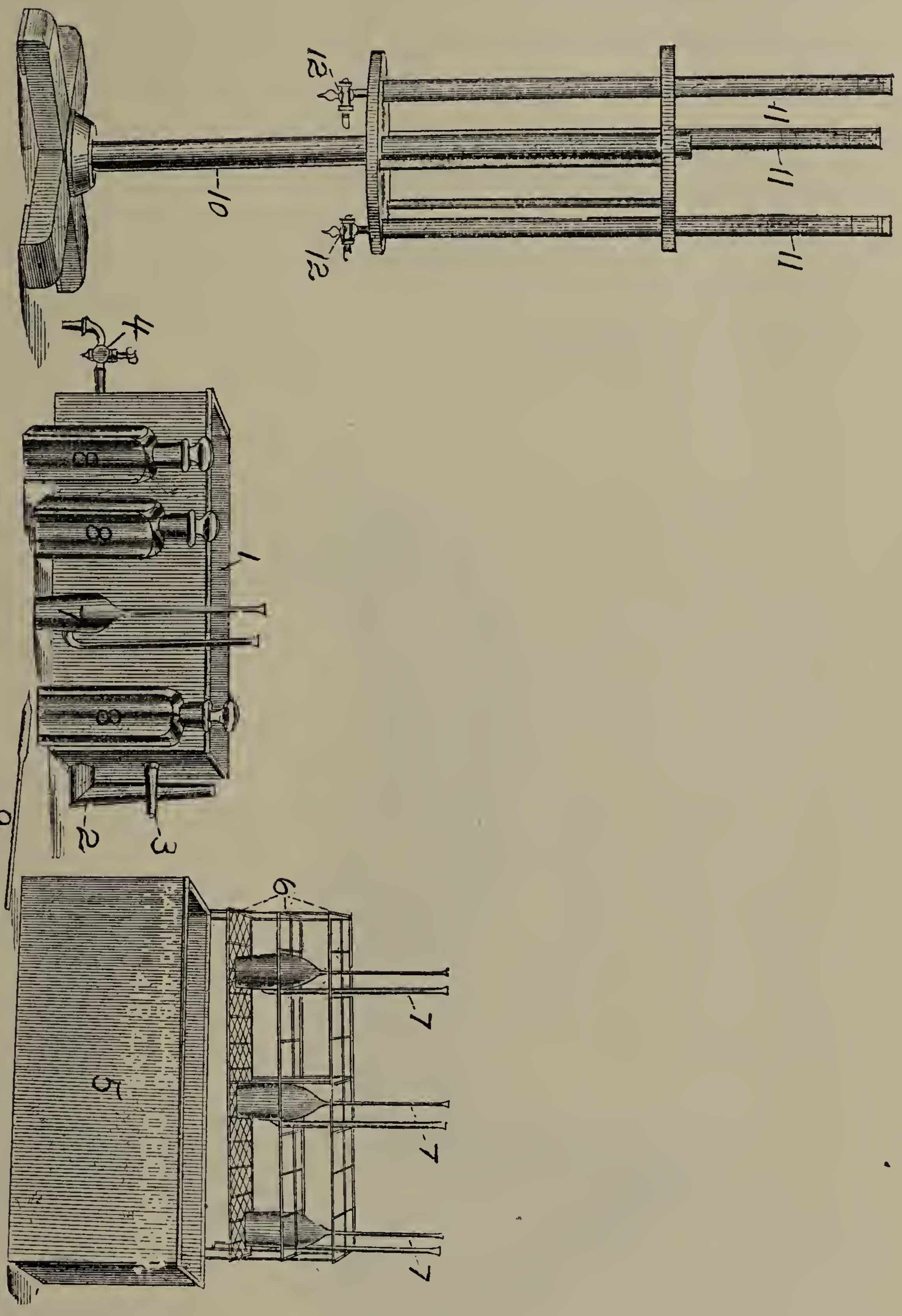


Stationary.



In Motion.

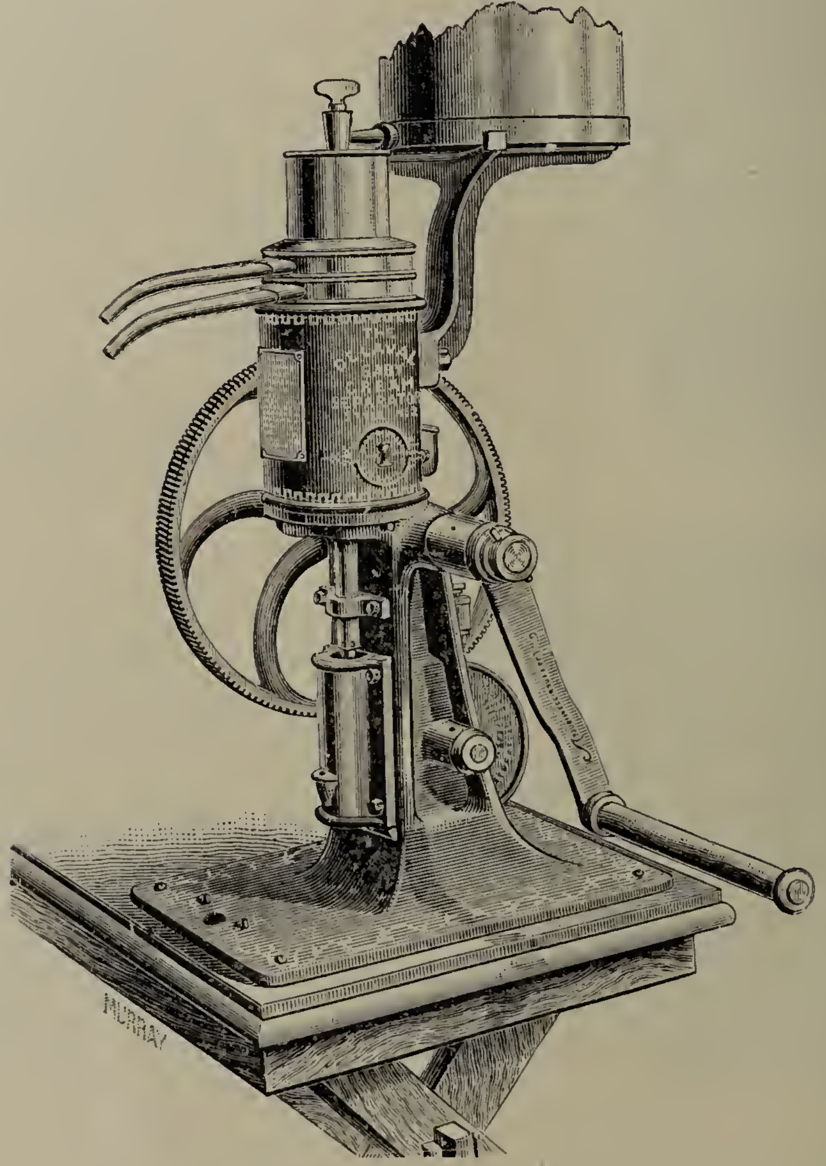
The Cochran and Shorts apparatus can be procured at any dairy headquarters at prices not varying much from those at which the Babcock is sold. Though requiring more care in manipulation, we consider the Cochran method the second best for determining fat, because of greater speed, together with the accuracy. It can be procured at $10.00, for a four-bottle test. We herewith give a cut representing this apparatus :



THE COCHRAN MILK TEST.

THE DE LAVAL SEPARATOR.

The skim milk for the foregoing analyses was separated from the cream by means of the De Laval "Baby" Cream Separator, which, from this experience, and other trials made and observed with this machine, and from observations at the trials of other separators, we believe to be the best on the market. Farmers who have enough cows to justify the expenditure, and dairymen who make sweet cream butter, and all who patronize creameries, can illy afford to be without this valuable separator. We append a cut of the machine:



II.

The Influence of Food Upon the Pure Fat Present in Milk.

WALTER J. QUICK.

It is quite generally understood that the quantity of food consumed influences the yield of milk. There is not very much conclusive and authentic evidence regarding the *quality* of food as materially modifying the richness of the milk. It will be acknowledged that certain foods and grasses influence the color of butter. Numerous experiments exhibit results to prove that an increase of the same ration will increase a cow's milk yield, but *not* the quality of that yield. By a few it is believed that the quality of milk can be changed very perceptibly by changing rations. Not enough has been accomplished to settle the question conclusively. Eminent men remain on both sides, many among the most prominent stoutly maintaining that the quality of the milk depends solely, or almost so, on the individual animal, some being producers of rich milk, and others of the poorer article.

It was not with the belief that we, by this experiment, would settle this mooted question, that we undertook it. If we can throw some light upon the subject, or inspire investigation among those interested in Colorado, we will be satisfied.

Much has been said, and many the belief expressed, by men of the West, where such abundant oat crops are always produced, that "oat chop" fed with alfalfa is better than wheat bran for producing rich milk. This question has been the source of much argument at farmers' institutes, and various meetings of dairymen and farmers. The statement has been made, and not successfully contradicted, that with oats worth $1.00 per hundred ($20.00 per ton), and wheat bran at $15.00 per ton, the oats, ground, and alfalfa hay is worth enough more as a dairy feed and butter producer to justify its use. This question we have been asked to test in connection with this experiment.

This feeding experiment was determined upon early in February, 1892. It was desirable to have cows representing at least two breeds. The College being in possession of a fine herd of Shorthorns, two cows were selected from it suitable for the trial. The loan of two Jerseys was secured, through the kindness of Mr. John Nelson, a Jersey breeder near Fort Collins. The feeding commenced February 18, Mr. A. Campbell, the College herdsman, in charge, and Mr. F. A. Huntley, Assistant Agriculturist, helping with the milk analyses.

With the above objects in view, the four cows were placed upon a ration of 2 pounds of oat chop—that is, ground or rolled oats—and the first crop of lucerne, or better known as alfalfa hay. They were given the ration morning, noon and evening; more hay was fed than they would eat, the residue always being weighed, and deducted from the original weight of the feed. Every forenoon, between 10 and 11 o'clock, each cow was weighed. They were given exercise in a lot, but not allowed access to anything they might eat, and were given all the water they desired.

At the close of the first feeding period, clear wheat bran was substituted for oat chop; this was, as stated, *clear bran*, specially ordered for this experiment, containing no shorts. All may not know that the so-called bran received from the mills contains all the shorts produced, run together from the mill into the bran bin. This is what the farmer gets when he buys bran. The clear bran costs us at Fort Collins $14.00 per ton; oats was worth $20.00.

From daily analyses and close observation, we ascertain it to be a fact that a longer time is necessary for securing an even yield of butter fat from some cows than others. While with some the per cent. may be influenced by a change in the ration in forty-eight hours, and such cows become regular in that length of time, with others we find the per cent. influenced, for better or worse, according to the quality of the ration, and grow regular in sixty-four to seventy-two hours, and still others (exceptions), requiring even more time. As should be expected, this is governed to a great extent by the appetite of the cow. Those animals that might be termed good feeders, and that will eat one ration with about the same relish as another, exhibit in the quality of the milk the results of a change in feed sooner, and in every case under our observation, a steadier flow, with more uniform per cent. of butter fat. Naturally, then, we would expect, and do find, that the shy or dainty feeder shows a greater variation in both quantity and quality.

We have consulted men of experience in the feeding of dairy stock, and several eminent experimenters located in other stations, and we are informed that while a longer period is usually taken for each ration, yet with care it is not absolutely necessary. The results of these experiments give indorsement to these statements, and while we would not recommend less than ten days for a feeding period, we believe that quite sufficient.

Having found, then, that the fluctuations in the per cent. of butter fat are reduced to a minimum in most cases after a change in a ration has been instituted seventy-two hours, we add twenty-four hours for safety, and include in our averages only analyses after ninety-six hours, or after twelve feeds have been consumed by the cows, except in starting the experiments. As some cows were moved, they were given from twenty-four to forty-eight hours still more, to become familiar with their new surroundings and feed before the analyses of their milk were taken into the averages. Analyses, however, were made from which to observe changes. Occasionally one has been thrown out, when by accident or other cause it is known to be wrong.

METHOD OF ANALYSIS EMPLOYED.

The most careful records of milk yield, feed, water, and animal weight, have been kept throughout the experiment, and the milk of each cow has been tested daily for its fat per cent. by the Babcock method. This tester was adopted, as we consider it the most accurate and speedy, and less subject to errors.

The analyses with the Babcock tester were nearly all duplicated by the Station Chemist with the gravimetric method. The difference in the results of these two methods is greater than was expected, but can be accounted for in the fact that the samples for the gravimetric examination of each day's milking (combined morning and evening) were drawn off the morning after, while those for the Babcock were pipetted from the combined milk as soon as the evening's milking was over, and were placed in the test bottles ready for analysis.

The variation being so great, not only in comparison with the Babcock, but frequently as compared with the same cow's milk the day before, by the same method, caused us to investigate. With the Babcock we found the duplicate samples in the evening run very close, never varying over .4 of 1 per cent., while those taken the next morning varied from $\frac{1}{2}$ to 2 per cent. The explanation is that the cream rises, sometimes dries on top, and frequently is sour, when it is impossible to mix and secure a fair sample. At times, without the knowledge of the operator, his pipette will draw in a clot of cream, while again from the same vessel its mouth is surrounded by the poorest of milk, containing almost no butter fat. We find, from repeated analyses with the Babcock, that after sampling, the milk may stand in the test bottles until it is sour and coagulated, without the results being changed.

From a study of the tabulation we learn that the quality of milk was quite perceptibly influenced by the change of food given these cows. It will be also observed that in every case by the Babcock analysis, the wheat bran produced the best results, and that the gravimetric analysis exhibited two cases as good or better, with the other two but slightly lower. It must be remembered that in the two cases which showed a lower per cent. when the cows were on bran, the samples were from the two longest in milk; and, further, that if there is any advantage from this fact, it was given the oat chop ration, which was fed first. Three of the cows lost in yield of milk, which might be due to some extent to the same cause, but more likely to natural fluctuations or the condition of the weather at that time. This is the more likely, since there is sufficient evidence extant, that bran causes a better flow of milk than oats. While they gained in weight on the oat chop, each lost a few pounds on the bran ration. The difference in either case could have been caused by the difference in water drank, at a single time. With these suggestions, we leave the conclusions to be drawn by the reader, asking his attention to the almost constant difference existing in the values of the foods in question, and that in this experiment clear bran was employed, instead of the usual mixed mill feed.

1st period, ration oat chop and alfalfa; 2d period, bran and alfalfa.

Period.	NAME.	BREED.	Age.	Calved.	Hay Eaten.	Per Ct. Fat. Bab.	Per Ct. Fat. Grav.	Weight of Animal. Begin.	Weight of Animal. Close.	Weight of Animal. Gain or Loss.
1	Bonnie Louan	..Shorthorn .	7	April, 1891	24.8	3.81	4.08	1315	1320	5
2	" "	"	....	....	25.0	3.95	4.10	1320	1315	—5
1	Orchard Lark.........	"	3½	Oct., 1891	28.3	3.43	3.75	1230	1270	40
2	" "	"	....	....	26.8	3.50	3.62	1270	1264	—6
1	Matilda...............	... Jersey ...	4	Dec., 1891	23.0	2.55	3.00	910	955	45
2	"	"	....	....	23.1	2.95	3.00	955	942	—13
1	Pride of the Rockies..	"	4	Sept., 1891	22.5	4.00	3.93	865	895	30
2	" " "	"	....	....	20.1	4.26	4.28	895	880	15

FEEDING EXPERIMENT CONTINUED.

Apparently, we secured a glimpse into the darkness with the oat and bran feeding. Our idea in this experimenting in the same line was, if possible, to learn more of the influence of different foods upon the butter fat.

Cows.—More cows were added. We employed in this work the same Shorthorns, secured from Messrs. Cornforth & Styles, of Loveland, two pure-bred Holsteins, retained one of the Jerseys and exchanged the other for an older cow; each breed was then represented by an aged and a young animal. These six cows received the same treatment and quarters as had the four, and were under the charge of the same herdsman until April 1, when he was succeeded by Mr. B. Roseberry, who gave them the same careful attention to the close of the experiment.

Feeds Selected.—A change was deemed advisable in feeding stuffs. Very dissimilar foods were selected, believing that it is better to compare two or three such than to try more, for the reason that it is difficult and requires most careful attention to details, to be certain from one trial as to the results of even two different rations. The selections consisted of linseed oil meal, corn meal, and wheat bran, with the first cutting of alfalfa and bright oat straw. Each kind of concentrated food was fed alone with one kind of rough stuff, except when the ration was changed to oil meal, at which time some bran had to be added as an appetizer. It is seldom that more than 4 pounds of oil meal can be fed a cow daily without salivating her, but we succeeded in feeding in this case 4.5 pounds, with alfalfa, without bad results. Since the question of the amount of food fed is conceded not to be of special importance as bearing upon or influencing the composition of the milk, the animals were given all they would consume without impairing their appetites. They were watched most carefully, fed according to their demands, and record kept.

FEEDING PERIODS.

The length of a period determined upon was ten days.

1. The six animals were fed alfalfa and bran for ten days, for the purpose of testing the milk, and making comparison on the same ration as a basis.

2. Beginning with the eleventh day, we fed one lot of three cows (one of each breed) with oil meal and alfalfa, and the other three with wheat bran and alfalfa.

3. Straw was substituted for alfalfa for ten days, other feed continued the same.

4. The conditions of the two lots of cows were reversed, giving the first lot wheat bran, and the second oil meal.

5. All were feed wheat bran and alfalfa.

6. The first lot of three cows were now changed to Indian corn meal, and the second to wheat bran, all receiving alfalfa.

7. Reversed the conditions of the two lots of cows.

8. All fed corn meal and alfalfa.

The object in the last three periods, and others similar, is the noting of variations in the quality of the milk, and to see if they correspond to the variation and quality of the foods employed.

During all of this work we took samples of each cow's milk, combining that of morning and evening, and analyzed them, as in the case of the four cows, by the Babcock method. Gravimetric analyses were frequently made by the Station Chemist, which do not correspond as well as we would wish with the other method employed, for the reasons heretofore stated. A careful record of the food eaten and water drank has been kept, and the cattle weighed daily between 10 and 11 o'clock. A great deal of attention and labor is connected with such an experiment. Analyses to the number of 706 have been made, recorded and averaged for this bulletin. It is believed that the experiment is not wholly without merit, and that the tables on the following pages are that interesting and comprehensive as to enable the reader, by careful study, to deduce from them information of much value.

No. 1.—Bonnie Louan, Shorthorn, age 7 yrs ; last calf April, 1891.

FEEDING PERIOD.	Food Consumed. Daily Average, lbs.			Milk Yield, Daily Average.		Per Ct. Fat.		Weight of Animal.		
	Feed.	Hay or Straw.	Water.	lbs.	ozs.	Babcock.	Gravimetric.	Beginning	Closing.	Gain or Loss.
1. Wheat bran and lucerne......	6	23.3	107.1	13	1	3.84	4.16	1232	1344	112
2. Linseed oil meal, some bran and lucerne	Bran, 1.9 O. Meal 1.8	22.8	106.3	12	5	4.53	4.16	1344	1342	—2
3. Lin. oil meal and oat straw..	4.3	7	60.7	9	7	5.22	5.15	1342	1312	—30
4. Wheat bran and oat straw....	6	14.6	75.8	10	3	3.99	3.77	1312	1304	—8
5. Wheat bran and lucerne......	8.7	20.1	105.9	12	12	3.90	3.50	1304	1342	38
6. Indian corn meal and lucerne	6.4	20.8	95.2	13	4	3.92	3.48	1342	1326	—16
7. Wheat bran and lucerne......	10.5	19.7	119.7	14	6	3.67	3.75	1326	1338	12
8. Indian corn meal and lucerne	9	20.4	107.3	13	12	3.38	3.55	1328	1356	18

No. 2—Orchard Lark, B. 2d, Shorthorn, age 3½ years ; last calf, October, 1891.

FEEDING PERIOD.	Feed.	Hay or Straw.	Water.	lbs.	ozs.	Babcock.	Gravimetric.	Beginning	Closing.	Gain or Loss.
1. Wheat bran and lucerne......	6	24.1	123.6	13	13	3.45	3.81	1180	1285	105
2. Wheat bran and lucerne......	6	24.2	126.4	13	4	3.18	3.22	1285	1294	9
3. Wheat bran and oat straw....	6	12.5	79.9	10	10	3.68	4.53	1294	1270	—24
4. Lin. oil meal and oat straw..	4.3	17.4	84.6	10	9	3.97	3.72	1270	1210	—60
5. Wheat bran and lucerne......	8.7	22	120.2	12	5	3.66	3.73	1210	1234	24
6. Wheat bran and lucerne......	10.5	24.5	122.7	13	1	3.52	3.54	1234	1298	64
7. Indian corn meal and lucerne	7.3	26.1	133	12	10	3.22	3.35	1298	1296	—2
8. Indian corn meal and lucerne	9	26.7	127.5	12	13	3.38	2.95	1296	1322	26

No. 3—May Lincoln, Holstein, age 8 yrs ; last calf, October, 1891.

FEEDING PERIOD.	Feed.	Hay or Straw.	Water.	lbs.	ozs.	Babcock.	Gravimetric.	Beginning	Closing.	Gain or Loss.
1. Wheat bran and lucerne......	6	22.3	110	21	12	3.14	3.35	1005	1115	110
2. Linseed oil meal, some bran and lucerne..............	O. Meal 2.1 Bran 1.2	24.8	118.2	20	10	3.42	3.12	1115	1132	17
3. Lin. oil meal and oat straw...	4.4	8.3	67.5	15	9	3.38	3.53	1132	1070	—62
4. Wheat bran and oat straw....	6	12.8	73.1	14	0	2.74	3.23	1070	1076	6
5. Wheat bran and lucerne......	8.7	18.4	106.3	16	6	2.78	2.95	1076	1128	52
6. Indian corn meal and lucerne	6.4	21.3	97.5	18	1	2.53	2.82	1128	1132	4
7. Wheat bran and lucerne......	10.5	20.8	129.6	18	8	2 60	3.10	1132	1138	6

No. 4—Queen Sontag, Holstein, age 4 years; last calf, July, 1891.

FEEDING PERIOD.	Food Consumed. Daily Average, lbs. Feed.	Hay or Straw.	Water.	Milk Yield. Daily Average. lbs.	ozs.	Per Ct. Fat. Babcock.	Gravimetric.	Weight of Animal. Beginning.	Closing.	Gain or Loss.
1. Wheat bran and lucerne......	6	27.9	129	21	1	3.34	3.50	1002	1145	143
2. Wheat bran and lucerne......	6	29.3	139.7	21	7	3.42	3.44	1145	1170	25
3. Wheat bran and oat straw....	6	12	84.7	15	6	3.53	3.93	1170	1164	—6
4. Lin. oil meal and oat straw ..	4	19.1	104.7	10	12	3.73	4.18	1164	1160	—4
5. Wheat bran and lucerne......	8.7	23.4	150	12	2	3.20	3.27	1160	1178	18
6. Wheat bran and lucerne......	10.3	27.1	160	16	3	3.18	3.40	1178	1214	36
7. Indian corn meal and lucerne	7.3	29.2	138.7	18	4	3.02	3.50	1214	1206	—8

No. 5—Lalite, Jersey, age 9 years; last calf, January, 1892.

FEEDING PERIOD.	Feed.	Hay or Straw.	Water.	lbs.	ozs.	Babcock.	Gravimetric.	Beginning.	Closing.	Gain or Loss.
1. Wheat bran and lucerne......	6	21.1	99.3	21	8	4.00	4.73	750	857	107
2. Linseed oil meal, some bran and lucerne	Bran 1.4 Oil m. 2.1	20.8	94.2	20	4	4.62	4.86	857	848	—9
3. Lin. oil meal and oat straw..	4.4	7.1	52.1	15	3	5.12	5.20	848	800	—48
4. Wheat bran and oat straw....	6	11.3	62.6	14	9	4.47	5.29	800	792	—8
5, Wheat bran and lucerne......	8.1	14.1	76.4	15	10	4.38	4.83	792	848	50
6. Indian corn meal and lucerne	6.4	19.6	75.6	17	15	4.27	4.36	848	826	—22
7. Wheat bran and lucerne......	10.5	15.4	102.3	18	5	4.42	4.85	826	830	4
8. Indian corn meal and lucerne	9	18.6	84.7	19	15	4.32	4.20	830	838	8

No. 6—Pride of the Rockies, Jersey, age 4 years; last calf, September, 1891.

FEEDING PERIOD.	Feed.	Hay or Straw.	Water.	lbs.	ozs.	Babcock.	Gravimetric.	Beginning.	Closing.	Gain or Loss.
1. Wheat bran and lucerne......	6	20.8	98.6	14	13	4.14	4.43	815	899	84
2. Wheat bran and lucerne......	6	20.1	96.6	15	1	4.45	4.86	899	892	—7
3. Wheat bran and oat straw....	6	8.6	62.7	13	2	4.68	4.80	892	886	—6
4. Lin. oil meal and oat straw..	3.9	14.6	81.9	12	11	4.70	4.90	886	862	—24
5. Wheat bran and lucerne......	8.7	19.4	92	13	13	4.46	4.43	862	910	48
6. Wheat bran and lucerne......	10.5	16.5	94.6	15	1	4.40	4.78	910	888	—22
7. Indian corn meal and lucerne	7.3	16.5	85.8	15	5	4.03	3.85	888	886	—2
8. Indian corn meal and lucerne	9	17.2	87.3	15	14	4.02	3.60	886	898	12

The State Agricultural College

The Agricultural Experiment Station.

BULLETIN NO. 21.

I. SUGAR BEETS. II. IRISH POTATOES.
III. FRUIT RAISING.

Approved by the Station Council.

ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

OCTOBER, 1892.

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The Agricultural Experiment Station,

FORT COLLINS, COLORADO.

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I.

SUGAR BEET CULTURE.

By FRANK L. WATROUS.

Sugar beets were first grown in the Arkansas Valley for sugar testing purposes, in the year 1890. Most of the work was done on this Station, but there were two or three enterprising farmers who thus early began to investigate the subject.

The work, that season, was altogether experimental. Little was known as to the best varieties for planting, subsequent cultivation, and most of all, nothing was known as to needed amount, or manner of irrigation. This year was spent in groping after facts and the product, though encouraging was not large. However, the work this year with that of the following season, proved among other things, that the Arkansas Valley was well adapted as to soil and climate, to the growing of sugar beets, and with this came a knowledge of the magnitude of the business. The farmers of this section, having already felt the consequences of soil deterioration, through the successive cropping of wheat on the same land, began to see an advantage, providing a market could be secured, in growing a crop not particularly difficult to cultivate, not too tender to be handled by ordinary labor, less deteriorating to the soil than wheat, and less liable than most other crops to suffer from the exigencies of climate or the depredations of insect enemies. A period of drouth in the latter part of the season is just what the sugar beet requires, so that an occasional water shortage at that time is no detriment to the crop.

The ideal sugar beet ground is a sandy loam, porous, warm and easy to cultivate. Topographically, the land should be smooth and nearly level, the better to facilitate proper irrigation.

An experiment made in 1891, would seem to indicate that in an ordinary season, one irrigation during the growing season is sufficient to produce the best results, both as to tonnage per acre and saccharine matter contained.

TABLE.

No.	NAME.	Area.	Culti-vated.	Hoed.	Irri-gat'd.	Tons per A.	Sugar per ct.	Purity, Coef.
1	Vilmorin	¼ A.	3 times	Twice	0	9	14.25	80.5
2	"	"	"	"	1	10 4-5	15.2	81.3
3	"	"	"	"	2	9 9-10	14.22	79.5
4	"	"	"	"	3	9 9-10	13.	76.0

Though it is quite generally understood that the irrigated beet is the best and most profitable, it has become apparent, not only here, but in the practical work in Utah and California, that unless irrigation and cultivation are carried on with a careful relative system, there will always be a lack of harmony between the crop and its environment, which will prevent the assimilation of the maximum amount of saccharine matter.

It will be readily understood, that hilly or uneven land cannot be made to produce equally good results on all portions, from the fact that on hillsides, water will run too fast to soak in well, while if there be low places, here, the water will stand, to the total ruin of the crop.

The season for planting at this Station extends from March 20th to June 20th and for harvesting from August 15th till November 15th. It is this wide range of the planting and harvesting season that, with suitable soil and facilities for proper irrigation, makes the Arkansas Valley especially adapted to beet raising for profit.

A number of experiments have been tried for determining the amount of seed to be sown per acre, depth of planting, proper space between rows, methods of irrigation, etc.

For field cultivation, the conclusion from many trials, both here and elsewhere, is that not less than 16 pounds of seed should be sown per acre. It is much better to thin than to plant again.

As to depth of planting, our best results have been obtained from planting from two to three inches deep. In very shallow planting, seed frequently becomes too dry for germination and in extremely deep planting, there may be danger of the seed lacking sufficient germinating power to force its way up, or a spell of wet weather might cause it to rot.

The following is a table showing results in certain experiments, the past season relating to subjects in hand, which through the courtesy of Professor F. A. Huntley, my successor at the Rocky Ford Station, since July 1, 1892, I am permitted to use here :

TABLE.

TEST.	Plat.	Name.	How Sown.	Depth. Inches.	Rows Apart, Ins.	Yield, lbs.	No. Beets.	Tons per Acre.
A	1	Vilmorin	Drills	1	16	439	193	21.95
A	2	"	Drills	4	16	340	108	17.
B	1	"	" 1 seed every 2 ins.	2	16	516	269	25.80
B	2	"	Drills 2 seeds every 4 ins.	2	16	525	262	26.25
C	1	"	Hills 8 ins. apart	2	8	499	244	24.95
C	2	"	Hills 12 ins. apart	2	12	528	191	26.4
D	1	"	Drills	2	12	497	312	24.85
D	2	"	"	2	16	505	251	25.25
Field	1	"	"	3	12 and 24	....	Good Stand.	21.50

The size of "test" plats was one, one-hundreth acre each, and as the product of small plats is apt to average above field culture, this accounts for the excess in tonnage per acre, of first experiment over the last tabulated.

The following method of planting was adopted at this Station the past season, for field culture and has been found very satisfactory:

After land had been plowed, harrowed, and made quite smooth, even and free from lumps, stones or trash, seed was sown with an ordinary hand-drill, sowing 18 pounds to the acre, covering an inch or less in depth, in double rows one foot apart, separated by a space two feet wide. Then, with one horse and a shovel plow, a trench was made in this space, the dirt being thrown both sides to finish covering the seed. The rows are worked over quickly with a rake or hoe and seeding is completed. Beet seed requires considerable moisture to produce germination, hence, in a dry spring, water may be turned in these ditches and beets brought forward, independent of dry weather.

To facilitate proper irrigation, rows should not be more than 300 feet in length, preferably less. It should not b necessary to drench the upper end in order to moisten lower end.

Proper cultivation, consists in hand hoeing, or with a fine tooth cultivator, the surface of the grou stirred as soon after irrigation as practicable. From experience at this Station it seems safe to state that the more careful cultivation, with a proper amount of water when needed, the more sugar per acre; conversely, the less cultivation, with more irrigation, which necessarily follows, the less sugar per acre and consequently less profit, although yield in tons may be the same, or greater.

Thinning should be done when four or six leaves appear and it is considered best to have no two beets nearer than four inches to each other. This, however, is governed by the distance apart of the rows and the fertility of the soil.

The best varieties of sugar beets, so far as our experiments have determined, are the Vilmorin with its various strains, and Klein Wanzlebener.

As a fertilizer for sugar beet land I would recommend the plowing under of alfalfa.

The crop of sugar beets raised on the Station has been sold each year to different parties and used as feed for cattle, sheep and hogs. In each instance, good results have been reported.

Below will be found a list of beets raised on this Station during each of the past three years, with the chemical analyses of the same.

TABLE.

Year.	NAME.	Area.	Sugar, per cent.	Purity coef.	Tons Beets per A.	Pounds Sugar per A.
1890	Red Top....................................	½ A.	11.94	....	13 1-2	....
1890	Dippe's Vilmorin..........................	Row	14.29	....	12 1-6	....
1890	Florimond Desprez........................	"	14.95	....	10 1-2	....
1890	Simon Le Grande's White Imperial	"	13.44	....	8 1-3	....
1890	Bultean Desprez	"	12.99	....	12 1-6	....
1890	Dippe's Klein Wanzlebener	"	12.69	....	15 1-8	....
1890	French Rose. (Samples sent to A. R. Pierce, Pueblo, for analysis; no report.) ..	....	....	....	9 1-2	....
1890	German White................................	....	....	....	13 1-3	....
1890	Verbesita Rosa..............................	....	....	....	7 1-2	....
1890	Late French Rose............................	....	....	....	17 1-10	....
1891	Vilmorin....................................	¼ A.	14.25	80.5	9	....
1891	"	"	15.2	81.3	10 4-5	....
1891	"	"	14.22	79.5	9 9-10	....
[illegible]91	"	"	13.	76	9 9-10	....
[illegible]	Klein Wanzlebener	1-100 A.	13.	76.9	24.829	4256
[illegible]	[illegible]ilmorin................................	"	15.83	85.4	24.393	5673
[illegible]	[illegible]'s Imperial..............................	"	9.66	76.	36.793	4629
[illegible]	[illegible], Brabrant Imperial...	"	14.24	80.5	34.412	6765

TABLE—Continued.

	Name.	Area.	Sugar. per cent.	Purity. coef.	Tons Beets per A.	Pou'ds Sugar per A.
1892	Dippe's Improved Richest Sugar...........	"	14.73	81.4	27.443	5642
1892	Dippe's White Imperial...	"	13.32	79.3	23.304	4213
1892	Klein Wanzlebener	"	14.67	81.	33.754	3879
1892	Vilmorin..................................	¼ A.	15.18	83.4	25.047	5435
1892	Lane's Imperial...........................	1-100 A.	8.54	70.	40.293	4126
1892	Klein Wanzlebener	"	13.33	80.8	34.195	6309
1892	Vilmorin, Brabrant Imp....................	"	15.72	83.6	30.056	6769
1892	Dippe's Imp. Richest Sugar................	"	14.92	78.5	27.878	5598
1892	" " White Imperial........................	"	13.88	81.2	32.888	6354
1892	Vilmorin..................................	¼ A.	16.69	81.8	20.500	4801
1892	"	"	18.87	85.	18.730	5151
1892	"	"	15.87	84.9	25.700	5937

The excess in yield of the planting of 1892 over that of preceding seasons we believe to be due to different and more satisfactory modes of planting already described.

II. IRISH POTATOES.

By FRANK L. WATROUS.

The first serious problem that presented itself for solution after the Arkansas Valley Experiment Station was ready for work, was that of growing potatoes. All that was known on the subject, was that "potatoes would not grow," and it was impossible, the first season to form any plausible theory on which to base an experiment. The first year's work was to no purpose except as it produced ideas to be tested in the work of the following season.

From forty varieties grown the first season, only eight varieties gave any promise, and these were by no means good. Seed was saved, however, and a more varied system of planting adopted. The following spring, potatoes were planted as early as March 17th, in newly manured ground, which was further enriched by the application of ashes from a lot of sorghum stalks, burned for the purpose. The seed was small, having been stunted, by unfavorable conditions the previous season and the outlook for the experiment was not the best. However, some of these early potatoes produced fairly well, the tubers reaching marketable size.

In June of that season, some seed potatoes from Salt Lake were secured and planted June 20th, in rich soil and wood ashes added to the hills. These potatoes yielded at the rate of 160 bushels per acre and were fine in size and quality.

The above experiments gave us the following points:— First, that home grown seed could not be depended upon to produce the best results; second, there seemed to be a deficiency of some soil element which was needed to produce thrifty growth, or, supposing the soil to be complete, it was thought that the system of irrigation used, in conjunction with the extremely warm weather prevailing in summer, might produce a chemical or mechanical condition of the soil, or both, whereby the element lacking might be locked up in some unavailable form.

The potato resembles every other vegetable, in useful, profitable agriculture, in that it has certain specific, well defined wants, as to the chemical constituents of the soil and their mechanical constitution. Even where the proper plant food exists in the soil, if the plant is hemmed in by a hard, baked surface, there can be no healthy development. To produce healthy crops, soil must be pliable and porous, so that, with the aid of air and moisture, assimilation may take place readily and a hospitable relation exist between the plant and its environment.

With the hope to overcome some of these difficulties, which, it may be said, are common in many Western soils, especially where irrigation is practiced, a half acre was prepared in the following manner: On land occupied by sugar beets the season previous, straw was placed to a depth of eight or ten inches. June 5th the following season, the straw was burned and the ashes plowed under at once. Then on the 9th and 10th one-fourth of an acre was planted to seed of Mammoth Pearl and the other one-fourth acre to Rose Seedling. The seed was cut in large sized pieces, with one and two eyes and planted in furrows four to six inches deep.

As soon as tops appeared above the ground, a light harrow was brought into use and this was continued at intervals of a few days until the tops were so large as to make the work injurious, after which time they were cultivated with a small, fine-tooth cultivator. When the ground was partially shaded by tops, a furrow was run between each two rows from north to south. On August 1st, when plants were in blossom, the ground being dry, irrigation was commenced. The water was confined to furrows and allowed to run long enough to moisten the rows quite thoroughly. By this time, the roots were spreading so far that cultivation would have been injurious, so that in order to keep the soil in healthy condition, it was necessary to irrigate about once a week, for the remainder of the season, which was done.

Potatoes were harvested October 7th. The plat of Rose Seedlings produced at the rate of 108 bushels per acre. The plat of Mammoth Pearl at the rate of 252 bushels per acre. These potatoes, in both instances were of most excellent quality.

During the winter of 1891, two one-half acre plats were prepared in same manner as described in last experiment. The first one-half acre was burned over and plowed in March and planted with Rose Seedlings potatoes, March 24.

The second one-half acre was burned over and plowed, June 5th, then planted with Mammoth Pearl, June 9th. After-cultivation and irrigation was intended to be the same as in previous year.

Following is a tabulation giving data of the different plats for the past two seasons.

1891.

NAME.	Where Secured.	Area.	When planted	Har-vest'd	Yield per A.	Expense per A.	Value.	Net.	Fertilizer.
Rose Seedling...	San Luis val.	¼ A	June 10	Oct. 7	108	$55.80	$ 64.80	$ 9.00	Straw Ashes
Mammoth Pearl.	"	"	"	"	252	55.80	151.20	95.40	"

1892.

NAME.	Where Secured.	Area.	When planted	Har-vest'd	Yield per A.	Expense per A.	Value.	Net.	Fertilizer.
Rose Seedling...	Table Rock	½ A	Mar. 10	Aug. 10	59	63.90	61.98	- 1.92	"
Mammoth Pearl.	"	"	June 11	Oct. 21	248	84.50	171.48	86.98	"

1891—SMALL PLATS.

NAME.	Where Secured	Planted	H'rvest'd	Yield per A bus.	Fertilizer.
Hercules	Station.	Mar. 17	June 25	90	Burned Bones.
California White	"	"	July 10	70	"
Chicago Market	Monument	June 3	Oct. 1	60	Ashes and rotted manure
California White	Station	"	"	84	"
Late Ohio	"	"	"	63	"
Hoag's Seedling	"	"	"	40	"
White Star	"	"	"	50	"
Mammoth Pearl	"	"	"	45	"
52 Seedling	"	"	"	35	"

1892.

NAME.	Where Secured	Planted	H'rvest'd	Yield per A bus.	Fertilizer.
New Early Market	Philadelphia	March 28	Oct. 19	152	Rotted Manure
Late Ohio	Monument	"	"	152	"
Mammoth Pearl	"	"	"	125	"
Rose Seedling	"	"	"	115	"
Rural New Yorker No. 2	Philadelphia	"	"	142	"

In estimating the expense of raising potatoes in the one-fourth and one-half acre plats, the regular farm wages were allowed, the value of the crop being estimated at the price it was actually sold for, so that the " net " is the amount gained or lost, after the work of raising the crop was paid for.

The failure of the one-half acre of Rose Seedlings, the past season, to produce a profitable early crop, was due to a very heavy frost in May which cut the vines to the ground, setting them back and making it necessary for the crop to come to maturity in the warmest weather, which has always proven an unfavorable time.

In explaining the efficacy of straw ashes as a fertilizer, it is not with the understanding that this amount of ashes, in a strictly chemical sense, could be termed a strong fertilizer. The belief is, that the limited amount of potash salts contained in the ashes, is in a readily assimilative form and this, with the sudden action of the heat, causing friability, with the presence of the ashes in the soil, produces a most salutary condition, both chemically and mechanically.

The management ot the soil may of course, work a great advantage or disadvantage. To grow first-class crops of potatoes, the soil should be in such a state of cultivation that it will yield to several inches beneath the surface, under the pressure of the foot. This condition cannot be secured on ordinary soils, so long as the ground is flooded with water when irrigated.

It is difficult for the ordinary farmer to understand that irrigation is, or should be, a supplement to cultivation; that, stirring the surface soil, obstructs its capillarity and, virtually promotes the existence of an underground reservoir, retained by its mulch, or upper layer.

A proper understanding of the relative needs of plant and soil in connection with irrigation, is destined to make clear, many of the perplexing difficulties, which are met by Colorado agriculturists, and no crop will better repay for the application of the required knowledge, than the potato crop.

The use of straw ashes as a fertilizer is, perhaps, the easiest, quickest and at present, cheapest way in which to supply the mineral elements most needed in the growth of potatoes. However, it must not be inferred that this is the only, or even the best way to raise potatoes in the Arkansas Valley. This is simply, the pioneer work. Its results point to the attainment of a better knowledge of the co-operative and co-relative elements in nature and their nicer dependencies, which may be secured by the careful study of practical agriculture.

It is not improbable that a heavy crop of green alfalfa, plowed under in July or August, with, perhaps, the addition of a small amount of ashes or commercial fertilizer the following spring, may produce a very desirable combination for potato ground.

There is yet much work to be done in this line, but in the meantime, it is believed any farmer may raise potatoes, sufficient at least, for home consumption, by following the methods described in this bulletin and epitomized below:

1st.—Select the best soil.
2nd.—Cover with straw in Winter.
3rd.—Burn just before plowing and plow deep.
4th.—Use seed from higher altitudes.
5th.—Plant very early or very late, five inches deep, in rows north and south.
6th.—Stir the surface soil frequently when the plants are small.
7th.—Irrigate, if needed, in furrows when plants are in blossom and after they are once wet, never allow them to get thoroughly dry until growth ceases.

III. FRUIT RAISING.

By FRANK L. WATROUS.

A large majority of those who in times of uncertainty and scepticism, had the temerity to plant fruit trees along the valley of the Arkansas, have reason to be much encouraged by the results of their ventures in that direction. There have been, perhaps, fewer than usual of the more serious obstacles met with in new countries, excepting the depredatians of itinerant tree peddlers, whose presence and genius are confined to no locality.

It has been planned by the Station management, to start a good sized orchard of the well known, hardier varieties, and each spring to keep adding the new and promising varieties as they are brought out aiming, by careful discrimination in selections for planting, in manner of setting, in after culture and finally by close observation as to habits and general qualities, to establish a criterion in as many points as possible, thereby making the Station work helpful to the class of orchardists who desire to learn otherwise than by personal experience.

Obtaining trees from various localities, near and far, it was noticed that a decided advantage was gained, where trees were home-grown, being selected, from the nursery, dug and replanted the same day.

Of the various methods of planting, nearly all are good, if properly carried out. Giving ample room for the root system and carefully pulverizing and packing the soil about the roots are the principal points.

Trees need water frequently during the first season. Ordinarily, it has been found good practice, to irrigate young trees once in two weeks until September, then withhold the water till November and give one thorough wetting just before freezing weather. In case of very dry winters, an irrigation in February is beneficial. This applies of course, to well drained land. During the second season, once a month is considered often enough to irrigate if careful and thorough cultivation is given. There is nothing gained and there may be much loss by watering trees too frequently after they have become well established and the same rule applies in filling out and maturing fruit, as would be followed by a sagacious farmer, in perfecting his grain crops.

It was found good practice to seed an orchard, after the second year, to red clover, leaving a space three feet wide each side of the trees for cultivation and irrigation, the furrows being two feet from the trees, as water should never be allowed around the trunks. If needed for fertilizer, the clover may be plowed under and the ground re-seeded the following spring. It is not deemed best to cut hay from orchard grounds, but sheep and swine are often pastured there with good results, it being advisable, however, to watch closely and remove animals before feed becomes short, lest damage is done to the trees.

Many people meet with disappointment from the fact that trees do not come in bearing so soon as the tree agent had given reason to believe. It should be borne in mind that apple trees, according to varieties, require from four to thirteen years to arrive at profitable bearing. Plums require from three to ten years, grapes, three to five years and smaller fruits from one to four years.

As a rule, it pays to thin fruit on all trees until there is no danger of their breaking down without propping.

Conditions in this locality are favorable to early and heavy fruitage and in many instances, both fruit and tree have been injured from excessive bearing.

Trimming and training should be done while trees are young, and the best practice goes to recommend that limbs should not be started less than three feet, nor more than five feet from the ground. There are serious objections to branching beyond these limits in either direction.

As a remedy against the Apple Tree Borer and to promote the vigor of trees, the trunks and lower limbs may be washed in May, with the following mixture:—Take two thirds of a pailful of slaked lime, the same as for whitewash, add one pint of gas tar and one pound of hard soap. Dissolve one pint of lye and put into the mixture, then add enough common soil to produce a proper consistency for applying with a whitewash brush.

The closest attention is necessary in order to preserve fruit from damage by insects. The Codling Moth is destroyed usually, by spraying with the paris green solution, just after the blossoms fall. The proportions generally recommended are 160 gallons of water to one pound of paris green. This also is a remedy for Leaf Rollers and should be applied as soon as the enemy's presence is noticed.

Kerosene emulsion is a remedy for a vast number of insect pests. To make it, dissolve a pound of hard soap in two quarts of boiling water, then remove from the fire and add one pint of kerosene and stir violently with a small force pump, four or five minutes. When emulsified, it resembles rich cream. This emulsion may be used upon stock to kill lice, but when applied to plants, it must be reduced by adding water until only one-fifteenth is emulsion. When the undiluted emulsion is left standing, it becomes a gelatinous mass, which is readily dissolved by using hot water.

Following is a list of varieties now growing upon the Station, giving such characteristics as were noted with accompanying data, the trees taken just as they stand in the orchard:

APPLES.

NAME.	No. Set.	Date Set.	Age, Yrs.	Where Secured.	Growth.	Habit.	Died.	Bearing.	Season.
Duchess	10	Apr. '89	2	College Nursery	Slow	Close	0	1892	Sum.
Wealthy	10	“	2	“	Medium	Spreading	0	......	Aut.
McMahon's White	1	Apr. '91	2	Station Nursery	“	“	0	......	“
McIntosh Red	1	“	2	“	“	“	0	.....	Win.
Ben Davis	11	Apr. '90	3	Rocky Ford Nur.	Fast	“	0	......	“
Pewaukee	11	“	3	“	“	“	0	......	Aut.
Fameuse	11	“	3	“	“	“	0	.....	“
Mann	11	“	2	“	Medium	Upright	0	.....	Win.
Early Harvest	11	“	3	“	Fast	Spreading	0	......	Sum.
Cooper's Early White	11	“	3	“	Stocky	“	0	1891	“
Tetofsky	11	“	3	“	“	Upright	0	1891	“
Whitney No. 20	11	“	2	“	Slow	“	0	1892	Aut.
Wealthy	11	“	3	“	Fast	Spreading	0	......	“
Red Astrachan	11	“	3	“	“	“	0	......	Sum.
Salome	5	Apr. '89	2	Illinois.	Slow	Upright	0	1892	Win.
Peter	5	“	2	“	“	Spreading	0	......	“
Missouri Pippin	5	Apr. '90	2	Rocky Ford Nur.	Fast	“	0	1891	“
Sops of Wine	6	“	1	Station Nursery.	Slow	“	0	......	Sum.
Fall Winesap	10	Apr. '91	2	“	Fast	“	0	1892	Aut.
Alexander	9	“	2	“	“	“	0	......	“
Smith's Cider	10	“	2	“	“	Upright	1	......	Win.
Wagoner	9	“	2	“	Slow	“	2	.....	“
Baldwin	10	“	2	“	Fast	Spreading	2	......	“
Utter's Red	9	“	2	“	Slow	Upright	3	......	Aut.
20-oz. Pippin	10	“	2	“	Medium	“	0	.....	“
Yellow Belleflower	9	“	2	“	Slow	“	2	......	Win.
Northern Spy	10	“	2	“	“	Spreading	3	......	“
Walbridge	9	“	2	“	Medium	“	0	......	“
Black Arkansas	10	Apr. '92	2	“	Fast	“	1	......	“
Peter	9	“	2	“	Medium	“	1	.....	“
Wolf River	10	“	2	“	Fast	“	1	.....	Aut.
Yellow Transparent	9	“	2	“	“	Close	0	......	Sum.

PEARS.

NAME.	No. Set.	Date Set.	Age, Yrs.	Where Secured.	Growth.	Habit.	Died.	Bearing.	Season.
Clapp's Favorite......	16	Apr. '89	2	College Nursery	Medium	Upright	0	......	Aut.
Flemish Beauty.......	4	"	2	"	"	"	0	......	"
Longworth............	5	"	2	Illinois	"	Spreading	0	......	"
Kiefer's Hybrid.......	14	"	2	College Nursery	Slow	Upright	5	......	um.

PLUMS.

NAME.	No. Set.	Date Set.	Age, Yrs.	Where Secured.	Growth.	Habit.	Died.	Bearing.	Season.
DeSota...............	10	Apr. '89	2	Greeley	Medium	Upright	0	1891	....
Forest Garden	10	"	2	"	"	"	0	1891	....
Chicasaw.............	10	"	2	"	Fast	"	0	1891	....

A small experimental orchard of plums, prunes, cherries peaches and apricots was set in the springof 1892. They came from Stark Bros'. Nursery in Louisiana, Mo., and were in very poor condition when received. About 20 per cent. of these died.

Small fruits, especially grapes and stawberries have done remarkably well at the Station. Of the latter, Manchester and Jesse have given the best results. The following table gives data of different varieties of grapes:

GRAPES.

NAME.	When Set.	Loss.	Growth.	Beari'g	Color Fruit.	Size.
Moore's Early.........................	1889	1	Slow	1891	Black	Large
Lady	1889	0	Medium	1891	White	Medium
Empire................................	1889	0	Slow	1891	"	"
Worden	1889	0	Medium	1891	Black	Large
Duchess....	1889	0	Rank	1891	White	Small
Concord...............................	1889	1	Medium	1891	Black	Large
Lady Washington.......................	1889	0	Rank	1891	White	"
Pocklington	1889	0	Medium	1891	"	"
Niagara	1889	0	"	1891	"	"
Brighton	1889	0	Fast	1891	Red	"
Delaware..............................	1889	0	Medium	1891	"	Small
Martha	1889	0	"	1891	White	"
Muscat	1890	0	Fast	1891	"	Large

The State Agricultural College.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN No. 23.

COLORADO WEEDS.

Approved by the Station Council.
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

APRIL, 1893.

Bulletins are free to all residents of the State interested in Agriculture in any of its branches, and to others as far as the edition will permit. Acknowledgment will be expected from all non-residents. Newspapers desiring continuation on the mailing list will please acknowledge by editorial notice and the sending of a marked copy of the issue containing it.

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FORT COLLINS, COLORADO.

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Colorado Weeds.

By Charles S. Crandall.

It is not our present purpose to attempt an exhaustive treatment of the weeds of the State, but by a few brief general considerations, and the mention of a limited number of well-known offenders, to bring the subject to the attention of the farmers, in the hope that they will aid us in the collection of data from which to compile a complete report. Our own observations have thus far been confined to a limited territory. We need detailed information from all portions of the State before we can properly classify our weeds, or draw correct conclusions regarding their distribution, and relative noxious qualities. Hence, for the State as a whole, our statements can only be general.

Every cultivated district has its weeds, and in most districts they are present in great variety; but the prevalent forms of one district may be widely different from those of another. The region adjacent to the eastern foothills is infested with one series of weeds north of the Divide, and by a greatly different series south of the Divide. The weeds of the plains of the eastern counties are mostly different from those near the foothills, and west of the range we find a class of weeds different from those prevailing on this side.

A plant may be present in two or more districts, but attract notice as a weed only in one; it may even be a very bad weed in one district and harmless in another. Thus our common *Thermopsis* (*Thermopsis montana*) is reported as a persistent weed in the San Luis valley, taking possession of moist pasture lands, and gradually extending its area to the detriment of the grasses; while here we would class it as one of the most indifferent weeds—existing, but not spreading to any injurious extent. A few kinds are everywhere present, and are universally classed as injurious. Owing to this diversity in the weeds of different regions, and to the various ratings that may be given particular species in the different districts, it is difficult to form a classification based upon relative badness. Adopting the commonly used division into worst, bad and indifferent, it is plain that conflict would arise in any attempt to adjust a list to all districts; even in a particular district there would be differences of opinion as to the class in which certain weeds should be placed, and as to the position in the class; there may even be differences of opinion as to whether a plant should appear in a list of weeds at all or not, and this would demand an answer to the question, What is a weed? The dictionary defines the word weed as "Any plant growing in cultivated ground to the injury of the crop or desired vegetation, or to the disfigurement of the place; an unsightly, useless, or injurious plant." Then we have the old definition, "A plant out of place," which is broad enough, and at the same time has the virtue of brevity. There is evident propriety in including in a weed list, not only the decidedly injurious ones, that cause so much trouble in gardens and fields, but also the unsightly and useless plants that disfigure our road-sides, ditch-banks, pastures, and waste places. We must include, also, some of our most useful plants, because they frequently give trouble by appearing out of place. Alfalfa is invaluable to this Western country as a forage crop, but when it springs up in your strawberry bed you regard it as a weed, and treat it accordingly. A field of alfalfa is broken up and sown to wheat; the roots are imperfectly cut, and we have two crops in competition on the same ground—neither is profitable. It was wheat that was wanted, but the yield was cut short by the alfalfa; in this case the alfalfa is in effect a bad weed. Many other plants may possess this two-faced character—useful or ornamental when in their proper places, but becoming noxious when appearing where they are not wanted.

From observations thus far made, we have included in our list of weeds 228 species of plants. Regarding most of them there is no question—they are plainly weeds; a few, however, are placed in the list provisionally, and our estimate of their position may be changed by further observation. A considerable addition will undoubtedly be made when our study has been extended to include the southern and western portions of the State.

A very natural inquiry concerning weeds is, Where do they come from? Ours are in great part native; they are plants indigenous to the foothills and plains, which, by reason of the favorable conditions afforded them in the irrigated districts, are enabled to develop strongly and multiply rapidly. They are aggressive in the struggle for possession of the land, and thus become pestiferous to our cultivated crops. Sixty-five per cent. of our 228 species of weeds belong to this class; the balance, or 35 per cent., are introduced. These foreigners are mostly European plants, which first secured a foothold on the Atlantic coast, and then, following civilization, gradually migrated westward. A few have come to us from the Southern States and Mexico.

The proportion of native weeds is greater here in the West than it is East. In some of the New England States a majority are foreign. In New Jersey, as appears from Dr. Halstead's weed list, the foreign and native species are almost equally divided.

That the Eastern States should have a larger proportion of European weeds than the Western, is perfectly reasonable; they have a much older agricultural development, are nearer the ports of entry, and the advantages for the growth and dissemination of plants have been greater. Considering the comparatively short period since cultivation of the soil began in Colorado, we have a remarkably large representation of European weeds, and we are yearly receiving additions. Our large percentage of native weeds may also be accounted for by the nature of the country. Dr. Gray, in an article on weeds, explained that the herbaceous plants native in the forest-covered East, were placed at a disadvantage by the removal of the forests, and could not successfully compete in the struggle for existence with the introduced European weeds. In our Western treeless region the native plants are subject to full exposure, and have become inured to the most adverse conditions. Cultivation and irrigation have given them new vigor; they no longer merely exist—they assert themselves, and find place among the most aggressive of our weeds.

Arranging our weeds according to their duration, we find that 128, or more than one-half, are perennials. Of these, 98 are native, and 30 are foreign. The biennials are represented by only 11 species, 7 of which are foreign. The 89 annuals are quite evenly divided, 43 being foreign, and 46 native.

Division according to relative badness is of necessity entirely arbitrary; an attempt has been made to base the position of each species upon the sum of its bad qualities. There is with many species a single quality which predominates over all others, and determines its position; one species, by reason of its prolificacy, may be ranked as one of the worst; another, much less abundant, may take the same rank because it is very persistent and difficult to eradicate. Our present estimate places in the list of worst weeds 56 species; 29 of these are foreign and 27 native. The species falling under the head of bad weeds number 81, 55 of which are native, and 26 foreign. In the list of indifferent weeds, the predominance of native species is still further increased, there being 66 native and 25 foreign, a total of 91.

Classified botanically, our weeds have a wide distribution. The 228 species and varieties represent 141 genera, belonging to 42 orders. Compositæ has much the largest representation; 55 species and varieties, or very nearly one-quarter of the whole, belong to this order; next come Leguminosæ and Gramineæ, represented by 12 genera and 21 species each; then follows Polygonaceæ, with 16 species; the balance are distributed in numbers varying from 1 to 8.

In any given locality additions to the number of weeds frequently appear; it may be a plant whose presence in the neighborhood has been noticed, but which has been passed by as inoffensive; suddenly we find it taking possession of our cultivated ground, and possibly the next year it develops into a formidable pest; another plant, an entire stranger, may from its first appearance be so aggressive as to leave no doubt of its having descended from ancestors that somewhere, by struggles through many generations, had developed those qualities, enabling successful competition with other plants for possession of good ground. The questions, Where did these plants come from? How did they get into our soil? are often difficult to answer. Most of our herbaceous weeds are great travellers; they migrate from one place to another in a variety of ways. Some are provided with structural features which aid dissemination, as the pappus of the fruits of many Compositæ, the coma of the seed of milkweed, or the hooked prickles of the fruits of our clot-bur and wild licorice; some are carried by animals or birds, or on the surface of streams, but the most effective agent in distribution is man himself. Weed seeds are sent across the country baled up in hay, in the packing about merchandise, with the grain and grass seed raised for market, and in a hundred other ways. This broadcast distribution of weed seeds is all unintentional, and in many cases it could be avoided by the exercise of a little care. There is no doubt that many of the weeds that are so troublesome are sown with the grain or grass seed. Seeds which from casual observation appear clean, may upon critical examination disclose an astonishing percentage of seeds of noxious weeds. Two years ago we ordered from the East seeds of twenty species of grasses and forage plants for trial and comparison with native species; only the species ordered appeared on the bill, but when the plants came in flower we found a number of species for which we had not bargained. As an example, two species of brome grass (*Bromus inermis*, Leyss., and *Bromus unioloides*, Kunth.) were ordered, but we did not order the four poor relations from Europe which accompanied them, namely: *Bromus secalinus*, L., *Bromus racemosus*, L., *Bromus sterilis*, L., and *Bromus maximus*, Desf. I may here mention another species of chess which appeared for the first time last season, and whose presence seems to trace directly to hay used as packing about some goods that came from the East, *Bromus Tectorum*, L., a useless importation from Europe, which has been reported from only a few Eastern stations.

The number of plants that make their first appearance on railroad embankments, or about station buildings, confirms the statement that railroads are active agents in disseminating weeds. The Eastern weeds that have found lodgment in our soil have mostly come by rail, and we may confidently expect the arrival of other species that are every year being reported from stations nearer to us.

But the travel of weeds is by no means in one direction; the West is sending some of its worst species in exchange for those contributed from the East; we hear of them in Illinois and Ohio, and even as far East as New York. A few recent introductions that have not yet spread to any extent are mullein (*Verbascum Thapsus*, L.), seen only along the railroad at Boulder; jimson-weed or thorn-apple (*Datura Stramonium*, L.), near Boulder and at Golden along the railroad; Canada thistle (*Cnicus arvensis*, Hoffm.), seen in one locality only; ox-eye daisy (*Chrysanthemum Leucanthemum*, L.), reported from the south and near Denver.

CAPSELLA BURSA-PASTERIS, (L.) Moench. (Plate I.)

(SHEPHERD'S PURSE.)

Annual; root leaves clustered, pinnatifid or toothed, stem leaves sagittate clasping; flowers white; racemes elongated; pod obcordate-triangular. This weed has a very wide distribution; it has followed civilization all over the world. With us it is an annoyance in gardens and a pest in fields, doing the greatest injury in fields of alfalfa; it has been sent us from several localities with the report that it was running out alfalfa. That it is capable of doing this I have seen demonstrated in a road-side piece of alfalfa, which in three years has entirely succumbed to the encroachment of the shepherd's purse. The plant is an annual; it may be found in flower and fruit from earliest spring until winter, and even all winter when the cold is not too severe. In size it varies greatly—from 2 inches to 2 feet; in irrigated fields it makes a rank growth and produces an enormous amount of seed. In order to estimate approximately the seed-producing possibilities, a count has been made of two average plants; 60 fruits from one plant gave an average of 30.1 seeds; for the other, 25 seeds; the average for both plants being 27½ seeds to each fruit. On one plant were 951 fruits, on the other 952; this would give over 26,000 seeds to each plant. But this would not fairly represent the possibilities; the plants were not mature; on one 1,444 buds and flowers were counted, on the other 1,499; assuming that all of these reach full development, and we would have an average of over 66,000 seeds to the plant. Allow for accidents and assume 50,000 as the average number of seeds produced; surely this is enough to account for the rapid spread of the plant. Multiplication is by seed only; it follows that the way to subdue the plant is by preventing the formation and scattering of seed; the hoe and the cultivator judiciously used will accomplish this. We rate the plant as one of our worst weeds.

SAPONARIA VACCARIA, L. (Plate II.)

(Cow Herb ; Cockle.)

Very smooth throughout; 1 to 2 feet high, branched above. Leaves opposite, connate, lower oblong, upper ovate-lanceolate. Flowers in open cymes, pink. Calyx 5-angled, enlarged in fruit. Stamens, 10 ; styles, 2. Annual.

This is an introduction from Europe. At one time it was grown in gardens as an ornamental ; its seeds were scattered, it became spontaneous, and is now well naturalized in many localities. It found its way to Colorado certainly as early as 1874, for on the authority of two collectors it is recorded as " introduced " in the flora published by Porter and Coulter in that year. The plant is now so abundant in grain fields as to rank among our worst pests ; in many places it springs up abundantly in gardens and among hoed crops, but where the ground is cultivated it is easily mastered. When once started among grain, there is no remedy except to destroy when in flower. Seed is no doubt often sown with the grain, but this can be avoided with a little care; the seed is easier to separate than that of the corn cockle (*Agrostemma Githago*, L.), so troublesome in the Eastern States; it is smaller, nearly globular, very minutely roughened, and can be screened out easily. Plants should not be allowed to mature in waste places; they are not strongly rooted, and in the fall they break off or blow out and go rolling like a tumble weed, carrying their seed with them to considerable distances.

GAURA PARVIFLORA, Dougl. (Plate III.)

(Small Flowered Gaura.)

Annual; 2 to 7 feet high, from a long, slender tap-root. Stem at first simple, at length branching from the axils of the leaves. Leaves sessile, ovate-lanceolate, denticulate, sparsely covered with long villous hairs, and also with short hairs which are somewhat glandular. As the plant matures the leaves fall away, so that in the fall only a few below the spikes remain. The small flowers in long virgate spikes. Calyx tube prolonged beyond the ovary, 4-lobed. Petals, 4 ; stamens, 8 ; stigma 4-lobed.

This weed is a native ; it ranges from Washington to Texas, east to the Misouri and westward to Utah. In some localities it is so abundant in grain fields and meadows as to give it rank among the worst weeds. It propagates only by seed, which it produces freely. Preventing seed formation by destruction before or at the time of flowering, is the remedy.

GRINDELIA SQUARROSA, Dunal. (Plate IV.)

(Gum Plant; Rosin Weed.)

Annual; branching from the base; 1 to 2 feet high. Leaves sessile, rigid, spatulate to linear-oblong, narrowed at the hase below, broadened and half-clasping above, acutely serrate or denticulate. Heads of yellow flowers rather large, terminating the branches. Involucre strongly squarrose with the spreading and recurving short filiform tips of the bracts; very viscid, especially at time of flowering. Rays narrow, very numerous.

This species is very common in all territory west of the Mississippi; it is extending eastward, and has been reported from Minnesota, Iowa, Missouri, and Illinois. Here it is most conspicuous along road-sides and on plains that have been broken up and then neglected; it invades cultivated land, and locally is very troublesome in corn-fields. The sum of its pestiferous and undesirable qualities warrants giving it a place among our worst weeds.

IVA AXILLARIS, Pursh. (Plates V. and VI.)

(Poverty Weed.)

Herbaceous, perennial, from woody creeping root-stocks; branching, 6 inches to 1 foot high, equably leafy to the top. Leaves sessile, obovate or oblong, tapering to a narrow base, entire, obtuse, about 1 inch long, minutely appressed pubescent. The small, greenish heads on short recurved pedicels, solitary in the axils of the leaves. Common from the Missouri River to the Pacific, and from New Mexico to British Columbia. The natural home of the plant appears to be in sandy or saline soils, but it adapts itself to all soils, and is everywhere very troublesome. Once established on the farm or in the garden, it spreads rapidly and is difficult to eradicate. Plants produce a moderate quantity of seed, but multiplication is mainly by the extension of the running root-stocks. Like the "quack grass," the breaking up of these root-stocks only increases the number of plants; pieces may be transported across a field on the tools used, and there take root, thus assisting the distribution. Constant cultivation, and the removal of the root-stocks from the soil, is the only remedy.

IVA XANTHIIFOLIA, Nutt. (Plate VII.)

Annual; tall and coarse, 3 to 7 feet high; pubescent, at least when young; leaves mostly opposite, large, broadly ovate, incisely serrate, acuminate, 3-ribbed at base, scabrous above. The small heads nearly sessile in crowded, spike-like panicled clusters from the axils of the leaves, and terminal.

A Western plant, ranging from New Mexico to Idaho. It has been reported from Iowa, and from northern Michigan, and is undoubtedly extending eastward. The plant produces seed in considerably quantity, and propagates only by seed. It is in many places a serious pest in cultivated fields, because of its abundance and rapid growth; being an annual, it is not difficult to destroy, and can be kept down by a little care; the trouble usually comes from delay in cultivation, which allows the weed such a start that it works injury to the crop, and requires much additional labor to eradicate. A mistake is often made in allowing it to grow and produce seed on waste land, or along road-sides. It is a too common sight to see such places covered with a tall, forest-like growth of this plant. From these places seeds are scattered upon our fields, and each year the trouble is repeated. Stop the formation of seed, and the plant will soon cease to be a pest.

SOLANUM ROSTRATUM, Dunal. (Plate VIII.)

(Beaked Horse-Nettle; Buffalo-Bur.)

Annual; yellowish, with copious stellate pubescence, much branched, 6 inches to 2 feet high. Stems, petioles, and veins of the leaves armed with straight prickles. Leaves 2 to 4 inches long, pinnatifid or sometimes bipinnatifid, the lobes rounded. Peduncles about an inch long, later 3 to 4 inches, bearing several flowers on short pedicels. Flowers yellow, an inch in diameter. Fruit enclosed by the close-fitting calyx, which is thickly beset with prickles.

Ranges from New Mexico to Wyoming, and across the plains. It has migrated eastward, being common in Iowa and Missouri, and is reported from Illinois, Indiana, Ohio, and New York. It is everywhere recognized as a bad weed; here, from its abundance, it ranks as one of the worst. Destroying early enough to prevent the scattering of seed, is an effectual remedy.

FRANSERIA DISCOLOR, Nutt. (Plates IX. and X.)

Perennial; the erect, slender stems from very slender running root-stocks, 6 inches to 1 foot high, usually somewhat branched. Leaves 2 to 5 inches long, oblong in outline, interruptedly bipinnatifid, the lobes short and broad, silvery white below, green above. Sterile racemes usually solitary, terminating the stem, occasionally small racemes on the lateral branches, fertile flowers few, the involucres ovoid, 2-flowered, armed with few short conical spines.

Ranges from New Mexico to Wyoming, and east to Nebraska. An aboriginal species that does not appear to have migrated very far eastward. We have no weed so persistent as this; its thread-like root-stocks grow very rapidly, and extend through the soil in all directions, forming a close network. By washing out, I have traced them four and five feet beyond the last plant appearing above ground. When plants are hoed up they are very soon replaced by others, which spring from these root-stocks; plowing, which breaks the root-stocks in pieces, only helps to multiply the plant. The only way to eradicate it is to so persistently cut it down that the plants are given no chance to carry on the processes of nutrition; if no leaves are allowed, the plant must soon die for want of them. The species does not spread rapidly from seed, as only a comparatively small number are produced; ten plants counted gave an average of 73. As the plants multiply mainly by root-stocks, it is important that they be dug out completely as soon as discovered, and before they become well established.

HORDEUM JUBATUM, L. (Plates XI. and XII.)

(SQUIRREL-TAIL GRASS; FOX-TAIL; WILD BARLEY.)

Annual; 6 inches to 2 feet high. Leaves flat, 2 to 4 inches long, margins scabrous. Flowers in a dense spike about 4 inches long, pale green, often purplish. Three florets at each joint of the rhachis, only the central one perfect, lateral florets short awned, central floret with awn 2 inches long, outer glumes 2 inches long, 6 at each joint, rough, upwardly barbed.

This is a Western species, that has become widely distributed over the northern United States. It is one of our worst weeds, spreading rapidly in lands wet from seepage, and also troublesome in cultivated ground. It is especially bad in meadows; its presence greatly lessens the value of hay on account of the injurious effect upon stock of the long, rough awns. When in bloom the grass is ornamental, but its beauty is short-lived; the rhachis soon breaks up, and the parts are scattered by the wind. It should be cut early to prevent seeding.

Plates I., II., VI., VII., VIII., IX. and XI. are from drawings made by Miss C. M. Southworth; plates III. and IV. from drawings made by Miss Alice Bell. Plates V., X. and XII. are from photographs.

We ask of farmers and others interested that they co-operate with us in the endeavor to designate and classify the weed pests from every agricultural region of the State.

Send us lists of the worst weeds that infest your region, with information as to the general habits of the plants, the kind of soil in which they are most abundant, and the crops most infested.

Where possible, it would be still better to send specimens of the plants; in some cases it will be necessary to have specimens, in order to accurately determine the species, for the reason that there is some confusion in local names. The same plant is frequently known by different names in different sections.

Small plants should be sent entire, roots and all; they should show blossoms, and, if possible, fruit also. Large plants may be sent in part—a portion of the stem showing leaves, flowers, and fruit. Plants may be dried under pressure, between sheets of blotting-paper, or newspaper; when sent dry, they should be protected from injury in the mails by pieces of heavy paste-board. If sent fresh, they should be slightly moistened, and wrapped in heavy paper.

Always write the name of the sender on the outside of the package. Address,

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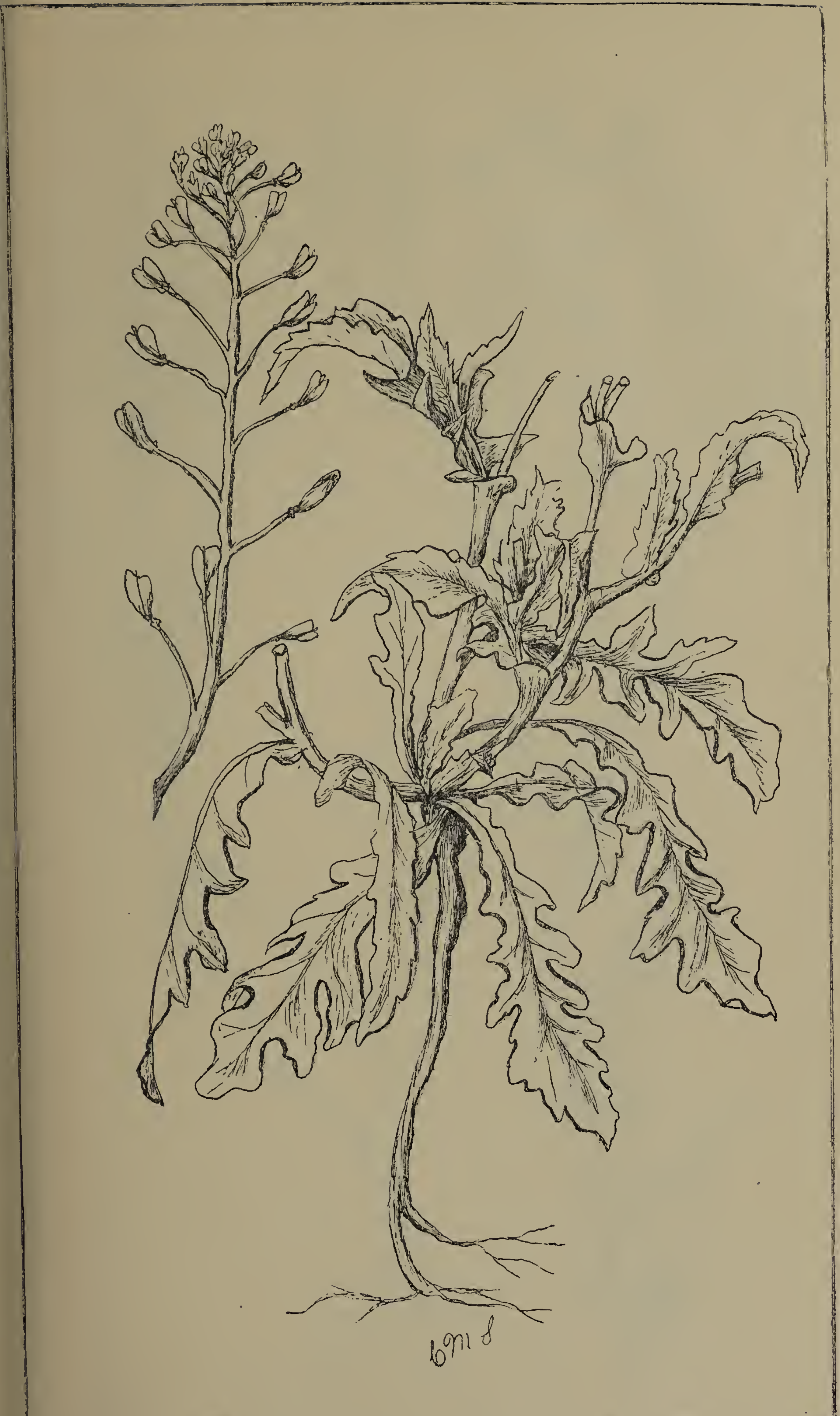
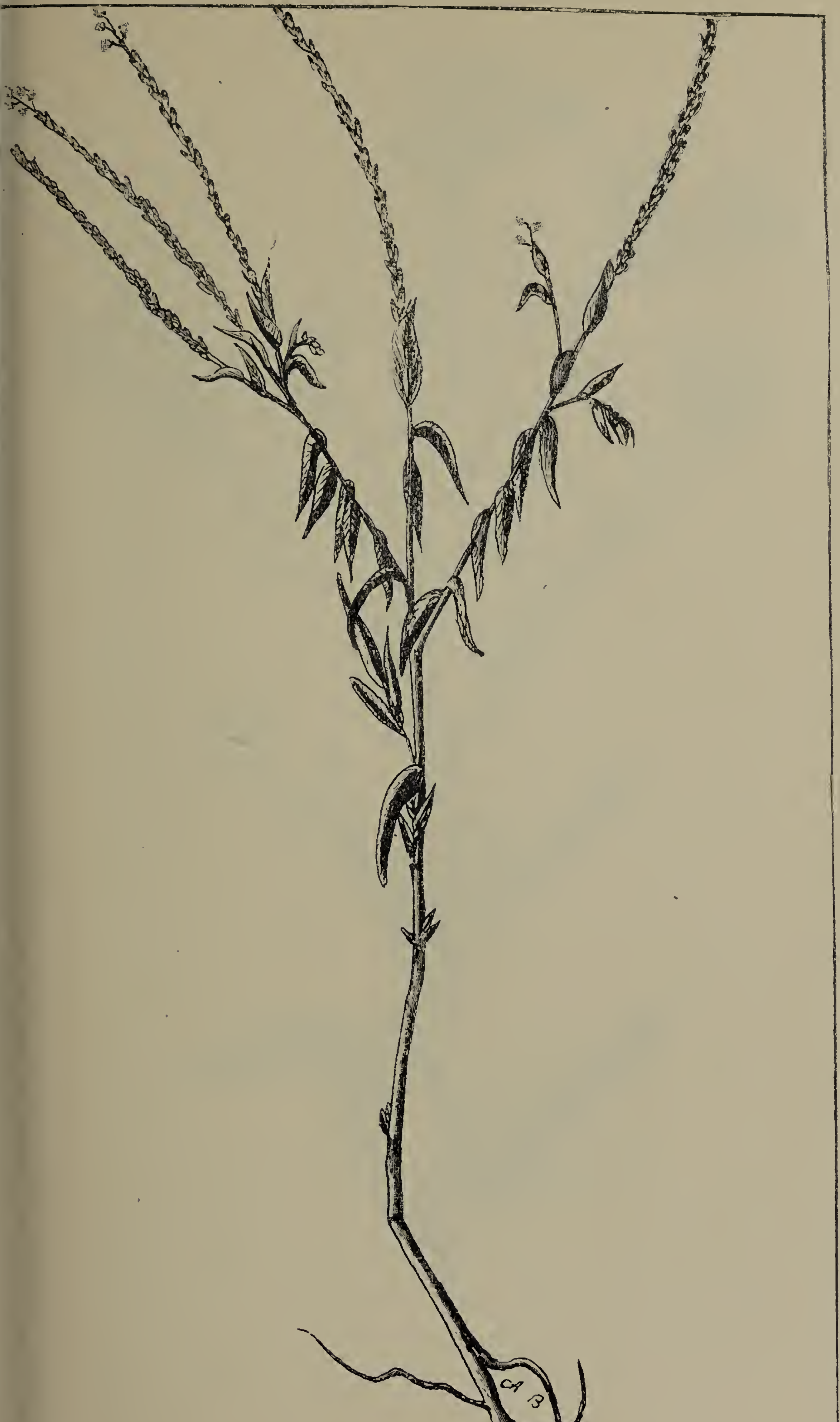


(PLATE I.)—CAPSELLA BURSA-PASTORIS, Mœnch.

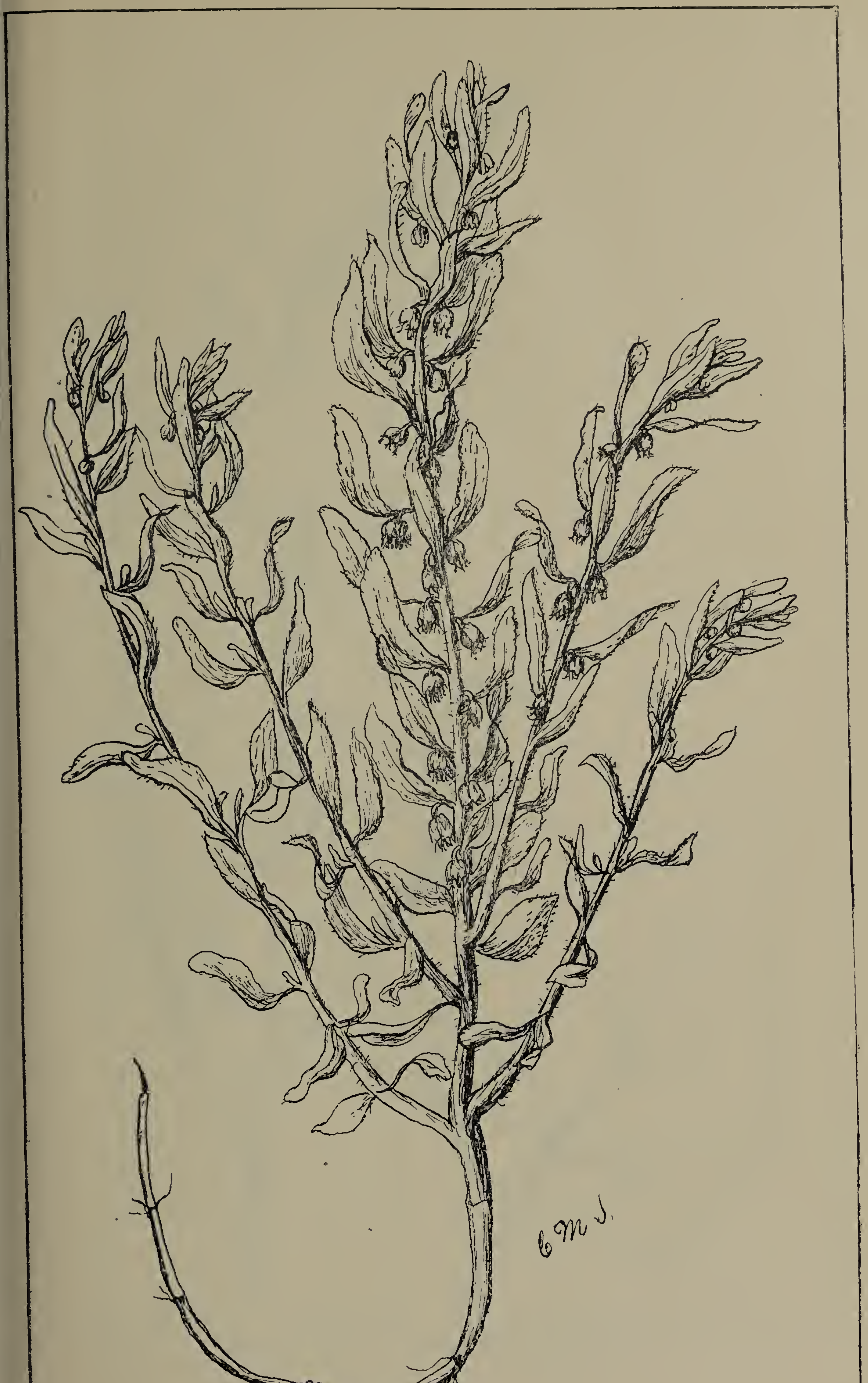
(Plate II.)—Saponaria Vaccaria, L.



(Plate III.)—Gaura parviflora, Dougl.

(Plate IV.)—Grindelia squarrosa, Dunal.

(PLATE V.)—IVA AXILLARIS, Pursh.



(Plate VI.)—Iva axillaris, Pursh.

(PLATE VII.)—IVA XANTHIIFOLIA, Nutt.

(Plate VIII.)—Solanum rostratum, Dunal.

(Plate IX.)—Franseria discolor, Nutt.

(Plate X.)—Franseria discolor, Nutt.

(Plate XI.)—Hordeum jubatum, L.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN No. 24.

A Few Common Insect Pests.

Approved by the Station Council.
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

JULY, 1893.

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FORT COLLINS, COLORADO.

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A Few Common Insect Pests.

By C. P. Gillette.

The present paper has been prepared, not because of the original matter that we wish to put into it, but because there seems to be a widespread need of information in the State concerning the insects herein mentioned. There are many other insects equally troublesome that might be mentioned had we time and space to do so. To those who suffer from such pests, we would say that the Entomologist of the Station is always glad to receive and reply to personal letters making inquiry concerning any injurious insect. Specimens of the insect doing the injury should, whenever possible, be sent with the inquiry.

THE IMPORTED CABBAGE WORM.

(*Pieris rapæ* Linn.)

This insect was imported from Europe into Canada about thirty-six years ago. It spread rapidly in all directions, and now is found in injurious numbers from the Atlantic to the Pacific, and, through the Northern States, at least, is the most destructive insect attacking cabbage and cauliflower.

Fig. 1.

Fig. 2.

The mature insect is a white butterfly [Figs. 1 and 2]. It measures a trifle over $1\frac{1}{2}$ inches from tip to tip of the front wings when spread, the female being a little larger than the male, as is usually the case among butterflies and moths. As seen from above, the body, bases of the wings and the tips of the fore wings are black or blackish in both sexes. The female [Fig. 1] has, a little beyond the middle of the fore wing, two black spots, and there is another spot in line with these on the anterior border of the hind wing. On the under side, the female has two black spots on the fore wing, and the tip of the fore wing and the entire surface of the hind wing are sulphur yellow.

The male [Fig. 2] differs from the female by having but one black spot on the fore wing above, and being a little whiter in color. These butterflies appear early in the spring, and the female is ready to deposit eggs for the first brood of worms as soon as early cabbages are transplanted into the gardens. The eggs are elongate, yellowish white objects, and just large enough to be plainly seen with the naked eye. They are deposited singly during daylight, and nearly always upon the outer surface of the spreading leaves, and not upon the cabbage head. When the butterflies are flitting abundantly over the cabbages, a moment's watching will be rewarded by seeing one or more of these eggs deposited. In a very few days the eggs hatch, and the little green worms begin to feed upon the leaves. They gradually work inward to the head, and

Fig. 3.

late in the season a large number of worms that are half grown or more may be found eating into the base of the head, often entirely ruining it. In from two to three weeks after hatching the worms become mature [Fig. 3 *a*], and then change to a green chrysalis [Fig. 3 *b*], in which stage they eat nothing, and remain quiet unless disturbed. If the worms were very numerous, some of these chrysalids may be found attached to the leaves of the cabbage, but most of the worms will crawl away to undergo their transformations upon other near objects.

In the course of a week or ten days, the chrysalis splits along the back and the butterfly emerges. In a few days more the females begin to deposit eggs for a second brood of worms.

How many rounds of development there are in a year depends upon the length of the summer season. There are probably not less than three generations yearly in central Colorado. The number of worms increases many fold with each generation, so it is important that the first brood be as largely destroyed as possible. If three-fourths of the first brood were destroyed, there would be only one-fourth as many in the second brood as if none of the first brood were killed.

Food Plants.—Although this insect does its chief injury to cabbage and cauliflower, it also attacks many other cruciferous plants, as kale, radish, turnip, and mustard.

Natural Enemies.—At Fort Collins there are three very important parasites that attack this insect. The most important of these is a minute green fly (**Pteromalus puparum* Linn.), belonging to the order *Hymenoptera*. This little parasite does not kill the larva, or worm, but the chrysalis. The chrysalids lose their green color and become very dark, and, in a short time, instead of butterflies, there will appear from each chrysalis forty or fifty specimens of this parasitic fly.

On the 9th of September, 1891, a quantity of chrysalids were gathered from the College garden, and in every case they were parasitized by this insect.

Another small, four-winged parasite (**Apanteles glomeratus* Linn.), which is black in color, attacks the larvæ and destroys many of them. By tearing open nearly mature worms, the maggots of this parasite can often be found in large numbers inside. Before the worm changes to a chrysalis, these maggots eat through the body wall, and each spins about itself a yellowish silken cocoon. Each of these little cocoons is about one-eighth of an inch long, and all together form a mass a half inch or more in length. These masses are usually found upon the leaves of infested plants, and would be liable to be taken by the gardener as some insect enemy in disguise. These little parasites are of great service to the gardener, and should not be destroyed.

Another parasite that is common here, attacking the cabbage worms, is a two-winged fly (***Anthomyia sp.*), which closely resembles the common house-fly. The flies themselves will seldom be noticed, but among the leaves of the cabbages late in summer will be found numerous barrel-shaped, mahogany-colored objects about one-eighth of an inch in length. These are the pupæ—or puparia, as the entomologist would say—of this fly. These puparia should not be destroyed, as each incloses an insect very beneficial to the gardener.

The time may come when these allies of the gardener will be numerous enough to exterminate the enemy without his assistance,

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* Determined by W. H. Ashmead, Dep. of Agr., Washington, D. C.
** Determined by Prof. C. H. T. Townsend, formerly of Las Cruces, N. M.

but as yet he will have to lend a helping hand or fail to gather a bountiful harvest.

REMEDIES.

As the eggs are mostly deposited upon the outer surface of the leaves, and the worms feed for some time before reaching the head, these insects may be nearly all destroyed by the prompt application of any one of several good remedies.

Among the cheapest, most easily applied, and, to our mind, the best of the remedies to destroy cabbage worms, are the arsenites, London purple or Paris green. We have given abundant proof of the harmlessness of such applications to those who eat the cabbages, in Bulletin 12 of the Iowa Experiment Station.

Thoroughly mix one ounce of the poison in six pounds of flour, and dust it very lightly over the plants from a cheese-cloth sack in the evening or early morning, when a little dew is still upon the leaves. The first application should be made soon after the plants are set out. Certainly, no one can think that there would be the slightest danger in making such treatment up to the time that the heads begin to form. After the heads have formed, the poison can be applied mostly to the outer leaves; but if any is put upon the head itself it is almost impossible that it should do harm, as the surface leaves of the head are not eaten, and these leaves in a growing cabbage are continually spreading and becoming outer leaves. Neither can the poison be washed by rain into the cabbage, for the outer leaves do not run into the head. I should not think it advisable to apply the poisons nearer than a week or ten days to the time of harvesting the cabbages, and it would never be necessary to do so.

Patent insecticides, such as Slug Shot and Oxide of Silicates, have been much used by gardeners for the destruction of cabbage worms. The poison in these insecticides is Paris green, but no one ever heard of a person being poisoned from eating cabbages thus treated. These patent insecticides are much more dangerous to use than one a person prepares himself, for he is usually ignorant as to the composition of patent compounds, and is more liable to be careless with them.

For those who prefer not to use the arsenites, there is probably no better remedy than insect powder, or Buhach. This substance kills by coming in external contact with the worms, and is best applied by means of a blower that sends the fine particles of dust down between the leaves of the plants.

This powder is not poisonous to man, and hence is very safe to use or to have in the house. The chief objection to this substance is its expense. Buhach may be purchased directly from the Buhach Manufacturing Co., Stockton, Cal., at 60 cents a pound.

The powder is very light, and a pound will treat a large number of plants.

A remedy much recommended by Dr. Riley is hot water. Water may be poured boiling hot into a watering-pot and applied at once to the caterpillars, and, if the plants are not too thoroughly drenched, the latter will not be harmed, while all the worms touched by the water will be destroyed. Worms that are protected upon the under side of the leaves cannot, of course, be treated.

Kerosene emulsion, if applied in extra strength and with considerable force, will also kill many of the worms, but I have not found this substance of much value in destroying the larvæ of *Pieris rapæ*.

THE SOUTHERN CABBAGE BUTTERFLY.

(*Pieris protodice* Bd.)

This insect [Figs. 4 and 5] resembles the preceding in the mature state, and has very similar food habits. It is a native of North America, and does its chief injuries in the Southern States. It is

FIG. 4.

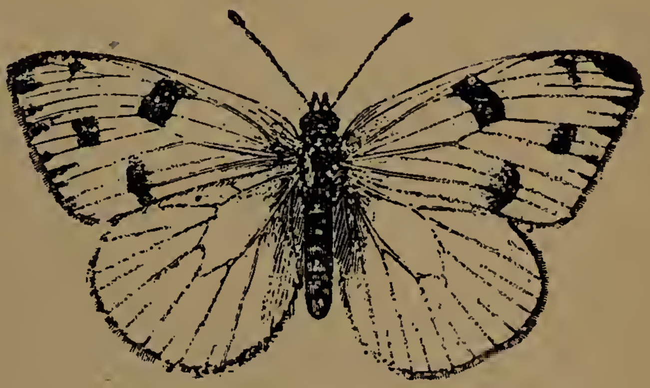

FIG. 5.

FIG. 6.

quite abundant as far north as Fort Collins, and, only a few *years ago, was said to do more harm to cabbages in Colorado than the preceding species. The markings of this butterfly, both male and

* Bulletin 6, Colorado Experiment Station, p. 15.

female, are so well shown in the accompanying illustrations [Figs. 4 and 5] that a description seems unnecessary. The female has more dark markings than the male, and the latter is usually more marked with black than the male of the imported species.

The larva [Fig. 6 *a*] is readily distinguished from the larva of the preceding species by having two longitudinal yellow stripes upon either side of the body, and by having the body covered with small black spots.

The remedies are the same as for the preceding species.

THE CABBAGE PLUSIA.

(*Plusia brassicæ* Riley.)

This insect in the mature state is a moth [Fig. 7 *c*], spanning about one and three-eighths of an inch from tip to tip of the fore wings when spread.

The color of the anterior wings above is dark brown, shaded with lighter brown and gray, and with a conspicuous silver patch near the center. Running forward and inward from these white

FIG. 7.

patches is a light colored stripe on either wing, extending to the anterior border. The wings in the illustration are too black, and the white spot is too small for the specimens of this insect in our collection. The posterior wings are dark brown, lighter towards the base, and are fringed with white scales, in which are dusky patches at the termination of each vein in the wing.

The female moth lays her eggs on the under side of the leaves, and the young larvæ, on hatching, perforate the leaves at first, and if numerous enough will finally eat all but the thick ribs. The larvæ [Fig. 7 *a*] are light green in color, with pale, longitudinal stripes, and are peculiar in appearance, being largest at the posterior end of the body, as is well shown in the figure. They also differ from any of the preceding larvæ in looping the body when they travel, like the so-called "measuring worms" and "inch worms." The larva, when mature, unlike the preceding species, spins a slight silken cocoon [Fig. 7 *b*]. At the end of ten days or two weeks it comes forth as a moth. These cocoons are found among the leaves near the base of the cabbage head, if the larvæ are very abundant. There are from two to five broods of this insect in a year, the number depending upon the length of the summer season.

The food-plants of this insect, as given by Dr. Riley, are cabbage, kale, turnip, tomato, mignonette, dandelion, dock, clover, and a few others.

The remedies are the same as for *Pieris rapæ.*

THE CABBAGE PLUTELLA.

(*Plutella cruciferarum* Zell.)

This insect, in the mature stage, is also a moth, but a very small, narrow-winged one, that is liable to escape notice. It measures hardly more than half of an inch from tip to tip of the fore wings when they are spread. The moth is shown with wings spread and closed at Fig. 8, *f* and *h*. The general color of the

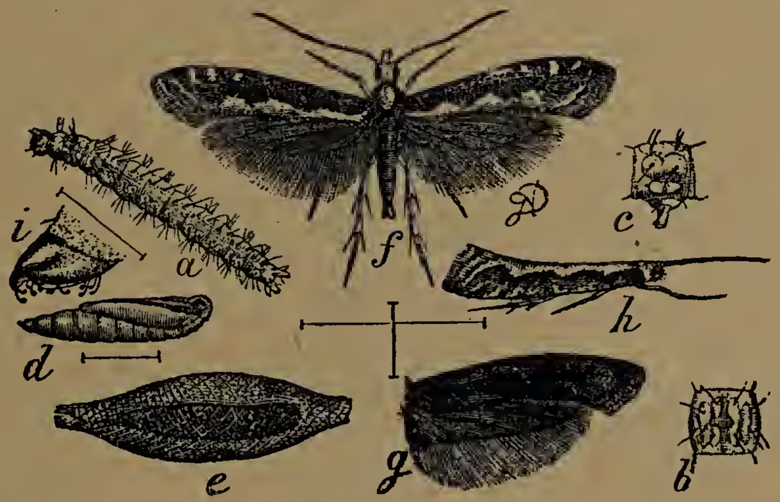

Fig. 8.

wing is dark to light brown, and there is a wavy, white line along the posterior margin. When the wings are closed over the abdomen the two white margins meet so as to make a conspicuous white dorsal stripe, which is continuous, with white upon the thorax and head. These markings are well shown at *f* and *h*, Fig. 8.

The winter is probably spent in the chrysalis stage, as the larvæ appear upon early cabbages about as soon as they are set out in this locality. These larvæ [Fig. 8 *a*] are slender, green in color, and are very active when disturbed, wriggling themselves quickly off the leaves and dropping on a silken thread.

When mature, the larvæ form delicate white cocoons [Fig. 8 *e*] among the leaves, and in a few days appear as moths. These cocoons were found abundant in early-set cabbages near Fort Collins on June 10, this year, and the moths began emerging in our breeding cages on June 16. Last fall moths were reared as late as August 3. If the insect hibernates as a chrysalis [Fig. 8 *d*], there must have been a brood after the last date, so this insect is at least two, and probably three or four brooded, here. This insect seems to be increasing in numbers, and it would not be strange if it should become a serious pest, especially upon young cabbages, unless prompt action is taken to check its increase.

There is one reason, however, for hoping that it will not soon become seriously abundant, and that is, that there are in this locality a number of parasites preying upon it in the preparatory stages. In the Department of Agriculture report for 1883, p. 130, Dr. Riley mentions having bred from this insect a small hymenopterous parasite, *Limneria annulipes* Cr. From larvæ brought into the laboratory here last summer, were reared specimens of **Smicra delira* Cr., **Limneria dubitata* Cr., **Phæogenes discus* Cr., and a species of **Pteromalus.*

The remedies are the same as for the preceding species. The applications should be made early, so as to destroy the first brood, and thus prevent the increasing numbers of the succeeding broods.

FLEA-BEETLES.

(The Two-Striped Flea-Beetle, *Systena tæniata* Say.)

Bibliography and Synonymy.—As given by Geo. H. Horn, M. D., in Trans. Am. Ent. Soc., Vol. XVI., p. 318:
- *S. tæniata*, Say, Long's Second Expedition, p. 294; edit. Lec., i., p. 195.
- *S. blanda*, Mels., Proc. Acad., iii., p. 164.
- *S. ligata*, Lec., Pacific R. R. Rep., 1857, p. 68.
- *S. ochracea*, Lec., Proc. Acad., 1858, p. 87.
- *S. mitis*. Lec., Proc. Acad., 1858. p. 87.
- *S. bitæniata*, Lec., Col.. Kan., 1859, p. 36.
- *S. pallidula*, Boh., Eugen. Resa, p. 192.

This is one of the worst flea-beetles that gardeners have to contend with in Colorado, and, at the present time (June 24), is doing serious injury to the small potato plants in the College garden. The mature insect is shown much enlarged in Fig. 9. The actual length varies from 1-8th to 7-48ths of an inch. Viewed with the naked eye, the beetle appears black in color, with a reddish brown head and thorax, and a distinct light yellow line running nearly the entire length of each wing cover.

Prof. Bruner, of the University of Nebraska, speaks of this insect as very variable in its color, some specimens being almost white. The color of those taken here have been very uniform, and as above stated.

This flea-beetle, though widely distributed through the United States, seems to do its chief injuries in the West. The specimens in the collection here were taken by myself at Fort Collins, North

* Determined by W. H. Ashmead, Dep. of Agr., Washington, D. C.

Park, Dolores, and Aspen, of this State. Prof. Webster, formerly of Purdue University, Ind., in the Indiana Horticultural Transactions for 1890, reports this insect as attacking sugar beets, corn, potatoes and beans in that State. Prof. Bruner, of the University of Nebraska, in the Fifth Annual Report of the Nebraska Agricultural Experiment Station, p. 60, speaks of it as being most injurious of all the flea-beetles that attack the sugar beet. Mr. J. F. Wielandy, Santa Fe, N. M., in " Insect Life," Vol. III., page 122, reports this beetle as injurious to beans in his locality, and Dr. Riley, in replying to Mr. Wielandy's letter, states that the beetle is particularly injurious

FIG. 9.

to the Cucurbitaceæ (melons, squashes, cucumbers, etc.). Prof. James Cassidy, in Bulletin 6 of this Station, reported the same insect as injurious to potatoes, beans, tomatoes, and beets. We have taken this beetle at Fort Collins during the past two summers feeding on potatoes, beets, alfalfa, lettuce, parsnips, egg plant, summer savory, and the following garden weeds: **Iva axillaris* (poverty weed), *Iva xanthiifolia*, *Salvia lanceolata*, *Verbena bracteosa*, *Solanum triflorum*, *Solanum rostratum*, *Helianthus annuus* (sunflower), *Helianthus petiolaris*, *Portulaca oleracea* (purslane), *Amarantus blitoides* (tumble weed), *Chenopodium spp.* (pig weed).

* The specific determinations of plants mentioned in this bulletin have been made mostly by Prof. C. S. Crandall, of this Station.

We have not seen this flea-beetle injuring the vines of cucurbitaceous plants in Colorado.

REMEDIES.

Although the flea-beetles devour the tissues of the plants upon which they feed, the arsenites, London purple and Paris green, have not been very useful in destroying them or preventing their attacks. From our own experience, we would put Buhach at the head of the list of remedies, if properly applied. To be of use, the powder should be applied dry before sunrise in the morning, while the beetles are cold, sluggish and damp with the dew of the night. After the sun is up and the beetles have been warmed into activity they will quickly jump away from any attempted application.

A strong kerosene emulsion, sprayed forcibly and thoroughly upon the plants early in the morning, will also be effectual in destroying the beetles.

As the beetles feed on a great variety of plants, they can usually be driven from cultivated crops by a thorough application of lime, ashes or road-dust in the evening or early morning, while the dew is still on.

THE COLORADO CABBAGE FLEA-BEETLE.

(*Phyllotreta albionica* Lec.)

This is one of the smallest of the flea-beetles, measuring from 1-15th to 1-16th of an inch in length. It is uniformly black in color, with the first three joints of the antenna pale [Fig. 10].

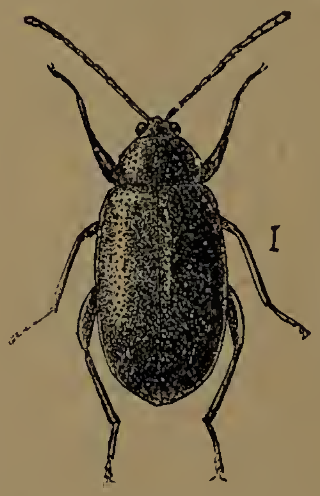

FIG. 10.

So far as we have been able to observe here, this is the only other flea-beetle that does serious injury to garden vegetables in Colorado.

We have taken this beetle feeding on cabbage, radish, beet, mustard, cauliflower, horseradish, and the Rocky Mountain bee plant, *Cleome integrifolia.* The injury is done, as with all the flea-beetles, by eating little holes through the leaves, until the latter turn brown and crisp.

The remedies are the same as for the preceding species.

ONION THRIPS.

(*Thrips striatus* Osb. ?).

Several inquiries have come to this office concerning a minute fly that is ruining the onion crop, by causing the tops to turn white and die in July and August. The same insect has been noticed by us doing serious harm to onions in this vicinity and in other localities in the State during the past two summers.

The *Thripidæ* are very small insects, the largest measuring only about one-eighth of an inch in length. The mouth parts are rudimentary, and do not seem to be well fitted either for biting or piercing and sucking the juices of plants. Some forms are carniv-

Fig. 11.

erous, but most that have been studied are vegetable feeding. In form they are long and slender; the wings, when present, are four in number, very narrow, and more or less ciliated with long, slender marginal hairs. In many there are also numerous stout hairs or spines on the surface and borders of the fore wings. The mature insects are usually very active, and when disturbed run about, throwing up the tip of the abdomen as if to sting, but they have no power to inflict such injury, and we have found by watching them under a glass that the abdomen is thrown up for the purpose of assisting in spreading the wings. Those studied seemed to have no power to spread the wings in any other way. After the wings have been spread in this manner, they usually jump and then fly for a short distance.

Limothrips tritici Fitch, has long been known as an onion pest in the Eastern States, producing what is known as "white blight" of the onion tops. In the 16th Report of the State Entomologist of Illinois, p. 9, Dr. Forbes speaks of this insect as doing injury to strawberries in that State.

Fig. 11 is a representation of this insect, much enlarged, from a drawing made by Mr. C. F. Baker, and first published in the *American Florist,* Vol. VII, p. 168. It serves well to illustrate the female of our supposed *Thrips striatus,* except in the arrangement of the cilia of the wings. Fig. 12 *b* represents the arrangement of the cilia and spines upon the fore wing of the species that has been doing so much injury to onions in this State.

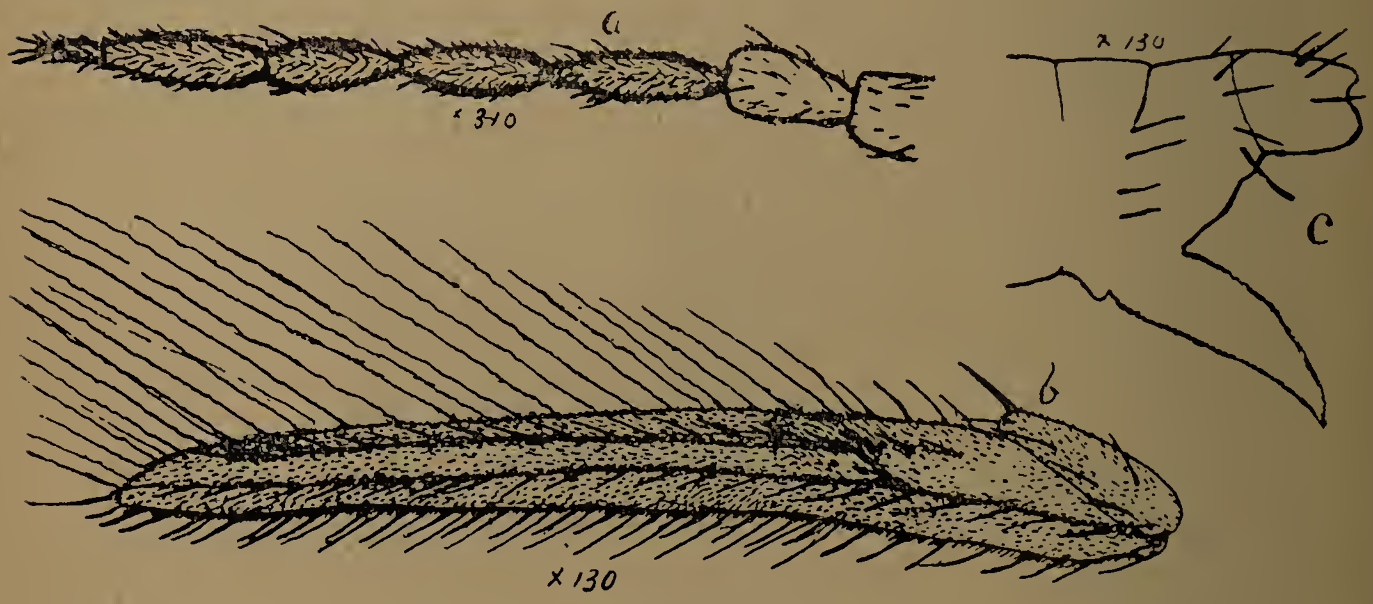

Fig. 12.

Numerous specimens of this insect were sent to Prof. Osborn, of the Iowa Agricultural College, and to Mr. Pergande, of the Department of Agriculture, Washington, D. C., and were, in both cases, determined as probably *Thrips striatus.* The mature female may be described as follows, from a quantity of material collected here: Length, 1-24th of an inch (1.1—1.3 mm.); color, from pale lemon yellow to brownish yellow, the darkest specimens appearing quite smoky. The only black parts are the compound eyes and the tips of the mouth parts. The antennæ are dusky towards the tips; the legs are concolorous with the body; the anterior wings are heavily fringed with slender, wavy hairs on the distal two-thirds of the posterior margin. [See Fig. 12 *b*.] On the anterior margin of these wings there is a row of short, stout black hairs along the entire length, the largest one being at the extreme tip. There is also on the outer two-thirds of this margin a second row of somewhat longer and more slender hairs. On the surface of the wing are two parallel longitudinal veins, set with stout spines, the median one extending the entire length of the wing. In a favorable light the posterior vein can be seen to arise from the anterior at about one-fourth of its length from the base. The entire surfaces of both wings are set with minute spines. The hind wing is heavily fringed along the posterior margin, and sparsely set with short cilia along the anterior margin, and there is a faint median nerve.

The antenna [Fig. 12 *a*] appears to have but seven joints, even when viewed under a high power of the microscope. It is only with the most careful focusing and arrangement of the light that a possible minute eighth joint can be seen. In no case has it been as plainly seen as represented in the illustration.

This insect differs from the original description of *T. striatus* by having two rows of spines on the anterior wings, and by having the row of spines on the costal margin of the wing continued to the base. The paired spines on the last abdominal segnent [see Fig. 12 *c*] would seem to us to put this insect in genus *Limothrips*.

Should the species prove to be new, we would suggest for it the name *Limothrips allii.*

There were certainly many hundreds, if not many thousands, of this insect in all stages of development upon single onion plants in this vicinity the past two summers. The young are usually found most abundant in the axils of the leaves.

Besides attacking the onion, this pest is common in various flowers, where it probably feeds upon the pollen or tender parts of the blossom.

Cucumbers are sometimes severely attacked by *Thripidæ* in this State, causing the leaves to turn white and die. From an examination with a hand lens, the species doing this injury appeared identical with that on onions.

(*Coleothrips trifasciata* Fitch.)

This insect also belongs in the family *Thripidæ*, but to a different genus (*Coleothrips*) from the preceding. It is black in color, and measures one-eighth of an inch in length. The name *trifasciata* was given it by Dr. Fitch, because of the bands across the fore wings—one at the base, one at the tip, and one about midway between these. This insect, which Dr. Fitch found common on wheat and in flowers of tanzy, we have found common upon onions in company with the preceding species. It is also common here in blossoms of alfalfa, wild sunflowers, and clover.

REMEDIES.

Several remedies were used against these pests last summer, the one proving most successful being kerosene emulsion, in the usual proportions. It should be thrown forcibly upon the plants, and care should be taken to wet thoroughly the axils of the leaves, where the young congregate. It will be an advantage here also to make the application early in the morning or in the evening, as the mature forms are less active then than in the heat of the day.

THE STATE AGRICULTURAL COLLEGE.

The Agricultural Experiment Station.

BULLETIN NO. 25.

PROGRESS BULLETIN

ON THE

LOCO AND LARKSPUR.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO,
OCTOBER, 1893.

Bulletins are free to all residents of the State interested in Agriculture in any of its branches, and to others as far as the edition will permit. Acknowledgment will be expected from all non-residents. Newspapers desiring continuation upon the mailing list, will please acknowledge by editorial notice and the sending of a marked copy of the issue containing it.

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PROGRESS BULLETIN

ON THE

LOCO AND LARKSPUR.

By DAVID O'BRINE, Chemist.

The literature of the so-called "loco" weed is quite extensive. In the Agricultural Report of 1874, page 159, we find the following, and as it describes the symptoms of the so-called "loco" poisoning, it is inserted here: "I think very few, if any, animals eat the loco at first from choice; but, as it resists the drought until other feed is scarce, they are at first starved to it, and after eating it a short time appear to prefer it to anything else. Cows are poisoned by it as well as horses, but it takes more of it to affect them. It is also said to poison sheep. As I have seen its action on the horse, the first symptom of the poison, apparently, is hallucination. When led or ridden up to some little obstruction, such as a bar or rail lying in the road, he stops short, and if urged, leaps as though it were four feet high. Next, he is seized with fits of mania, in which he is quite uncontrollable, and sometimes dangerous. He rears, sometimes even falling backward, runs or gives several successive leaps forward, and generally falls. His eyes are rolled upward until only the white can be seen, which is strongly injected, and, as he sees nothing, is as apt to leap against a wall or man as in any direction. Anything which excites him appears to induce the fits, which, I think, are more apt to occur in crossing water than elsewhere, and the animal sometimes falls so exhausted as to drown in water not over two feet deep. He loses flesh from the first, and sometimes presents the appearance of a walking skeleton. In the next and last stage, he only goes from the loco to water and back again; his gait is feeble and uncertain; his eyes are sunken, and have a flat, glassy look; and his coat is rough and lustreless. In general, the animal appears to perish from starvation, with constant excitement of the nervous system, but sometimes appears to suffer acute pain, causing him to expend his strength in running wildly from place to place, pawing and rolling, until he falls, and dies in a few minutes."

The plants that were said to cause these symptoms are the *Astragalus Hornii* and *Astragalus lentiginosus*. Dr. Vasey in speaking of the plant says: "The plant submitted to us as the one in question was the *Oxytropis Lamberti*, a plant of the pea family, nearly related to the Astragalus, and also to the Lupin. It grows in considerable abundance upon the elevated plains near the mountains, and extends up into the mountains to the elevation of 7,000 to 8,000 feet. It is perennial, and grows in small clumps, the leaves all at the base, and sending up a few erect flower-stalks, seldom over a foot, which have a spike-like raceme of rather showy flowers, varying in color from cream to purple. These are succeeded by short, stiff, pointed pods, which contain a number of small clover-like seeds. If the statements above given respecting these two or three leguminous plants are substantiated by further experiment and observation, it will be interesting to determine by chemical analysis what is the peculiar poisonous principle which they contain. Plants belonging to this natural order (*Leguminosæ*) have generally been considered as not possessing poisonous properties." The Agricultural Report of 1878, page 134, again speaks of the loco and says: "A further examination will be made of the plant, and any facts concerning it are desired by the department. An examination of this weed by Miss Catherine M. Watson, of Ann Arbor, Mich., is reported in the *American Journal of Pharmacy*, December, 1878. The plant was obtained from Rosita, Colorado, and she reports the presence in small quantity of an alkaloid and a resin. The dried root was taken by way of experiment in four forty-grain doses within one and a half hours, with no other perceptible effect than a slight smarting of the eyelids and slight colic pains. One and one-half ounces of the fluid extract was given to a kitten two months old with no perceptible effect."

In the Report of 1884, page 123, the symptoms are in substance again described, and Dr. Vasey says: "After becoming affected, the animal may linger many months, or a year or two, but usually dies at last from the effects of the complaint. This diseased condition has been attributed to various plants, but mainly to a few which belong to the order *Leguminosæ*. Of these, two species of *Astragalus* have been ascertained in California, and in Colorado and New Mexico another species of *Astragalus* (*A. Mollissimus.*) and a closely related species of *Oxytropis* are generally charged with the

Oxytropis Lamberti.

trouble in question." Omitting the account from Wheeler's report, he says: "Several analyses have been made of the plants which are said to be the cause of this affection, without satisfactorily ascertaining what is the peculiar poisonous principle. No antidote has been discovered. If the plants can be ascertained and exterminated, the trouble should come to an end; but, even if the plants are recognized, their extermination over large tracts of country will be difficult and expensive." From the same source we give the botanical description and cuts of the plants, *Astragalus Mollissimus*—loco weed: "A perennial herbaceous plant of the region of the great plains from Colorado to New Mexico, Texas and Arkansas. It belongs to the order *Leguminosæ*, or pea family. There are usually a great many stalks, proceeding from a large root stock. They are reclining towards the base and erect above. These stalks are so short that the leaves and flower stalks seem to proceed directly from the root. They are branching at the base and give rise to numerous leaves and long stems bearing the flowers and pods. The leaves are usually from 6 to 10 inches long, composed of 9 to 15 leaflets (in pairs except the upper one). These leaflets are of oval form, ½ to ¾ of an inch long, of a shining, silvery hue, from being clothed with soft, silky hairs. The flower stalks are about as long or sometimes longer than the leaves, naked below, and at the upper part (¼ to ½) bearing a rather thick spike of flowers, which are nearly 1 inch long, narrow, and somewhat cylindrical, the corolla of a velvety or purple color, the calyx half as long as the corolla and softly pubescent. The flower has the general structure of the pea family and is succeeded by short, oblong, thickish pods, ½ to ¾ inch long, very smooth and with about two seeds in each. *Oxytropis Lamberti*—loco weed: A plant belonging to the same family as the *Astragalus Mollissimus*. It is about the same height, and like it grows in strongly-rooted clumps; but it differs in having an erect habit, with shorter leaves and longer and stiffly erect flower stalks. The leaflets are longer and narrower, about 1 inch long by ¼ to ⅓ inch wide, and hairy, especially on the upper surface. The flower stalks proceed from the root stock, are usually 9 to 12 inches long, and naked except near the top, which has a rather close and thick cluster of flowers, much like those of the *Astragalus* in general appearance, but differing in some minute characters which separate it into another genus, and are succeeded by erect, lance, oblong, pointed pods, of about 1 inch long. This plant is very abundant on the high plains and in the mountains ranging from British America to Mexico. The flowers are subject to much variation in color, some varieties being purple, some yellow, and others white."

From the Agricultural Report of 1886, page 75, the same description of symptoms are given, and Dr. Vasey again says: "We invite further information from those acquainted with the plant and its poisonous qualities. The plants sent were those of *Astragalus lentiginosus*, locally called 'rattle weed' and 'loco.' It belongs to the order *Leguminosæ*, and is somewhat similar to lucern in appearance, and produces bladdery pods, in which the seeds rattle when ripe. Hence the name 'rattle weed.' In Colorado and New Mexico the same disease among horses and cattle is produced by *Astragalus Mollissimus* and other allied plants. The loss of stock from the eating of these plants has been very great." The other accounts of the loco are mostly found in the *Journals of Chemistry and Pharmacy*. In *The Druggists' Circular and Chemical Gazette* of October, 1888, there is an article by James Kennedy, read at the Austin meeting of the Texas Pharmaceutical Association on the loco weed—*Astragalus Mollissimus*. The chemical analysis used in the method is described in detail. We have room but for his conclusion: "Our experiments were conducted upon the dog, because horses and cattle were not to us available subjects ; and we believe they have demonstrated conclusively the non-toxic or innocuous character of the drug. If death is produced by the plant at all, it is not dependent on any poisonous principle contained therein, but is perhaps due to the tough, fibrous and indigestible character of the plant acting as a foreign body, producing irritation and symptoms consequent thereupon, or else its action is identical with an overload of green food of any kind. As the observations heretofore reported were all upon animals feeding in pastures, there seems to be no positive evidence that 'loco' has ever caused the death of any animal, and the immense destruction of stock with which it is charged may have been caused by some poisonous plant heretofore unsuspected. Our conclusions, therefore, are that the 'loco' (*Astragalus Mollissimus*) is non-poisonous and does not possess any of the properties ascribed to it by popular superstition."

In the *Druggists' Bulletin*, May, 1889, page 145, in an article headed "Loco Weed," by Prof. L. E. Sayre, Department of Pharmacy, Kansas State University, he states his attention has been called to the loco weed since 1885. Cuts of the *Oxytropis Lamberti*, *Astragalus Mollissimus*, and *Astragalus tridactylicus* are given. The chemical examination is described, and also his visits to Indian Territory, No-Man's Land, the western part of Kansas, Colorado, and New Mexico during the

Astragalus mollissimus.

summers of '87 and '88. When speaking of his journeys through the country, he says: "I was unable to find a single animal with symptoms answering to those ascribed to this weed. Among the few I found suspected of this distemper was one of a herd from Indian Territory, just south of Arkansas City, brought from Texas for pasture. When informed of the case, I was very eager to avail myself of the opportunity, and at once went to the ranch. But on inspecting the animal was very much disappointed to find no symptoms corresponding with my expectations of an ideal locoed animal. On the contrary, the creature was affected with some loathsome disease combined with very old age.

"In the summer of '87, I had a good opportunity to kill and make post-mortem examination of a cow said to have been eating the weed for two years, and which was given to me as an example of an animal possessed of the loco habit. She was four years old, though no larger than at two years. The loco had not only stopped her growth, but made her quite poor, and gave her a wasted appearance. She seemed stupid, debilitated, unsteady in her movements, the breathing short and rapid, with muscular force very much impaired. Whether walking or standing, it was seemingly beyond her power to so control the muscles as to keep her head perfectly still. Her eyes had exhibited a wild stare, so said, but this had recently disappeared.

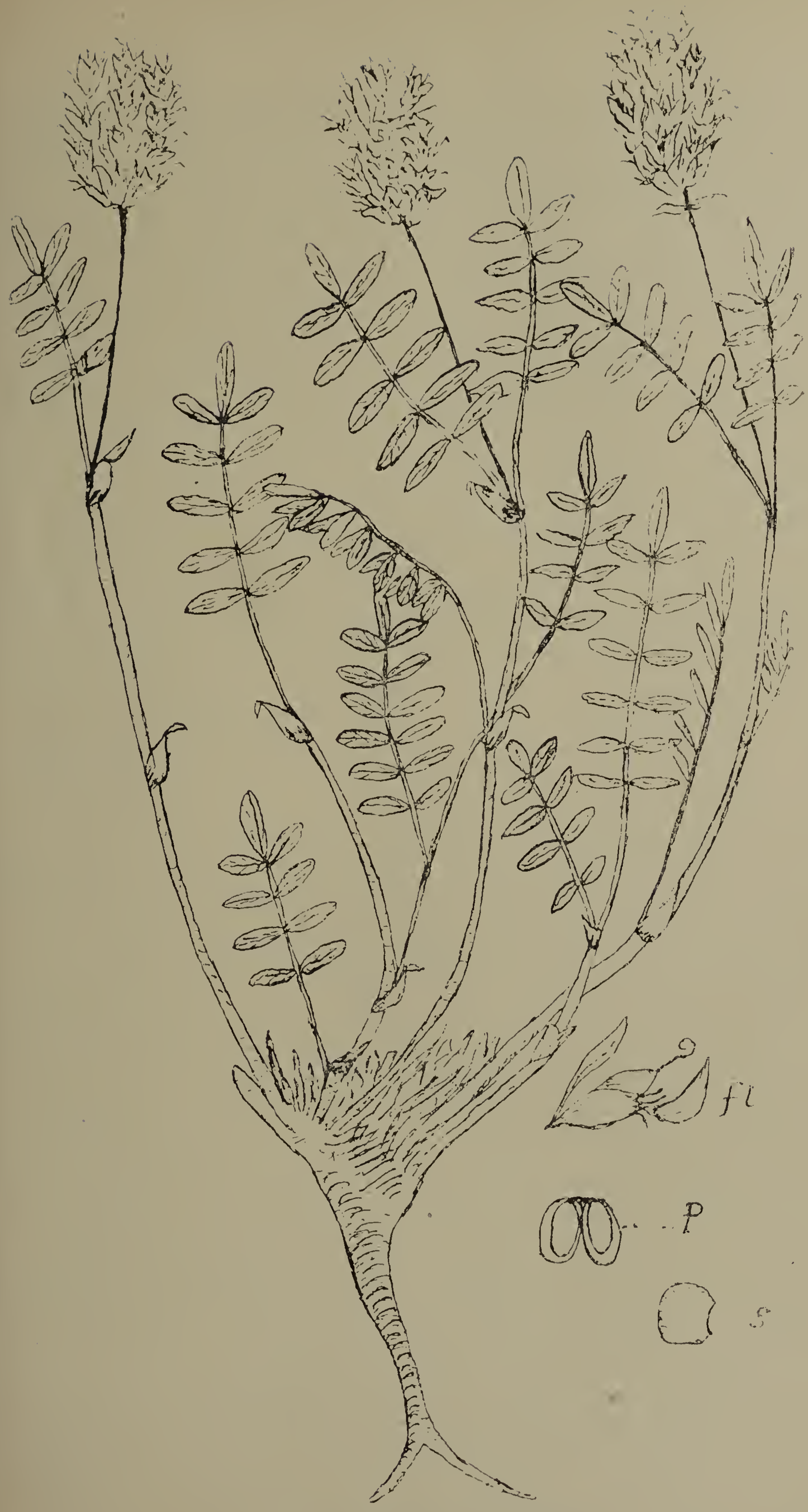
POST-MORTEM.

"The blood was light but not normal; having no instrument at hand it was not microscopically examined. The paunch was in a normal condition; the reticulum and psalterium softened, and apparently diseased. Throughout the entire length of the intestines there seemed to be degeneration of tissue, being on the inside peculiarly soft. Two or three perforations were observed in the small intestine. Both the large and small intestines were delicate; devoid of elasticity, and even with most careful handling would be torn or broken apart in places; they appeared to be as one expressed it, rotten in spots. The peritoneum and omentum were inflamed, and presented numerous tumors about the size of a pea, fleshy in appearance and of fibrous nature, The pleura appeared normal, as also did the diaphragm. The pericardium was streaked with red on the inner side, the sac containing about a pint of liquid of a pale color. The heart seemed to be about one third larger than the normal. The mitral and tricuspid valves were inflamed around the edges. The valves of the aorta appeared normal, and just above them the serous coat was streaked with red; in other respects, nothing abnormal. The bile was thin and watery, even after standing twenty-four hours. The pancreas and spleen appeared natural; kidneys normal; inner coat of bladder softened. Membranes of the brain congested and adherent; the congestion may have been caused by a blow on the head previous to killing the animal. She was, however, only stunned by a light blow, and then immediately bled to death. The brain itself appeared pale, but the bleeding may have caused this. The membranes of the spinal cord were inflamed and adherent, the cord itself normal.

"Evidently the disease was one of mucous and serous membranes, which would account for the nervous and debilitated condition of the animal. The general diseased condition of the alimentary canal, by interfering with digestion and proper nutrition, would account for stunted growth and weakness in traveling." Here follows a quotation from *New Remedies*, August, 1882, page 226, where the physiological experiments of Dr. Isaac Ott, of Easton, are described. He goes on to state his own physiological experiments, and says they have given negative results:

"So fully have I been impressed with the non-poisonous properties of the drug, that I have tried the effect of concentrated solutions of it upon myself. Commencing at first cautiously with a dose of 15 minims every three hours, I have increased it from a tablespoonful to two tablespoonfuls (corresponding to one ounce of the drug). This dose, although repeated at short intervals, produced not even the slightest effect upon the nerves, upon the pupil of the eye, and not much other than a stimulating effect upon the stomach and circulation. Similar experiments with the solution of the supposed crude alkaloid as prepared by Dr. Ott, were made. A tablespoonful of this solution gave not the least evidence of narcotism, although several times repeated.

"I do not put forward these results as showing conclusively that this weed is not poisonous to horses and cattle. The subject needs further study and close inspection, and is one the State of Kansas can well afford to spend money upon to secure the same. The State Board of Agriculture has done already a very creditable work in this direction, and it is to be hoped they will continue unceasingly until the question is finally settled. I may state incidentally, that I am now making preparations to continue the work, in connection with Dr. Burleigh, during the summer of 1889, experiments upon herbiverous animals now being proposed.



Astragalus adsurgens.

"It might seem an easy matter to reach a conclusion upon this subject which is of such vital interest to the farmer and ranchman of the West; but to do this, and satisfy the exactions of science, requires not only careful chemical investigation, but physiological work of a peculiar kind, and close and long-continued observation. To uproot a prejudice of many years' standing, and confront long-established hearsay evidence, even if possessed of no basis of truth, scientific men must push their investigation to the farthest limit."

The *Botanical Gazette*, July, 1889, contains an article by F. W. Anderson, Great Falls, Montana, in which he calls the attention of botanists and others to the fact that something should be done to help the ranchmen with their stock. Much valuable work has been done in Kansas by Prof. Sayre. In the report of the Kansas State Board of Agriculture, December 31, 1887, a prescription is offered for the diseased mucous and serous membranes and for the nervous and debilitated condition of the animal. Dr. Harding thinks that

Pulverized extract belladona	10 grains.
Corrosive sublimate	1 to 1½ grains.
Licorice	1 oz.
Glycerine	q. s.

Mix. Make a thin paste, and give a tablespoonful. The belladonna and mercury may be increased according to the severity of the symptoms. In the *Rocky Mountain Druggist*, July, 1889, page 81, notes on the so-called loco weeds by Prof. Dr. Frederick B. Power, taken from *Hoffmann's Pharm. Rundschau*, the work of Prof. Sayre is reviewed and the experiments of Dr. Mary Gage Day are cited as to the toxicity of the loco weed. Prof. Power seems to think that it is clearly established that the loco weed contains some alkaloid that affects cattle and horses. In the *Rocky Mountain Druggist*, January, 1891, pages 5 to 9, and in the *Pharmaceutische Rundschau*, January, 1891, page 8, the same article appears: Chemical examination of some loco weeds, *Astragalus Mollissimus*, Torrey and *Crotalaria Sagittalis*, Lin. by Prof. Dr. F. B. Power and J. Gambier, in which the literature of the subject is first noticed and then the chemical examination of *Astragalus Mollissimus* is taken up, giving in detail the method and tests used. We have room only for the conclusion: "In concluding this investigation the authors are sensible of the fact that the chemistry of the plants under notice has not been pursued to its furthest limits, but being unable at present to devote more time to the subject we have thought it proper to record the results thus far obtained. These results have, however, afforded us the conviction that both the *Astragalus* and the *Crotalaria* contain very small amounts of toxic alkaloids, to which we believe the symptons of poisoning produced by these plants may reasonably be attributed. It is only to be regretted that these alkaloids, as well as most of the other constituents of the plants, are of such a character as not to render their further chemical study specially alluring."

In the report of the Veterinary Department of the State Agricultural College, by Dr. Faville, issued in January, 1885, page 13, he says: "With a view of determining the symptons and *post mortem* appearances of the disease, (during the month of August,) President Ingersoll, of the college, visited the ranch of Hon. J. M. Givens, of El Paso county, who set aside for his experiments, a number of sheep that were "locoed." I append the report of the President, made to me upon his return from the investigation. He found the animals showing a very great degree of emaciation, and also showing to its greatest degree, the loco habit. They would wander about in an aimless way, refusing all other food except the loco. President Ingersoll made several *post mortem* examinations, and found the same condition of things that I shall describe further on. As an experiment he tried the effect of feeding the loco. A young lamb about two months old, that was being raised on a bottle, was selected. Twenty pounds of loco were cut just below the crown, and that contained no seed; in other words, just the portion that the sheep were getting to eat. This was placed in a wash boiler, in seven or eight gallons of water, covered tightly, and boiled for twelve hours. The juice was then expressed and evaporated to the volume of one quart, when it was a thick syrup, with a smell and taste much like glucose. This was then given to the lamb instead of milk, being fed from the bottle, just as the milk had been. It was given as follows: Seven tablespoonfuls at 4:30 p. m.; four tablespoonfuls at 5:30 p. m.; four tablespoonfuls at 7 p. m. The next morning the bowels were slightly loosened, but nothing more could be seen. The next day two tablespoonfuls were given at 6 a. m.; four tablespoonfuls at 7 a. m.; six tablespoonfuls at 12 m.; two tablespoonfuls at 1:30 p. m.; four tablespoonfuls at 6 p. m. The next morning two tablespoonfuls at 6 a. m.; four tablespoonfuls at 12 m., making thirty-nine tablespoonfuls that were given, in the place of the regular allowance of milk, and which constituted all the food it got for forty-three and one-half hours. There were no deleterious effects, that could be noticed, and I saw and very carefully examined the lamb, about two weeks after-

Astragalus Drummondii.

ard. The results of chemical examination of a syrup made the same way, I will speak of further on.

"During the first week in September, I spent a few days at [M]r. Givens' repeating the experiments of President Ingersoll. [T]he animals that I had to examine were not so badly locoed [a]s many of the flock had been, and most of them had begun [t]o recover. I noticed a condition of things almost identical [w]ith those that are described in the President's report. Upon [m]aking *post mortem* examinations, I found the following [c]onditions: Organs of thorax were normal. In the abdom-[in]al cavity, I found the stomach filled with a mass of semi-[d]igested loco leaves. The liver was normal in appearance; [g]all bladder filled with a greenish color bile. In the duct, [r]unning from the gall bladder to the small intestines, I found [a] mass of tape worms (*tænia expansa*). The small intestine [I] found filled with a mass of these worms, varying in [l]ength from six inches to five or six feet. The kidneys were [n]ormal in size and color, but, upon section I found the pelvis [fi]lled with a gelatinous material (*amyloid degeneration*). The [m]uscular system was exceedingly flabby and pale in color. [T]he body seemed to be absolutely destitute of fat. The [u]rine was normal. The brain showed a slight, serous effusion [a]bout the base, and to a slightly greater extent in the region [o]f the medulla oblongata. There also was a slight effusion [i]nto the abdominal cavity. The only other change that could [b]e found in the brain of these sheep was a slight con-[g]estion of the arachnoid membrane. About the middle of [O]ctober, I received a letter stating that, if I so desired, I [c]ould obtain some fine specimens of locoed horses, on the [r]anch of Mr. J. T. Cheatham, at Lake station, on the Kansas [P]acific railroad, about one hundred miles southeast of Denver. [I] arrived at Lake, Oct. 19th, and at once began my investiga-[t]ion. I found several affected horses. Two of these I killed [b]y bleeding, and made careful *post mortem* examinations upon [t]hem. I found the two cases exactly similar, a description of [o]ne answering perfectly for the other.

"The first case examined was a sorrel gelding that had [b]een brought through from Texas. He presented the follow-[i]ng conditions: Great emaciation; the horse was found standing apart from the rest, and could not be observed to [b]e eating, to any appreciable degree; bowels extremely con-stipated. The animal apparently had lost all muscular con-[t]rol. Whenever he moved it was in an irregular manner, as [i]f he were intoxicated, and frequently he knuckled over at the fetlocks, as if from complete exhaustion. When a motion was made at him, he would throw his head upward, and stagger to one side. The power to back was completely lost. If the animal were left to himself he would wander about in a listless, aimless manner, or stand for a long time, with head drooped, in a sort of stupor. The mucous membranes were exceedingly pale. When it was desirous to lead him, we found it to be impossible. When the rope was thrown on to him, he reared backward, and it was impossible to get him to move forward. In the attempt to lead him, he fell. I killed him by opening the jugular vein.

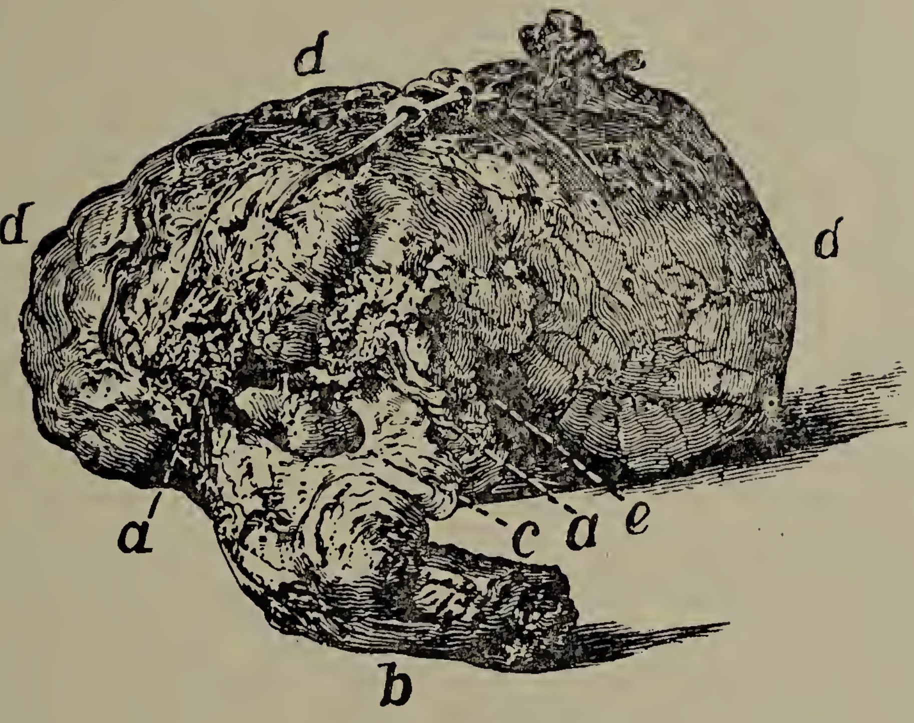
POST MORTEM CONDITIONS.

"The organs in the abdomial cavity were in the following conditions: The stomach was empty, except a small quantity of partially chewed grass and weeds, and a small amount of sand and dirt. The small intestines and cæcum were in a normal condition, except that the coats appeared thinner than they should, and the muscular coat was flabby and relaxed. The colon was enormously distended with food, that was undigested and presented a partially chewed appearance. The spleen was somewhat shrunken and much more dense than normal; kidneys were normal; the liver was considerably shrunken and hardened, and extremely adherent to the capsule. The capsule of the liver showed numerous spots of more or less perfectly organized lymph. The liver pulp, granular and friable.

NERVOUS SYSTEM.

"The *spinal cord* was softened considerably throughout the greater portion of its extent.

"The cerebral hemispheres of the brain appeared normal, except a slight congestion and fibrous hardening of the arachnoid membrane. The middle ventricles were almost filled with serum of a yellowish color. The fourth or cerebellar ventricle was filled with a hemorrhagic effusion, the whole base of the cerebellum being covered with a blood-clot, more or less organized, and a large quantity (three fluid ounces) of serum bathing the base of the brain, and the medulla oblongata. The hemorrhagic effusion, or blood-clot, completely covered the base of the brain, floating in this serum, as well as the fourth ventricle, and was held to the brain substance by well organized tough fibers and also to the meninges of the brain. The blood was deficient in fibrine, only, imperfectly coagulating. All of the serous cavities had an abnormal quantity of serum in them. The second case was a brown three-year-old gelding. The colt showed all the symptoms of the other case, except that he was stronger, and, if possible,



EXPLANATION OF CUT.

a-a—Blood clot in fourth ventricle.
b—Medulla oblongata.
c—Fourth ventricle.
d-d-d—Cerebrum.
e—Fissure between cerebrum and cerebellum.

The cerebellum was lifted away from the medulla oblongata by means of the chain hooks, and as the brain is viewed from the posterior aspect, it shows the fourth ventricle.

owed a greater craziness. The whole system was so run own that, in running and throwing himself, he bled profusely the nose. The unsteadiness and emaciation were the me as in the first case. The *post mortem* symptoms were e same, a description of one answering for the other. I ad the brain from this case photographed and a cut made f it, which is appended."

Dr. Faville's conclusion was that the loco contained some oisonous principle "that caused a hemorrhagic effusion into ie base of the brain, causing symptoms of craziness and loss f muscular control." During the fall of 1889, Dr. McEckran, ien of the college, instituted the experiment of feeding the oco to an animal, the property of Hon. B. S. LaGrange, a iember of the State Board of Agriculture. I have not een able to obtain the record of the experiment, and can nly state the general plan and the conclusion of the experiient. The animal was placed in a stable and the loco (*Asragalus Mollissimus* and *Oxytropis Lamberti*) was cut up fine, nd mixed with other food so the animal would eat it. This eeding was continued about two months with no symptoms f the so-called loco disease.

Enough has been given of the history of the loco and also f the symptoms by which the animals are affected. I have iade many inquiries of those that stated they had any experence with the loco or locoed animals.

INFORD & SPENCER,
COAL DEALERS,

DENVER, Colo., September 27, 1890.

. O'Brine, Professor Chemistry, Agricultural College, Fort Collins, Colo.:

DEAR SIR.—You will please excuse my apparent neglect in not complying with our request sooner, in giving you my experience with the loco weed in New Mexo. The summer of '81 was the most disastrous to stockmen that to my knowldge has ever occured in that Territory, and probably the cattle in Ute Creek Valey suffered more than those on other streams. The loco weed was that bearing urple and white flowers; the conditions were, dry weather and short grass. The tock ate freely of the weed, and at any time one could see horses and cattle in all tages of the disease, caused by eating thereof. The rough examination that we vere able to give the stock which died, showed the stomach and sometimes porions of what is commonly called the manifold, to be lined and perforated by a mall parasite.

A certain druggist in Springer, whose name I cannot recall, had a fair microcope. This we used in examining the plant. We found that almost every plant had one or more leaves that were rolled, indicating that some worm or bug had been at work on it. These leaves, on being unrolled, contained a very small, white parasite. I cannot say that the two, that is the parasite in the stomach and the one in the leaf, had much resemblance to each other, in fact, rather the contrary. But this, if our theory is true, might be due to the growth of the insect. It was the common opinion of those of us who were investigating this matter, that the loco plant of itself was harmless, and that the effect on animals was the effect of the parasite in their system. The common symptoms, such as near-sightedness, trembling of the limbs, are greatly aggravated by running or any continued quick movement. It is commonly known to be a fact that the loco weed is harmless after severe freezing, and this point will appear to show that there is some other cause than any poison that may be in the plant itself.

From conversation with horsemen in Wyoming, I have heard the same opinion expressed regarding the effect of freezing on the plant. I fear this is not as full a statement as you had hoped for, but at the present day it is about the best I can do.

I should be pleased, at your convenience, to have a summary of the experiments that you are conducting. Hoping that you will be able to get at the bottom of the matter, I am,

Respectfully yours,

BINFORD & SPENCER.

UNITED STATES DEPARTMENT OF AGRICULTURE,
Division of Chemistry.

WASHINGTON, D. C., March 11, 1890.

David O'Brine, Fort Collins, Colo.:

DEAR SIR.—In regard to the analysis of the "loco weed," I will say that we have made several examinations of this weed for an alkaloid or poisonous matter, and have separated a substance which exists only in small quantities and which has some of the characteristics of an alkaloid, but which we have not yet obtained in large enough quantities for further examination. We use various methods for extracting the alkaloid, among the best of which we find the saturation of the finely-ground material with sulphuric acid, the addition in excess of sodium hydrate or ammonium hydrate, and shaking the alkaloid out with ether. Among other methods, those used for the separation of Calycanthine, described by me in the *American Chemical Journal*, Vol. II., No. 8. may also be used.

I should expect the largest yield of the alkaloidal principle from the plants after they had reached maturity.

Respectfully,

H. W. WILEY,
Chemist.

JOURNAL OF ANALYTICAL CHEMISTRY,
EDWARD HART, Editor.

EASTON, Pa, March 14, 1890.

Mr. David O'Brine:

DEAR SIR.—I worked some time, myself, several years ago with loco weed (*Astragalus Mollissimus*), but could not get any alkaloid. I was forced to lay it aside by press of other work, and have not been able to take it up again. If you succeed with it, I wish you would let me know. In the limited time I worked with the weed, I could only get a gummy residue, which refused to crystallize.

Very truly yours,

EDWARD HART.

The people of Colorado had great faith that it was the loco weed that caused so much disease and death among horses, sheep and cattle, for the Legislature passed an act, as follows :

"Any person who shall dig up, not less than three inches below the surface of e ground, any loco or poison weed during the months of May, June or July, all receive a premium of 1½ cents per pound for each pound of such weed dug), to be paid out of the state treasury as hereinafter provided; *provided*, that such eed shall not be weighed in a green state, but shall be thoroughly dried and eighed."

On writing to Hon. W. H. Brisbane, State Treasurer, I reeived the following reply :

OFFICE OF
TATE TREASURER,
W. H. BRISBANE, Treas.

DENVER, Colo., May 30, 1890.

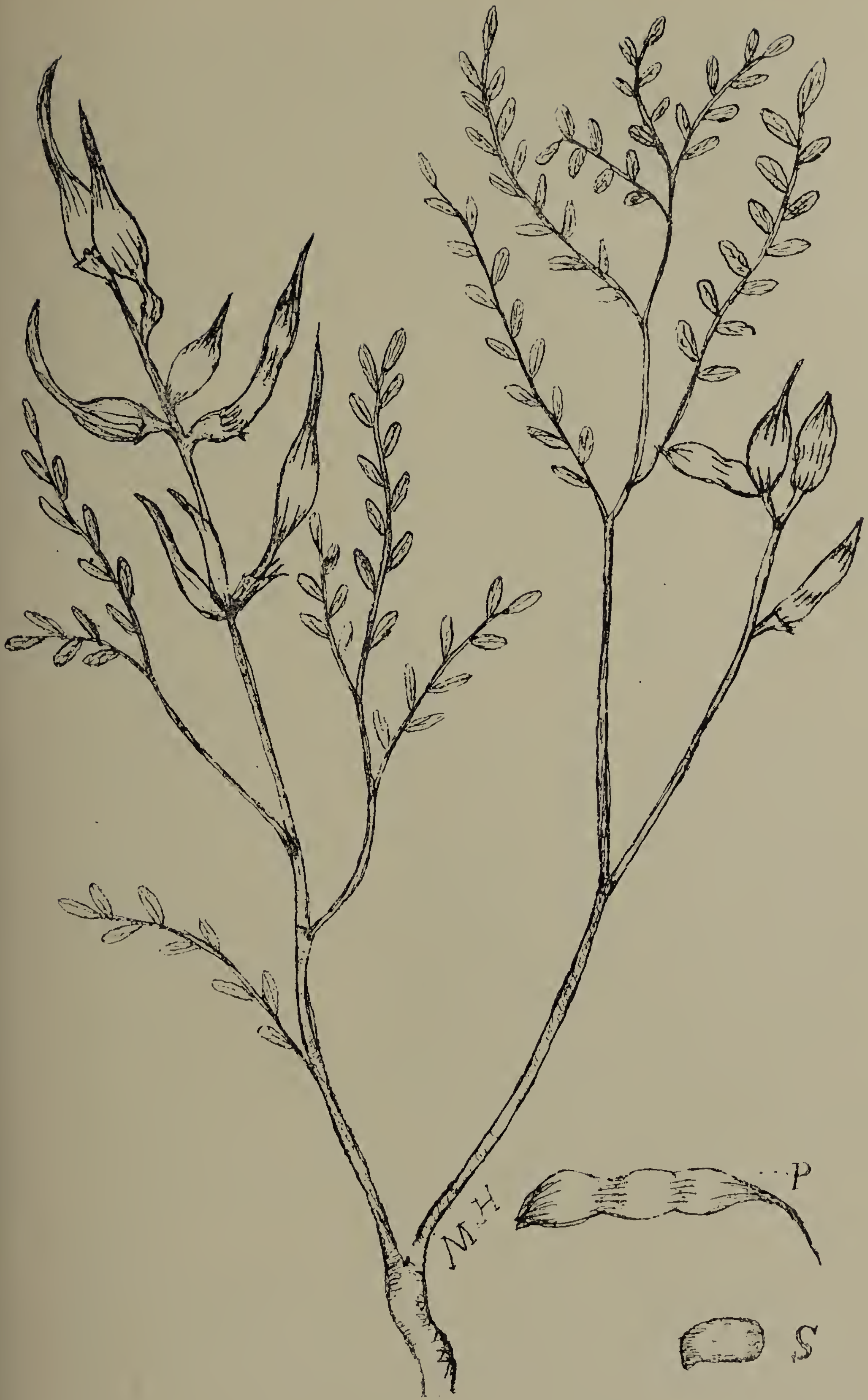
rof. David O'Brine, Fort Collins, Colo.:

DEAR SIR.—The State has paid out in bounties on loco weed nearly $200,000. he law was repealed April, 1885. I should like to know your conclusions when nished.

Yours truly,
W. H. BRISBANE,
State Treasurer.

On examining the statute, we find the law was passed March 14, 1881, and repealed February 18, 1885. It cost the State $50,000 a year for bounty.

The plants that we examined on this occasion were identified by Professor Cassidy and later by Professor Crandall. They were dried, ground and sifted, and treated first by the Dragendorff method. The method is described in his work on plant analysis, 1884, published by J. H. Vail & Co., New York, or in Wharton and Stille's Medical Jurisprudence, Vol. II. on poisons, page 356, § 348. It has been thought too technical to be inserted here. In every instance I failed to get anything that would crystallize, only a gummy extract, that gave reactions with Wagner's reagent (iodine in potassium iodide solution), with Mayer's (potassium mercuric iodide), with Sonnenschein's (phosphomolybdate), with Marme's (potassium cadmium iodide), with Dragendorff's (potassium bismuth iodide), with Hager's (picric acid), with Schibler's (Metatungstic acid), with Berzelius' (tannic acid) and also with the chlorides of platinum and gold. Their general action was reducing; when ammonium molybdate was dissolved in strong sulphuric acid it acted like morphine, reduced it to a sapphire blue (Frœhde's reagent); with iodic anhydride and bisulphide of carbon free iodine was liberated. These reactions were tried from the chloroform, ether and absolute alcohol extracts, and it seemed to make but little difference which was used, or whether the extract came from an acid or an alkaline solution. After I had thoroughly tried the reaction, I tried alfalfa, treated identically like the loco and got the same reactions with the reagents above described. I tried treating with sulphuric acid first, and afterwards I tried hydrochloric, then tartaric, then acetic acids. When the sulphuric acid extract was evaporated down, it gave a blacker residue than the other acids. Nearly all the samples when treated with alcohol, there separated out crystals of lime, that were insoluble in the alcohol. At Dr. Wiley's suggestion I obtained a copy of the *American Chemical Journal*, Vol. II., No. 8, and carefully followed out the method recommended there, with the same results as before. Prof. Sayre visited me in 1890 and called my attention to what Prof. Power had done, and almost at the same time I saw the article of Profs. Power and Gambier in the *Pharmaceutische Rundschau* and in the *Rocky Mountain Druggist*. This year I secured other specimens and carefully followed the method there laid down. The results were the same as in former years. Also tests were made with rabbits by feeding a teaspoonful of the aqueous extract every hour, from 8 to 5 p. m., on Friday, Sept. 2, 1892 to Monday, Sept. 5, 1892, with no bad effects. During the summers of 1891 and 1892, considerable time was spent on the analyses of the loco plant. I visited Livermore or vicinity five times, and made three post mortems. A brief outline of the post mortems is here appended. The first post mortem was made on a 3-year-old colt, the property of Mr. C. The colt was brought in from the range, and was in very poor condition. When driven around the yard he had the peculiar high step so often described as being a characteristic symptom of loco. He was roped, thrown, and his throat cut. The post mortem appearance was as follows: The heart, lungs and liver were normal in appearance. The stomach was completely covered with bots, and contained, besides, a large number of thread worms. The intestine connected with the stomach (duodenum) was filled with sand. I estimated that about two gallons were in the intestines. (When it is known that the post mortems are held from twenty to thirty miles from the College, and in such conditions as we can obtain the animals, only estimates can be made of some things). The brain had a clot of blood at the base of it. I advised the owner (because he had twenty horses suffering from like symptoms) to put the animals on good, green feed, so it might act as a physic, and carry the sand out of the system. I recommended a tonic of nux vomica. He told me the affected animals improved so they were all finally sold. The sand, as I think, comes from the animals not being properly salted, and from eating the alkali soil.



Sophora sericea.

The second animal was 2 years old, and in fair condition. He had been taken up, fed and treated for a month in the stable, but he was injured so by throwing himself in the stable that he had to be turned out in the pasture to live or die. I found the liver, heart, kidneys and spleen normal. The lungs were congested, and covered with dark, livid spots about the size of a twenty-five cent piece. The stomach and intestines did not have a normal appearance, but were pale and apparently bloodless. The small intestines were cut with a scissors, and were found filled with spindle-shaped worms about 6 to 8 inches long. About one quart of them, (*Ascaris Megalocephala*) was obtained. In cutting the intestines, before we came to the worms, I would find a green mucus discharge; as many as six of them would be found in one place, completely closing up the intestines. Bots were found in large quantities. The reason why so many parasites were found, as I think, is because the animals have to get water wherever they can find it, and in many cases drink stagnant, filthy stuff that is loaded with many forms of animal life. The brain was examined, and the usual clot of blood was found at the base. The colt was owned by Mr. J.

Post mortem No. 3 took place about thirty miles from Fort Collins. The owner, Mr. S., had about 100 head of horses. The colt was 3 years old and had been affected the year before. He had been put up in good pasture about one month before I saw him. The liver, lungs and kidneys were more or less diseased. The liver was tuberculous, the lungs congested, the kidneys were filled with ulcers so the pus could be scraped off when cut into. The clot of blood was found at the base of the brain. As the animal had been on green feed for one month, but few parasites were found. Samples were brought to the laboratory for microscopic examination.

The Bureau of Animal Industry at Washington has kindly consented to assist me in identifying the parasites, and in the miscroscopic examination of the affected parts. "Franks" were sent me to send the specimens to Washington for identification.

In all the examinations thus far made, I have found cause enough to account for the symptoms. The more I examine the loco question, the more I am persuaded that we must look for some other cause besides the loco weed. The loco weed is so common in and about Fort Collins that if it was the cause of the trouble, animals in *this* vicinity must be affected with the so-called loco disease; but I have not been able to find a single specimen in the neighborhood, while the loco is as abundant here as in the localities where the animals are affected. I have had a great deal of trouble in obtaining subjects for post mortem, as the ranchmen do not want it known that they have any animals affected with loco. They say it would interfere with the sale of their stock. I have been unable to form any reliable estimate of the number of animals that yearly die from the so-called loco disease.

METHOD OF ANALYSIS.

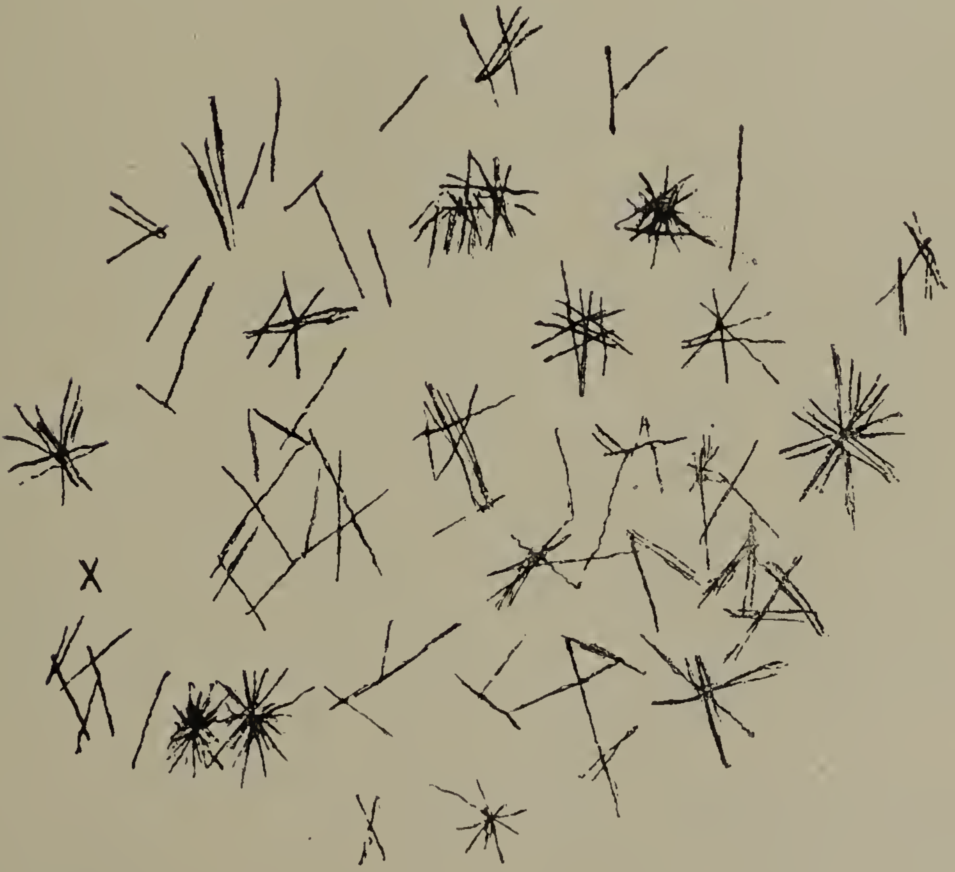
There are quite a number of methods of analyses for the detection and estimation of poisons and ptomaines:

The Otto-Stass method; Granteir and Etard's method; Brieger's method; Luff's method; Graham's method; Fischer's method; Sonnenschein's method; Dragendorff's method. Almost everyone who has had any great experience with this kind of work modifies the method he uses, or adapts the method to his own case. Last year Prof. Sayre called my attention to a method described in *Pharmaceutische Rundschau* for January, 1891, p. 8, by Profs. Power and Gambier, as they claim to have found alkaloids or something that gives alkaloidal reactions. I have followed their method in detail and in every particular, as follows: One kilogram (2.2 lbs.) of the dried and finely ground powder was extracted with strong alcohol for 5 days. The alcohol was pressed out with a filter press. The alcoholic extract was distilled in a Remington still to recover the alcohol; the concentrated residue was treated with water and a little acetic acid to precipitate the resin. This resin was given to a rabbit and produced no effect. I took it in 10 grain doses and could feel no effects. The taste was very disagreeable. The aqueous liquid was treated with lead acetate and the precipitate washed with water, and treated with sulphuretted hydrogen, filtered, boiled down to a small bulk and given to rabbits; it produced no effects. The filtrate, after the lead acetate had been added, was filtered and evaporated to a small bulk and the following tests applied:

Mayer's (potassio mercuric iodide) gave a...... yellowish white precipitate
Dragendorff's (potassio bismuthic iodide) gave a. reddish yellow precipitate
Wagner's (iodine in potassium iodide) gave a.... reddish brown precipitate
Sonnenschein's (phospho-molybdate) gave a......... yellowish precipitate
Hager's test (picric acid in alcohol) gave a..... light yellowish precipitate
Berzelius (tannic acid in alcohol) gave a........... light brown precipitate

The unused portion of this liquid was divided into two parts; one half was made acid by a few drops of sulphuric acid, and the other half made alkaline with a few drops of ammonia. These solutions were evaporated to a small bulk on the water bath, and each treated with Prollius' fluid that was made as follows: 70 c. c. of 94 per cent. alcohol, 30 c. c. of 28 per

Astragalus sericoleucus.



Crystals of Sulphate of Lime.

cent. ammonia, 300 c. c. of absolute ether, and 300 c. c. of chloroform were mixed in a bottle, and the mixture well shaken before being used. The substance obtained by treating with Prollius' fluid was, in each case, evaporated to dryness on the water bath, redissolved in water and again evaporated to see if any crystalline precipitate could be seen by the microscope; but none could be found. These residues were fed to rabbits and I could not see that they were in the least affected. I tasted the residues and found a bad, pungent taste that would be difficult to describe. Thinking that the quantity used was too small, I tried the method over again, using 3 kilos. (6.6 lbs.) with the same result as to crystalline products and as to effects upon rabbits. 4 kilos. (8.8 lbs.) of the dry and finely-ground powder were treated with distilled water containing ½ per cent of sulphuric acid for 6 hours on the water bath. The liquid was strained through a new linen filter and this filtrate evaporated to a small bulk on the water bath. During the evaporation a white cyrstalline salt separated out and was filtered off. This, on examination, I found to be calcium sulphate (see cut). Microscopic drawings were made of these three years ago. The crystals were in the plant as calcium acetate, as I afterwards found.

The liquid above described was evaporated to a soft extract and the extract divided into two parts. One part was made acid with sulphuric acid, and the other part made alkaline with ammonia, and these treated with alcohol, ether and chloroform successively and evaporated to dryness on the water bath. The undissolved residue, as well as the amount dissolved by the ether, alcohol and chloroform, was tested for alkaloids by dissolving in water, and gave reactions with Mayer's and the other reagents before described. The residue was diluted with water to the consistency of molasses and given to rabbits every hour for two days, with no bad results. Last year and this year I tried alfalfa in the same way: 1 kilo. (2.2 lbs.) was cut fine and pounded in an iron mortar until it became soft and pulpy, and then treated with dilute (½ per cent.) sulphuric acid for three days, then filtered, the filtrate concentrated on the water bath to a syrup; this syrup was divided into two parts. One half was treated with 95 per cent. alcohol, and the alcohol extract filtered and allowed to evaporate, the residue dissolved in water and tested for alkaloids, as follows:

Wagner's test gave a	dirty red precipitate
Hager's test gave a	yellow precipitate
Marme's test gave a	light yellow precipitate
Berzelius' test gave a	light yellow precipitate
Mayer's test gave a	yellowish white precipitate

The residue that was not treated with alcohol, when diluted with water, also gave reactions with the above reagents. To be sure that the alcohol was not the cause of the trouble I tried the dilute alcohol with the reagents, but could get no reaction. The results of this year with alfalfa were confirmatory with those of two years ago.

One hundred grams (1-5 lb.) of the finely-ground plant were digested with water strongly acidulated with sulphuric acid. This was filtered and distilled; the distillate had an acid reaction; barium carbonate was added to form a barium salt. This barium salt was heated with alcohol and sulphuric acid when acetic ether was given off, showing the presence of acetic acid.

In all my work on the loco, I have never failed to obtain tests for the alkaloids, and I have never succeeded in obtaining any physiological effects upon myself or rabbits. Last year I tried the Dragendorff method as described in his Plant Analysis, 1884, and also the method of Dr. Wiley, as published in the *American Chemical Journal*, Vol. II., No. 8, page 557. In either case I did not succeed in eliminating any residue that gave physiological reactions. My attention was called to a paper on the recovery of alkaloids by J. U. Lloyd of Cincinnati, read at the meeting of the American Pharmaceutical Association, at New Orleans. He kindly sent me two copies. His method consists in treating the fluid extracted with a mixture of equal amounts of dry hydroxide of iron and bicarbonate of soda. The stiff magma is treated with chloroform a number of times. He says: "By this method I now find alkaloids in many drugs that failed to yield them heretofore. Indeed, comparatively few drugs are destitute of organic bases." I tried his plan, as follows: Two kilos. (4.4 lbs.) of the dried and finely-ground plants were packed in a percolator. Percolate it with dilute alcohol (1 alcohol to 3 of water); evaporate the alcoholic extract to the consistency of thick honey; thicken this with a mixture of equal amounts of hydroxide of iron and sodium bicarbonate to a thick paste; exhaust with chloroform and evaporate the chloroform. The chloroform residue is treated with a little dilute sulphuric acid and examined for alkaloids. This residue gave me alkaloidal reactions but no crystalline substance, nor physiological test with rabbits. Prof. Lloyd's letter contained a statement that may be of use to others who may investigate the subject. "It seems to me from a review of the papers that I have seen concerning the action of this plant, that it is evident that the result of its use is that of an increasing toxic agent, that is, the effect is not such as I would suppose would follow the action

Astragalus caryocarpus.

f a known amount of poisonous ingredient, but is rather that f a substance that becomes increasingly virulent after it has een eaten. It seems to me that the chemical assay of the lant, as far as I have determined, does not at present acount for the physiological action of the drug, and I will say hat I would not be at all surprised if it would be shown that he plant does not contain a fixed constituent that will produce he craziness that follows after its use as a food. I am rather f the opinion, therefore, that we will have to look for a fer-nentative poison that results after the plant is eaten, rather han a poison contained in the plant. I would not be at all urprised if, in the study of this plant, it will be shown that nder the influence of the digestive agents, a substance is pro-luced which accounts for the subsequent action of the plant. n other words, it is my surmise that the poisonous action of he loco weed is due, perhaps, to a *product* instead of an *educt*. t remains to be seen whether this product is of a nature of he microbe or of the ptomaine, whether it is an alkaloid or an organism. I will add that in this surmise I am not carrying myself beyond what has been demonstrated to be true of other substances outside of foods, and will call your attention that in modern medicine we now use a preparation of jequirity, which depends altogether on its action from the swarms of microbes that form in the infusion of the beans, and I will add that it is then a violent poison, while the bean itself does not contain a constituent of that nature. It may be that I am off in my surmise, but at least I think that loco will bear investigation in this direction, and I would suggest that a careful examination be made microscopically, locally, of the parts of the animal affected after the plant has been eaten. You will perceive from the foregoing that while the plant undoubtedly contains an alkaloid, or alkaloids, I do not believe this alkaloid is of the importance some think it will prove to be."

The statement of Prof. Lloyd is worthy of very careful consideration. I have been long persuaded that the best way to study the loco question is to spend the summer where the animals are said to be locoed, to see what the animals eat, how they act, what they drink, and to carefully observe their symptoms and post mortem appearances. The reason why I make these comments is that there are so many contradictory statements made to one, that you can believe but little of what you hear about locoed animals. Many of the ranchmen call the larkspur, or poison weed, the loco. A chemical anal-ysis was also made of the larkspur. It was treated the same as the loco weed by the Dragendorff method. The solution from Prollius' fluid was in appearance like the loco extract, a thick, molasses-looking mass, soluble in water, and giving it a coffee-colored appearance when diluted. Millon's, Berzelius', Marme's, Hager's, Mayer's, and Wagner's tests, before described, gave precipitates with the solution. Bulletin No. 3, Oregon Station, October, 1889, page 25, contains the following statement in regard to the

LARKSPUR.

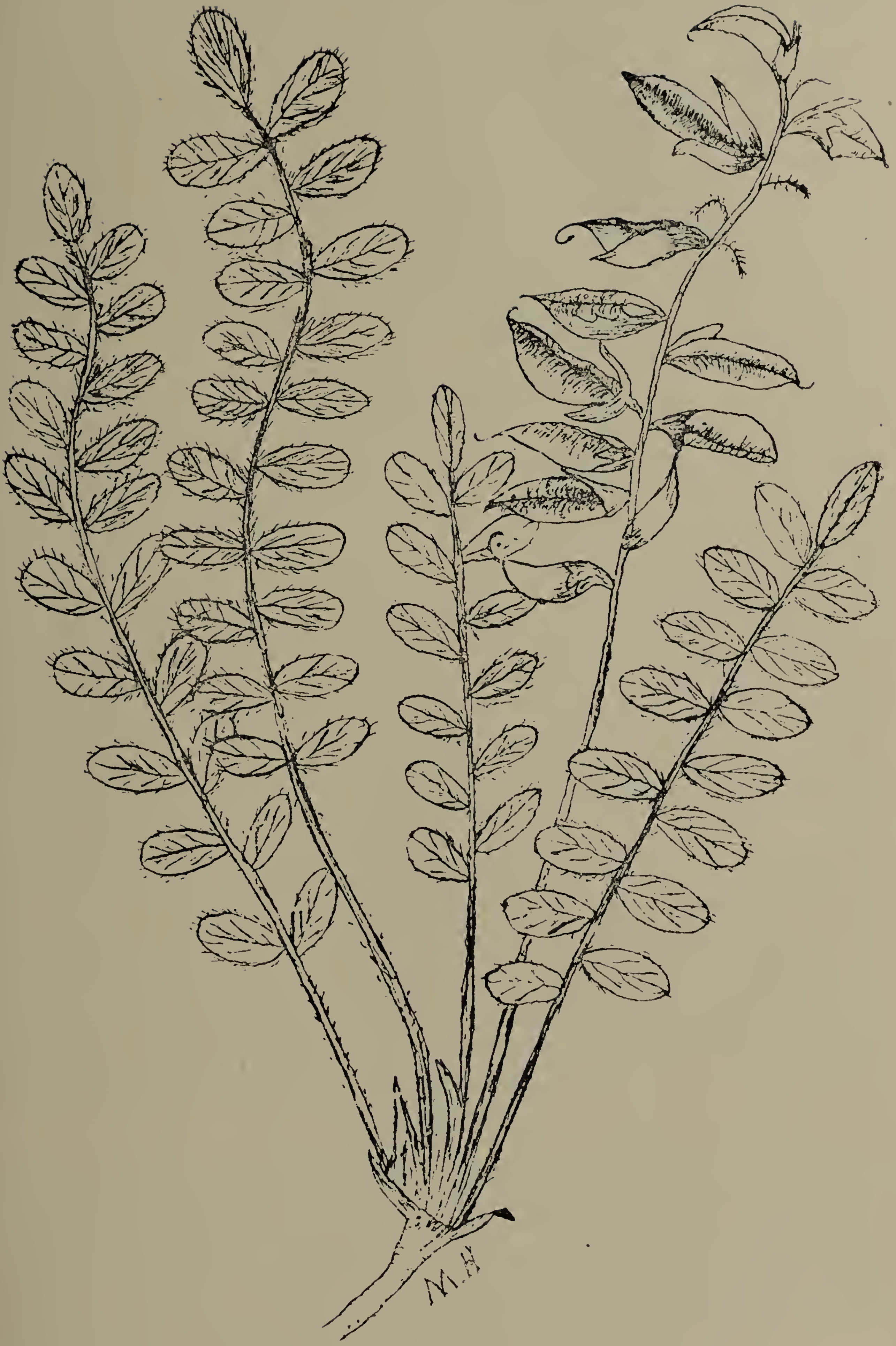
"The matter was taken up on account of the numerous letters received at the station during the spring and summer, asking information with regard to plants which were thought to be poisonous to stock. The method of investigation was the following: Two well-developed, healthy, yearling steers were bought for the experiments, which were primarily to discover whether the plants under examination were injurious, and if so, to note the symptoms developed and try various antidotes for the effects produced. That all parts of the plants might be tested, the tops, *i. e.*, the leaves and stem were fed to one animal, the roots to the other. As great a quantity of the plant was fed to each as cattle under ordinary circumstances would be liable to obtain in the pasture. That the plants might be readily eaten they were, in most cases, mixed with some chopped grass and a small amount of oats added. The experiments commenced May 7. and the first plant tried was the common blue larkspur (*delphinium exaltatum*).

"Twenty-four specimens were taken. The tops chopped and mixed with about an equal amount of clover grass, were fed to one, the roots prepared in a similar way, were fed to the other animal, in both cases without any apparent ill effect. The larkspur used was mostly in full bloom and the individuals were chiefly good-sized plants."

"White larkspur was next tried. Thirty plants, well developed, in full flower, were fed in a manner similar to that noted with the blue larkspur. No effects noted."

In Bulletin No. 35, December, 1892, of the Kansas station, page 115, a cut of the *Astragalus Mollissimus* is shown. The article is headed, 'Some Observations upon the Loco.' The article contains the usual symptoms and post mortem appearances. The conclusion is especially interesting:

"A careful survey of the experiments performed and observations noted leads me to the opinion that the disease known as 'loco' is the result of mal-nutrition, or a gradual starvation, caused by the animal eating the plants known as 'loco weeds,' either *Astragalus Mollissimus* or *Oxytropis*



Astragalus mollissimus—large species,

Lamberti. If there is a narcotic principle in the plant chemists have failed to find it, and a fluid extract does not possess it, and a ton of the plant eaten by an animal ought to contain enough of the poisonous properties to destroy an animal.

"It is extremely doubtful, even though there might be a narcotic agent in the plant, that an animal can reason sufficiently to know that eating this plant would produce narcosis. Why they do eat the plant is probably because the plant remains more green and fresh after other plants have dried up, and also because of its peculiar taste, perhaps disagreeable at first, but soon accustomed to and attractive.

"Whether the disease is the result of mal-nutrition or malassimilation, I am unable to say. It is reasonable to suppose that, as the loco plants remain green throughout the year, they would not contain as much nutritious material as other leguminous plants. If they do contain the nutritious material it is not in a form in which it can be assimilated by the animal. The reason why horses have fits of delirium or insensibility may be due to the formation of clots or thrombi in the blood-vessels of the brain, as there is a well-known tendency to their formation during wasting and debilitating diseases.

"The general emaciation of the body, the flaccid atonic condition of the digestive system, the large amount of serum surrounding the brain and in the abdominal cavity, the swollen and dropsical condition of dependent parts (from an enfeebled circulation), and the low temperature of the body, all point to the same cause, *mal-nutrition.*

"The diseased condition of the brain gives rise to the peculiar 'crazy' symptoms associated with the disease. It is well-known that if an animal suffers from degeneration of brain tissue, even though the animal may recover from the disease which caused it, it does not recover its normal mental faculties. This may account for the fact that a locoed animal never makes a complete recovery.

TREATMENT.

"Prevention, by not allowing animals access to the plant or by furnishing suitable food after the pastures have dried up, is much better than treatment. If an animal has acquired a taste for the plant, it should be placed where it cannot get the weed, and fed upon nourishing food. Some good 'condition powders' may be given, as the following :

Sulphate of iron, pulverized	1	ounce,
Gentian root, pulverized	4	"
Ammonia muriate, pulverized	1	"
Potassium nitrate, pulverized	1	"

"Mix thoroughly, and give from a heaping teaspoonful to a tablespoonful, according to the size of the animal, in the food three times daily. It will, probably, require considerable time for the animal to recover somewhat of its former vigor, and good nutritious food is to be depended on more than medicine."

The following letters from Dr. Riley explain the parasites that infests the loco.

UNITED STATES DEPARTMENT OF AGRICULTURE,
Division of Entomology.

WASHINGTON, D. C., July 24, 1890.

Professor David O'Brine, Agricultural Experiment Station, Fort Collins, Colorado.

DEAR SIR:—I have your letter of July 14, and the fruit of the "loco weed," with the contained larvæ.

This insect seems to be a weevil of the genus *Bruchus*, allied to the common Bean and Pea Weevil; but it will be impossible to determine the species without rearing the adult. It is very interesting matter, and I trust that you will send me on more of these fruit from time to time.

Hoping to hear from you again, I remain

Yours truly,
C. V. RILEY,
Entomologist.

U. S. DEPARTMENT OF AGRICULTURE,
Division of Entomology.

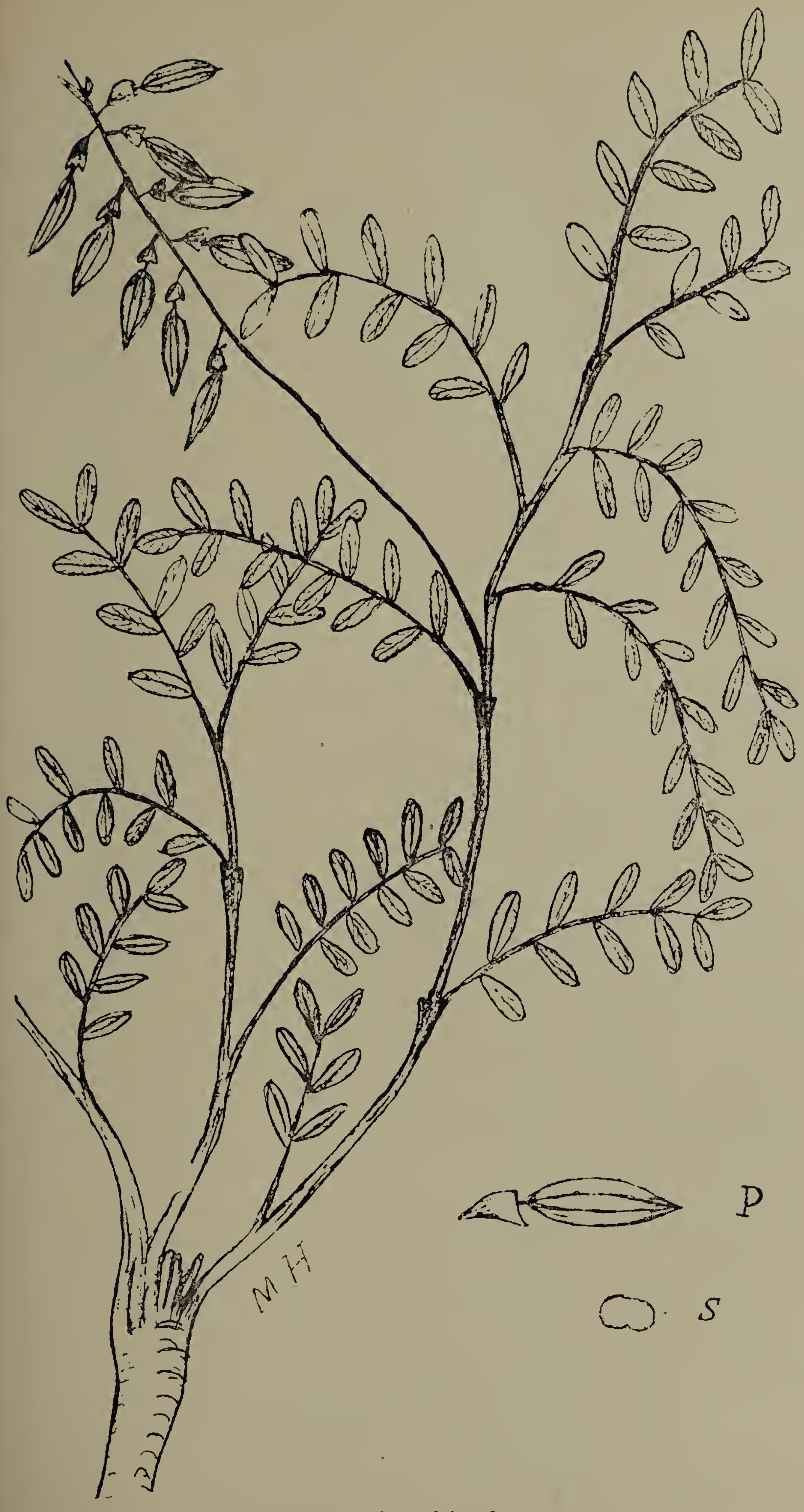
WASHINGTON, D. C., December 6th, 1890.

Dr. David O'Brine, Agricultural Experiment Station, Fort Collins, Colorado.

DEAR SIR:—Yours of the 4th inst. has just come to hand. I am thoroughly convinced that the insects which infest the loco weed have nothing whatever to do with the effect of this plant upon live stock. The loco weed has a number of insect enemies in which I have been for some years quite interested. It is a common thing for persons to suppose that the insects might cause the trouble rather than the plant. I shall always be glad to hear from you further and should especially like to get some more specimens of the Bruchus which you sent last year.

Yours truly,
C. V. RILEY,
Entomologist.

The following table gives the ash analyses of the loco and larkspur: It explains itself.



Astragalus bisulcatus.

ASH ANALYSES OF THE LOCO AND LARKSPUR.

	Total Ash.	Carbon C.	Silica. SiO_2.	Iron and Alumina. Fe_2O_3, Al_2O_3	Calcium CaO.	Magnesia. MgO.	Potash. K_2O.	Soda. Na_2O.	Sulphuric Acid. SO_3.	Carbonic Anhydride. CO_2.	Chlorine. Cl.	Phosphoric Acid. P_2O_5.	Total.
Leaves and Stems No. 1	10.75	2.25	4.13	7.46	7.86	6.43	20.95	10.04	14.98	13.52	6.60	5.49	99.71
Roots No. 1	8.54	3.89	42.80	16.97	7.13	1.43	8.03	6.87	1.73	6.72	1.96	2.53	100.06
Whole Plant No. 2	12.15	4.13	32.77	16.23	6.05	3.11	13.30	3.21	3.90	10.55	.47	6.12	99.87
Fruit of No. 3	10.44	1.52	33.46	11.32	3.00	2.34	20.14	4.31	4.18	7.79	3.73	7.47	99.66
Plants and Fruit of No. 3	12.36	4.00	7.82	5.97	12.10	3.55	23.35	3.38	5.56	20.62	9.00	4.67	100.02
Whole Plant No. 4	13.52	2.22	17.08	12.21	14.27	2.62	17.26	5.75	3.22	17.87	3.87	3.30	99.66
Whole Plant No. 5	14.61	1.44	56.81	16.90	5.70	1.89	5.55	3.30	1.06	4.61	.60	1.98	99.84
Whole Plant No. 6	8.68	2.50	5.20	5.08	12.50	5.64	26.33	3.94	6.00	20.53	7.07	5.11	99.85
Larkspur	13.23	3.40	9.00	8.87	16.72	3.14	20.05	4.15	2.25	27.57	7.82	4.00	99.97

Last year the following specimens were analyzed: No. 1, *Astragalus Mexicanus*; No. 2, *Astragalus Mollissimus*; No. 3, *Astragalus Caryocarpus*; No. 4, *Oxytropis Lamberti*; No. 5, *Oxytropis Monticola*; No. 6, *Astragalus Drummondii*; No. 7, *Larkspur*.

	Moisture.	Ether Extract.	Absolute Alcohol Extract.	Chloroform Extract.	Albuminoid Nitrogen.	Ash.	Nitrogen free extract.	Crude Fiber.	When Collected 1890.	Part Examined.	Stage of Ripening
No. 1	8.90	5.12	8.30	.93	11.43	10.75	40.60	22.87	May 24	Leaves and Stems	Bloom.
No. 1	8.10	1.74	5.46	1.69	6.60	8.54	33.57	42.40	" 24	Roots No. 1	"
No. 2	8.97	4.77	14.38	.96	12.86	12.15	35.56	19.32	" 27	Whole Plant No. 2	"
No. 3	13.52	4.36	15.16	.71	10.91	10.44	40.62	17.80	June 10	Fruit of No. 3	Fruit
No. 3	7.36	4.74	12.12	.75	12.68	12.36	39.50	17.85	" 10	Plants and fruit No. 3	"
No. 4	7.27	3.43	5.85	1.32	7.02	13.52	33.26	35.60	" 14	Whole of No. 4	"
No. 5	6.74	3.32	6.65	1.30	6.50	14.61	37.14	30.48	" 18	Whole of No. 5	Bloom
No. 6	8.55	3.88	10.38	.43	9.95	8.68	36.02	30.66	" 23	Whole of No. 6	Fruit
No. 7	10.26	5.12	3.41	1.12	6.75	13.23	47.59	22.78	" 24	Larkspur.	Bloom

It is quite common to find the loco, that was abundant in a certain locality one year, the next year to be nearly all gone. This is no doubt due to the ravages of insect parasites We examined the root and found a larvæ or grub of *Tineidæ*. Prof. Riley's letter shows the leaves may contain a weevil, *Bruchus*, and we have seen a great many snout-beetles, curculionid, on the plants. Coulter's manual of The Rocky Mountain Region gives under *Astragalus* 64 kinds, and under *Oxytropis* 11 kinds, making 75 kinds of the so called loco weeds. The figures of the loco weeds were drawn from nature by Miss Minnie Harrington, a student of the College. During the past year my assissant, Mr. Ryan, helped me in the chemical examination of the plants, and in confirming the tests of former years.

CONCLUSION.

In conclusion we would say we have been unable to find any alkaloid in the plants examined, though we get alkaloidal reactions from the loco and the alfalfa.

We have not been able to produce any physiological action upon rabbits with the extract from the loco in any of its forms. In the case of the sheep in the southern part of the state, said to have been locoed, it has long been known that the disease was caused by parasites in the liver.

The post mortems made showed such a variety of diseased conditions that in our judgment they could hardly be due to one or the same cause.

It has always been noticed that when the feed on the range is good, locoed animals are scarce. The range about Fort Collins contains the loco in large quantities, but I have never seen a locoed animal except upon the mountain range or foothills.

In our experience the animals affected, and the subjects for post mortems, were in every case young animals, mostly under four years old, the great majority yearlings and two year olds,

I have long been persuaded that the person who investigates the subject of loco should spend considerable of his time on the range and notice very carefully the habits of the animals, the food they eat, and the water they drink. The subject has not been investigated to the extent that its importance demands.

It is never wise to draw hasty conclusions from imperfect data, or from a few post mortems. Judgment had better be withheld until the subject is more thoroughly investigated.

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The State Agricultural College.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN No. 26.

I. Farm Notes for 1893.

HOME STATION, Fort Collins, Colorado.

II. Garden Notes for 1893.

HOME STATION, Fort Collins, Colorado.

III. Seeding, Tillage, and Irrigation.

ARKANSAS VALLEY STATION, Rocky Ford, Colorado.

Approved by the Station Council.

ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

FEBRUARY, 1894.

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Fort Collins, Colorado.

The Agricultural Experiment Station,

FORT COLLINS, COLORADO.

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Farm Notes for 1893.

(Home Station, Fort Collins, Colorado.)

By W. W. Cooke and F. L. Watrous.

SANDWICK---A Promising Fodder Crop.

For several years this crop has been grown at various experiment stations in the United States under the name of the Hairy Vetch (*Vicia villosus*). Sandwick is its German name. In Germany it has long been grown as an important forage crop. It belongs to the pea family, but the leaves are smaller and narrower and the stem not so long but with many branches. Several stems grow from the same root.

The sandwick was grown at this Station in 1893. It was sown in drills, a double row in each 39 inches. About 30 pounds of seed per acre were used. The seed was sown June 10th. The plants were cultivated three times and received one irrigation in July. The growth was not rapid, but in spite of an exceedingly dry summer and fall the plants kept green and continued their growth. The plant has shown itself, in Nebraska, able to withstand the winter, and it bids fair to do the same here, since it is still green at this writing (the last of December) and sending out new growth, although it has been twice covered with snow. The ground was frozen for two weeks in November.

The amount of the crop is enormous. Its green weight at the present time averages 13,400 pounds per acre, and as it has 43 per cent. of dry matter, this growth is equivalent to 3⅛ tons of well-dried hay. This is a much heavier growth than that reported from any of the six States where it has been previously grown and shows that it is particularly adapted to Colorado soil and climate.

It is well relished by cattle and horses. The analysis given below shows that it is rich in the albuminoids or flesh producing elements and, hence, well adapted for the production of milk or for fattening cattle. When sown by itself thinly, it spreads close to the ground, so low that it cannot be cut with a machine or a scythe. Its special use is as fall, winter, and spring pasture, and as such it bids fair to find a large usefulness in this State.

In Germany it is sown with grain, and after the wheat is harvested it covers the stubble with the finest of feed. In this State, where winter wheat or rye is sown, it should do well, as it does not winter-kill and seems to be able to grow with very little water. It also belongs to the class of plants that can draw from the air part of the nitrogen they need and store some of it up in their roots for the use of a crop of wheat. When sown in the spring with oats, sandwick makes an upright growth and can be cut and cured for hay. The oats and the sandwick together make a well-balanced feed for a milch cow.

Seed of the sandwick will be distributed next spring to many parts of the State for trial.

ANALYSIS OF HAY OF SANDWICK.

Water	10.00	per cent.
Ash	8.31	" "
Crude fibre	23.05	" "
Fat (Ether extract)	3.96	" "
Albuminoids	15.25	" "
Starch, sugar, etc.,	39.43	" "

This analysis would indicate that sandwick is about a fifth more nutritious than an equal amount of alfalfa hay and also better proportioned, being almost a perfectly-balanced food for a milch cow.

CORN VERSUS ALFALFA.

Throughout the northern half of the Mississippi Valley corn is the great crop. It produces more feeding material per acre than anything else that can be grown. In Colorado it meets a worthy rival in alfalfa. Both these crops were grown side by side in acre plots on the Station farm in 1893. The land was in good condition and in addition a very heavy application of stable manure was given to the corn ground, so as to show it at its best. Colorado is not so well adapted to corn culture as are Kansas and Nebraska, owing to the cool nights that result from its high altitude and the near presence of the mountains. But the crop of corn to be described would compare well with crops of the Eastern and Middle States, being equivalent to one of their crops of 14 tons of green fodder per acre. It is also fully up to the average of the great corn States of Kansas, Nebraska, and Iowa.

The variety was the Golden Beauty, planted May 16th in hills three feet apart each way, harrowed two times, cultivated four times, and irrigated once. It was harvested September 21st and the entire crop, ears and stalks, weighed 15,500 pounds per acre. The analysis showed 35.62 per cent. of dry matter, so that the crop contained 5,539 pounds of dry matter per acre.

The alfalfa growing on a neighboring plot was not fertilized and was three years from seeding. It was irrigated twice and cut three times, yielding at the first cutting 4,600 pounds of hay per acre, at the second 3,350 pounds, and at the third 3,250 pounds, a total of 5.6 tons of hay, containing 10,304 pounds of dry matter per acre.

The alfalfa therefore yielded almost twice as much dry matter per acre as the corn. But this is not quite a fair comparison, for a pound of dry matter from the corn crop is more digestible and has a higher feeding value than an equal amount from the alfalfa. The corn crop contained **3,605** pounds of digestible feeding material, while the crop of alfalfa contained **5,611** pounds, or a little more than half as much again. The corn crop per acre in feeding value was equivalent to three and a half tons of alfalfa hay.

There is no doubt but that it costs much more to grow and harvest the corn than the alfalfa. Moreover, while the corn crop rapidly exhausts the soil, the alfalfa sends its roots deep into the soil, and gathers stores of plant food from the air, so that it seems, for the present at least, to benefit rather than deplete the land.

It is evident that in the irrigated portions of Colorado, alfalfa is a more profitable crop than corn.

YIELD PER ACRE OF CORN AND ALFALFA.

	TOTAL.		DIGESTIBLE.	
	Corn. lbs.	Alfalfa. lbs.	Corn. lbs.	Alfalfa. lbs.
Dry Matter	5,539	10,304	3,605	5,611
Albuminoids	405	1,602	296	1,198
Starch, sugar, etc	3,263	4,782	2,186	3,114
Fibre	1,472	2,800	1,060	1,198
Fat	84	246	63	101
Ash	315	829	.....	.....

GRAINS.

WHEAT.

Plot.	VARIETY.	Date of Planting.	Date of Harvest.	Yield per Acre in Bushels.
A 14–21	Polish	April 27	August 8	13.5
A 34–41	Improved Fife	April 27	August 8	16.4
B 1	Gypsum	April 28	August 8	20.0
B 2	Ontario	April 28	August 8	20.0
B 3	Egyptian Flint	April 28	August 8	2.5
B 4	Mica	April 28	August 8	failed
B 5	Dominion	April 28	August 8	15.0
B 6	Algerian, No. 2	April 28	August 8	13.3
B 7	China Spring	April 28	August 8	17.5
B 8	Feldspar	April 28	August 8	13.3
B 9	Canadian Club	April 28	August 8	16.7
B 10	Golden Drop	April 28	August 8	13.3
B 11	Prussian	April 28	August 8	20.0
B 12	Uxbridge	April 28	August 8	20.0
B 13	Chili	April 28	August 8	25.0
B 14	Nox No. 5	April 28	August 8	20.0
B 15	Eldorado	April 28	August 8	13.3
B 16	Defiance	April 28	August 8	27.5
B 17	Royal 346	April 28	August 8	13.3
B 18	India No. 1	May 2	August 9	40.0
B 19	India No. 3	May 2	August 9	8.8
B 20	India No. 4	May 2	August 9	13.3
B 21	India No. 6	May 2	August 9	10.0
B 22	India No. 9	May 2	August 9	15.0
B 23	India No. 12	May 2	August 10	5.0
D 2	Australian Club	May 2	August 8	24.5
D 3	Clawson	Oct. 7, 1892	July 29	33.2

OATS.

B 24	American Beauty	May 2	August 10	13.3
B 25	Chinese Hulless	May 2	August 10	17.5
B 26	Fox Excelsior	May 2	August 10	20.0
B 27	Swiss Black	May 2	August 10	40.0
B 28	Golden Giant	May 2	August 10	22.5
B 31	Colorado Excelsior	May 2	August 14	12.5
B 32	New Zealand	May 2	August 14	40.0
B 33	Canadian	May 2	August 14	30.0
A 22–31	Excelsior	April 27	August 8	24.0
G 1	Fox Excelsior	May 10	August 8	26.0
G 2	Silesian	May 10	August 8	37.0
G 3	Black Tartarian	May 10	August 8	20.0
G 4	Colorado Excelsior	May 10	August 8	25.0
G 5	Excelsior	May 10	August 8	15.0
G 6	Excelsior	May 10	August 8	15.5

BARLEY.

A I	Guy Malye	May 15	August 8	24.0
G 7	Success	May 11	August 8	21.0

All grains were irrigated twice, once in June and once in July.

SUGAR BEETS.

Plot.	VARIETY.	Date of Planting.	Date of Harvest.	Yield per Acre. lbs.	Sugar. Per Cent.	Purity Co-efficient.	Sugar per Acre. lbs.
A 7	Dippe's Klein Wanzelbener	May 16	Sept. 10	12,440	12.70	81.1	1,579
A 8	Original Klein Wanzelbener	May 16	Sept. 10	11,390	9.30	60.8	1,059
A 9	Elvoir	May 16	Sept. 10	15,680	9.85	70.6	1,544
A 10	Desprez	May 16	Sept. 11	9,725	9.04	72.3	879
A 11	Vilmorin, Improved........	May 16	Sept. 11	15,280	10.40	64.6	1,589
A 12	Knauer's Imperial	May 16	Sept. 11	14,680	10.01	59.4	1,468
A 13	Gov't, Klein Wanzelbener..	May 16	Sept. 11	12,690	13.05	60.0	1,650
G 1	Desprez	May 22	Sept. 12	24,186	10.12	63.2	2,443
G 2	Klein Wanzelbener	May 22	Sept. 12	27,188	12.97	76.3	3,534
G 3	Original Klein Wanzelbener	May 22	Sept. 13	26,988	13.06	68.7	3,510
G 4	Elvoir........................	May 22	Sept. 13	19,632	9.02	61.3	1,771
G 5	Vilmorin, richest...........	May 22	Sept. 14	18,018	10.90	72.7	1,964
G 6	Klein Wanzelbener...	May 26	Sept. 14	37,660	9.70	56.6	3,653
G 7	Klein Wanzelbener..........	May 26	Sept. 14	33,390	9.03	56.4	3,015
G 8	Desprez	May 26	Sept. 14	38,430	9.25	60.5	3,555
G 9	Elvoir	May 26	Sept. 14	33,644	4.88	44.4	1,642

All the sugar beets were cultivated four times, and all but the last four varieties were irrigated twice. These four kinds were put on ground that was moist enough without irrigation, and it will be noted that they made the largest growth of all. But the abundance of water exerted the usual effect of decreasing the per cent. of sugar.

MISCELLANEOUS FODDER CROPS.

During the season of 1893 quite a large number of crops were tested as to their value for forage under the conditions of Colorado soil and climate.

Both German and Golden millet were raised, but in both cases the amount grown was small. Four varieties of Soy Beans were sown May 23rd. The growth was slow, though they were the hardiest varieties of this plant. None of the seeds ripened and but few pods formed. The crop was far too small to be profitable. The same remarks would apply to the crops of Mexican beans and of lentils.

An extensive trial of sorghums was made, principally of the saccharine varieties, fifty-two kinds being tested. Although the frost held off longer than usual, yet when the first freeze came, September 23rd, only one kind—Haori—had matured seed. The amount of forage from the largest kinds was not equal to an average crop of corn.

Several varieties of non-saccharine sorghums had reached the following stages of growth when they were killed by the frost September 23rd:

Red Millo Maize—Seeds partly mature.
White Millo Maize—Seed heads beginning to show.
Red Kaffir Corn—No seed.
Egyptian Rice Corn—Grain not filled.

White Kaffir Corn—No seed salk.
African Millo Maize—No seed stalk.
Brown Dhoura—Not quite ripe.
Jerusalem Corn—Fairly well matured.

These crops had all been cultivated and irrigated and had had the advantage of a late fall, and yet the growth was not nearly up to an average corn crop. It was not one-third of what would be considered a fair crop for these fodder plants in Nebraska.

The reason for the failure of all these fodder crops is the same, *i. e.*, the cool nights of summer. They are all hot-weather plants, and there is not much use in Colorado farmers trying to raise them in high altitudes near the mountains.

THE LEAVES AND STEMS OF ALFALFA HAY.

The leaves of alfalfa hay fall off very readily from the stems. A little pounding was sufficient to separate a quantity of the hay into two equal parts, one of which was mostly leaves with a few short stems, and the other mostly stems. Samples of each gave analysis as follows for the dry matter:

	Leaves.	*Stems.*
Ash	12.36	7.05
Crude fire	25.68	42.47
Fat (Ether extract)	3.46	2.95
Albuminoids	13.12	8.61
Starch, sugar, etc.,	45.38	38.92

DIGESTIBLE PORTIONS OF DRY MATTER.

	Leaves.	*Stems.*
Crude fibre	11.04	18.36
Fat (Ether extract)	1.38	1.15
Albuminoids	9.84	6.46
Starch, sugar, etc.,	29.49	25.30
Total digestible material in 100 lbs of dry matter	51.75	51.27
Nutritive ratio	1 : 4.5	1 : 7.2

It will be seen that the two are about equally digestible. But they are quite different in the proportions of their digestible parts. The stems are properly proportioned for horses at moderate work, while the leaves are well adapted to the needs of growing calves and yearlings.

CURING CORN FODDER.

It has been generally assumed that in the dry climate of Colorado all forage crops would cure rapidly, perfectly, and with little or no loss of feeding value. Experiments during several years at the Vermont Station have shown that, in that damp climate, with frequent fall rains, it is possible to cut corn while still green, set it up in large shocks, and have it dry out and cure with a loss of from 18 to 25 per cent. of its entire feeding value.

A similar test was made during the fall of 1893 at this Station. A lot of corn was cut up September 23rd, and, without pulling off the ears, was set up in a shock. Samples were taken for analysis at the time of shocking, and three months later the whole shock was cut up into quarter inch pieces and again weighed and samples taken.

The weights and analyses showed that the corn had lost 62.50 per cent. of its weight and, what was most important, had lost 34 per cent. of its dry matter, and therefore of its feeding value. There was no sign of heating or mouldiness; the leaves were still bright green; but there was a decided smell of fermentation that reminded one strongly of ensilage.

This of course is but one trial, and the first that has been made in the State. Further tests will be made to ascertain more fully what the losses are from drying corn fodder in this climate.

Credit should be given to the Chemical Section of the Station for all the analyses mentioned in this bulletin.

THE GROUNDS AND B

Garden Notes for 1893.

(Home Station, Fort Collins, Colorado.)

By Chas. S. Crandall and M. J. Huffington.

TOMATOES.

Sowing the Seed.—Seed should be sown in forcing-house or hot-beds by the first of March ; the last week in February would, doubtless, not be any too early. As we generally have a cutting frost in this locality from the 10th to the 15th of September, every effort should be made to force the plants as much as possible, so that the bulk of the crop will be off before that time. For the south where the season is longer, we would still recommend giving the plants an early start. To realize the best results we should have strong, stocky plants, and to accomplish this strict attention should be given to regulating the heating, airing, and watering. All the conditions should be as uniform as possible; an even temperature should be aimed at and water should be applied at regular intervals, the forenoon being the best time. The water used should not be too cold; the sudden chill resulting from the application of ice-cold water is very injurious to the plants. On bright, pleasant days the plants should have plenty of air and as the season advances the exposure should be increased, so that when the plants are transferred to the open ground the change will not be felt by them. Care should be taken at all times that the plants do not get chilled from a sudden fall in temperature; the check in growth resulting from any such sudden change affects the plants for some time and greatly retards their development.

Transplanting once or twice before being taken from the beds to open ground is conducive to a more stocky growth and a better root system. The time for removing plants to open ground must be governed by experience in particular localities. In this latitude plants for extra early fruit may be set between the 15th and 25th of May. Do not plant the entire crop so early that a late frost might kill the plants; it is a good plan to hold some plants in reserve for replacing those that may receive injury from frost.

Soil.—Where earliness is aimed at the best soil for the tomato is a light, sandy loam; the ground should not be too rich, or an over luxuriant growth of plant will be the result to the detriment of earliness. A shovel full of well-rotted barn-yard manure thoroughly incorporated with the soil where the plants are to be set will increase their productiveness and hasten maturity. There seems to be an advantage in not manuring the whole surface when earliness is desired. If only a space of 10 or 12 inches is fertilized around the plant, this will be sufficient to stimulate plant growth until the fruit begins to ripen, after which we do not wish the plant to increase in size but bend all its energies toward ripening its fruit. Should the ground be manured broadcast the growth will continue much longer.

Varieties Grown in 1893.—Seed of 15 varieties was sown on March 14th in flats in the forcing-house. The young plants made their appearance in from 9 to 11 days from time of seeding. When three or four inches high they were transplanted to 4-inch pots, in which they were allowed to grow until set in the open ground. On June 6th, 12 plants of each variety, excepting Royal Red, of which there were 24, were set in the garden in rows 4x5 feet. Clean culture was given throughout the season. Water was applied four different times as follows: June 15th, July 3rd and 17th, and August 8th. Cultivation should cease and water should be withheld after fruit begins to ripen, as further stirring of the soil and the application of water would induce plant growth and thus retard the maturity of fruit.

VARIETIES.

Aristocrat.—A dwarf variety, more erect than the Dwarf Champion, a strong, stocky grower, early—the first fruits being picked August 15th. It possesses the advantage of ripening its fruit rapidly, a desirable feature in a market variety. Fruit medium size, smooth and solid, of a beautiful scarlet color. It greatly exceeds Dwarf Champion in productiveness, but falls considerably below some other varieties, such as Puritan, Ignotum, and Table Queen.

Buckeye State.—Plant vigorous in growth, fruit large, fairly smooth, in color resembling the Mikado or Turner Hybrid. The variety, however, can not be recommended because the fruit ripens slowly and is not solid.

Gold Ball.—A rank-growing variety, very productive for a tomato of its class; fruit small, oval, smooth, a beautiful golden yellow, firm, and solid; fine for preserving or pickling. Its size, shape, and color are against it as a market variety.

Ignotum.—Originated at the Michigan Agricultural College in 1887, introduced in 1889. A strong, healthy grower possessing many points of excellence; fruit ripens medium early, is large, regular in shape, solid and remarkably smooth, of a bright scarlet color. For slicing and canning it would be difficult to find its superior.

Large Rose Peach.—Plant a remarkably strong grower, very productive, fruit early, nearly round, rose-peach color, very soft, containing many seeds. This is one of the novelties, but has no qualities that would recommend it as a variety for general culture.

Matchless.—This is a variety of the Ignotum type, possesses vigor of growth, but falls far below Puritan, Potato-leaf, and Ignotum in productiveness. It ripens medium early, is fairly large, very smooth, and has an attractive scarlet color.

Peach.—The fruit of this variety possesses the same general characters as that of the New Rose Peach, except that it is much smaller. The habit of growth of the plant is, however, quite different, being much more compact. It deserves no place in a collection of varieties, except as a curiosity.

Ponderosa.—A variety introduced in 1892 by Peter Henderson & Co. Plants seem to lack vigor, and the variety appears to be not well fixed; out of 12 plants there were four distinct types. Fruits nearest the introducer's described type were very large, many single specimens weighing over one pound, quite smooth for so large a fruit, a little ridged about the stem, solid, slow in ripening, color as in Mikado. When by further selection the apparent good qualities of this variety become fixed so that their reproduction is assured, it will be valuable.

Potato-leaf.—This is a distinct variety originated by Livingston & Sons, and introduced by them in 1887. The foliage resembles that of the potato, as the name implies. Plant a strong grower, ripens its fruit rapidly, and is very productive; the fruits are medium large, very smooth and solid, color the same as in Mikado. This is a fine tomato for canning and also a good market sort.

Puritan.—A variety of New England origin, introduced by Rawson of Boston. The plants are strong and stocky. This was the first variety to ripen fruit; fruit large, solid, sometimes slightly furrowed about the stem, ripens very evenly, color a deep scarlet. The Puritan was the most productive desirable variety under test, and is one that will give entire satisfaction.

Royal Red.—Seed from Livingston & Sons, originators. Plant a remarkably vigorous grower, not as early as some; fruit large, solid, smooth, occasionally slightly furrowed about the stem; color a beautiful cardinal-red. A desirable variety.

Table Queen.—Seed from Peter Henderson & Co., introducers. A good grower, medium early, productive; fruit large, solid, generally smooth, sometimes slightly ridged, color as in Mikado. A variety that will give general satisfaction.

Trucker's Favorite.—A vigorous variety, productive, ripening fruits as early as Ignotum and Table Queen, but at succeeding pickings falling below those varieties in quantity of fruit ripened; showing a tardiness in the matter of ripening, which makes the variety undesirable, at least for this locality. The fruit is large, very smooth, dark pinkish-purple in color.

Shah.—Seed from Peter Henderson & Co., introducers. The foliage of this variety is of the Potato-leaf type. The plants were vigorous, and the most productive in our test; fruit begins to ripen early, is of large size, golden yellow, firm and solid; as the season advances the fruit becomes more and more irregular in shape, the late pickings yielding only very ill-formed and undesirable fruits. Its color and poor shape would exclude it from the list of market varieties.

Dwarf Champion.—Seed from Peter Henderson & Co. This variety did very poorly this season; it was the least productive of those under test. Fruit ripened early, was small, below the usual size, smooth and solid; color as in Mikado. As a dwarf variety Aristocrat is far preferable to Dwarf Champion, producing as much again fruit.

The following table shows the comparative earliness of varieties, number of fruits picked, weight of same, and approximate yield per acre in pounds of ripe fruit, and also the yield of green fruit. The figures in the columns showing yield per acre being derived from so small an area, can be regarded as only approximate.

VARIETIES.	No. of Plants.	First Ripe Fruits.	Last Picking.	No. of Ripe Fruits Picked.	Weight in lbs.	Average Weight per Plant.	Weight of Three Specimens.	Yield per Acre in lbs.	No. of Green Fruits picked Sept. 23rd.	Total Weight of Green Fruits in lbs.	Average Weight of Green Fruits per Plant in lbs.	Yield of Green Fruits per Acre in lbs.
Aristocrat	12	Aug. 15	Sept. 23	216	46.96	3.91	1.1	8,515	262	45.96	3.83	8,341
Buckeye State	9	Aug. 22	Sept. 23	102	30.91	3.43	1.7	7,470	345	71.73	7.97	17,358
Gold Ball	12	Aug. 14	Sept. 23	581	50.24	4.18	.4	9,104	846	59.40	4.95	10,781
Ignotum	11	Aug. 23	Sept. 23	183	52.89	4.80	1.5	10,454	280	74.47	6.77	14,745
Large Rose Peach	11	Aug. 17	Sept. 23	229	44.81	4.07	1.0	8,864	853	121.20	11.01	23,979
Matchless	11	Aug. 22	Sept. 23	106	27.54	2.50	1.3	5,445	266	64.13	5.83	12,697
New Dwarf Champion	9	Aug. 11	Sept. 23	109	18.50	2.05	.6	4,464	126	19.98	2.22	4,835
Peach	12	Aug. 17	Sept. 23	313	28.12	2.34	.7	5,096	1,277	81.36	6.78	14,766
Ponderosa	11	Sept. 2	Sept. 23	91	37.54	3.41	5.2	7,426	293	74.58	6.78	14,766
Potato-Leaf	11	Aug. 17	Sept. 23	320	78.60	7.14	1.4	15,550	375	85.91	7.81	17,010
Puritan	12	Aug. 7	Sept. 23	257	87.08	7.25	1.7	15,790	406	118.30	9.85	21,453
Royal Red	23	Aug. 23	Sept. 23	328	112.08	4.87	1.7	10,606	957	118.25	10.28	22,389
Table Queen	12	Aug. 23	Sept. 23	220	75.46	6.28	2.1	13,677	443	131.10	10.92	23,773
The Shah	12	Aug. 16	Sept. 23	353	109.76	9.14	2.2	19,906	284	78.90	6.57	14,303
Trucker's Favorite	12	Aug. 23	Sept. 23	156	41.77	3.48	1.8	7,579	461	117.20	9.76	21.237

BEANS.

Bush or Snap Beans.—As the bean plant is very tender and easily injured by low temperatures, the seed should not be planted until all danger of the young plants being nipped by late spring frosts is over. It is a good rule to make the first planting about the ume time that corn is planted, which for this latitude is about the 5th of May. By making a succession of sowings at intervals of bout two weeks, their season may be prolonged until frost. The ean plant succeeds in a great variety of soils, and will produce a air crop on land that is only moderately enriched; yet it readily esponds to good treatment, and as is the case with most crops is nore productive and profitable when grown on ground that is in a iigh state of cultivation.

While only five varieties of beans were tested at this Station the ast season, yet the results, so far as these varieties are concerned, vere very satisfactory. No damage was done by the bean weevil or ny other insect pest. The main points brought out were those of omparative earliness and productiveness. In the matter of earliness here was but little difference in the time of edible maturity, the first icking of each variety being made on the same date, but as will be een from the following table there is a wide difference in the quantity of marketable beans gathered from the different varieties at he first picking, a fact which it seems should decide the earliest variety, or at least the earliest productive one.

On May 16th, four rows, 93 feet long and 15 inches apart, were planted of Cylinder Black Wax, Golden Wax, Henderson's Earliest Red Valentine, Round Six Weeks, and Yosemite Mammoth Wax. Clean culture was given throughout the growing season with the hand cultivator; water was applied three times on the following dates —June 16th and July 3rd and 19th. The first beans of marketable size were picked on July 18th, nine weeks from time of planting.

Cylinder Black Wax.—A wax sort as the name indicates; pod round, somewhat curved, light yellow, 4½ to 5½ inches long, seed black; a good variety.

Golden Wax.—Pod flat, beautiful golden yellow, 5 to 6 inches long; this variety is more extensively grown for market than any other, being productive, of fine appearance, and a good shipper; the very best of the wax sorts; seeds white, variously marked with purple.

Henderson's Earliest Red Valentine.—Pod round, light green, 4½ to 5½ inches long; a popular variety of the green-podded sorts, and largely grown for pickling; seeds mottled in various shades of red.

Round Six Weeks.—The earliest and most productive variety under test; pods flat, 5 to 6 inches long, of a light green color, an excellent variety; seeds uniformly of a dull yellowish-white color.

Yosemite Mammoth Wax.—Pods round, very much curved, 7 to 8 inches long, light yellow; this is a mammoth variety, but it can not be recommended as it is not productive, and ripens very slowly; seed black.

Bush Lima Beans.—With the introduction of the Bush Lima a great event is marked in the history of this popular vegetable; now its cultivation is easy and simple, requiring no hills or stakes as with the pole Limas, and they are from a week to ten days earlier. They require a richer soil and more attention than the snap sorts, but well repay the grower for his trouble; as they are more tender than the bush varieties they should be planted a week later; they do best in a warm loamy soil that is highly manured; the plants being somewhat larger more room should be given them than is required by the snap sorts.

Burpee's Bush Lima.—This is indeed a valuable acquisition, possessing, as it does, extreme earliness, productiveness, and large size, and having that bushy habit of growth it requires no poles or stakes whatever for it to run upon; the plant grows from 15 to 24 inches high, branching freely, forming a bush 12 to 18 inches in diameter. The pods are long, producing three or four mammoth beans to each; they are tender and of fine flavor. Seed planted May 16th produced marketable beans (in the green state) August 16th, three months from the time of planting. One hundred pods green beans weighed 2.7 pounds; these shelled gave 1.1 pounds of beans.

Henderson's Bush Lima.—This is a vigorous and productive variety, though not so rank a grower as Burpee's Bush Lima; the leaves are of a much darker green. The beans are much smaller, and four days later in maturing. One hundred pods, green, weighed 1.2 pounds; these shelled gave .5 pounds of beans.

Willow-leaf.—This novelty was brought before the public in 1891 by W. A. Burpee & Co. It is a distinct variety; the divisions of the leaves are long and narrow, resembling the leaves of the willow, whence the name. It is really worthy of growing as an ornamental climbing vine, the rich dark green leaves making a very pretty effect, with the great profusion of bloom that continues throughout the season; aside from its use as an ornamental vine it is very productive, though not so early by ten days or two weeks as the bush Limas; the pods are larger than those of Henderson's Bush Lima, the beans pure white, tender, and of fine flavor.

VARIETIES.	Date of 1st Picking.	Weight in lbs.	Date of 2nd Picking.	Weight in lbs.	Date of 3rd Picking.	Weight in lbs.	Date of 4th Picking.	Weight in lbs.	Total Weight of Green Beans Picked.	Approximate Yield per Acre in lbs.	Weight of Dry Beans Picked.	Approximate Yield per Acre.
Cylinder Black Wax ..	July 24	4.37	July 28	11.50	Aug. 2	41.60	Aug. 9	59.10	116.57	10,841	16.31	1516
Golden Wax	July 24	2.53	July 28	8.30	Aug. 2	37.40	Aug. 9	75.20	123.43	11,478	15.15	1408
Henderson's Earliest Red Valentine......	July 24	7.48	July 28	11.30	Aug. 2	32.70	Aug. 9	45.30	96.78	9,000	15.61	1451
Round Six Weeks.....	July 24	12.92	July 28	36.02	Aug. 2	55.90	Aug. 9	90.00	194.84	18,120	15.55	1446
Yosemite Mammoth Wax	July 24	.79	July 28	1.12	Aug. 2	8.00	Aug. 9	9.00	18.91	1,758	.....	....

EGG-PLANT.

This is a vegetable that is not as well known or as highly appreciated as it should be; especially is this true in the West. When properly prepared and cooked, egg-plants make a very appetizing dish, not much inferior to the world-famed fried oyster. Being natives of tropical America they at all times require a high temperature, and for that reason succeed better at the south than at the north.

For this locality seed should be sown from the first to the middle of March. When grown in hot-beds the plants should be separated from the frames containing plants of a hardier nature by a partition running across the bed; in this way more heating material can be used under the egg-plant beds and each lot of plants can be kept at the proper temperature, which would be hard to regulate were they not separated; more attention should be given to covering sash at night with mats or straw, than is required by the tomato or cabbage. Nothing is gained by transplanting too early to open ground, as the plants will not make any growth until the weather becomes warm. For this latitude, June 1st is about the proper time to set in garden. The egg-plant is a heavy feeder and the soil can not be too rich for its best development; a warm, sandy loam is where it gives the best results. Belonging to the same genus as the potato, it often happens that the potato beetle is quite troublesome; a mixture of paris green and flour—one ounce of the former to six pounds of the latter—dusted through a cheese-cloth bag over the plants while the dew is yet on, will kill the pests.

The egg-fruit is fit for use from the time it is the size of a turkey's egg until it is five or six inches in diameter, or until the seeds begin to harden, which indicates that the fruit is maturing.

March 15th, seeds of Early Long Purple, Black Pekin, and New York Improved were sown in the forcing-house; June 6th the plants were set in open ground, the same distance apart as tomatoes; they were given the same culture, and were irrigated on the same dates as the tomatoes.

Black Pekin.—One of the newer varieties of superior excellence; fruit of a glossy, almost black color, globular in form and solid; this variety is earlier than the New York Improved, and of finer flavor; average weight of ten specimens, $1\frac{1}{4}$ pounds each.

Early Long Purple.—Early and productive; fruit long, nearly the same size at both ends, of a deep purple color; this variety does not attain the size of either of the others tested. Average weight of ten specimens, $6\frac{1}{2}$ ounces each.

New York Improved.—This is a leading market variety; the plant is a stronger grower than the early long purple, the leaves and stems are thickly studded with spines, which do not appear to any great extent on the other varieties. The fruit is pear-shaped, large, purple in color. Average weight of ten specimens, 1½ pounds each.

PEPPERS.

Seeds should be sown in hot-beds or forcing-house from the first to the middle of March. As peppers are among our most tender vegetable plants, more care should be given them than is required in growing tomato plants; at all times they need a high temperature; strict attention should be given to the details of heating, airing, and watering as recommended for the tomato; every effort should be made to keep the plants in a vigorous growing condition; at no time allowing them to receive a check to their growth. Plants may be set in open ground about a week after tomatoes are planted; a warm, mellow soil that is highly improved is the best for their development. Seeds of the varieties herein described were sown in forcing-house March 15th; plants transplanted to open ground on June 6th. They received the same culture as tomatoes, water also being applied on the same days. The varieties designated as sweet, and being used in the green state, are a different type from the Cayenne, and while green are sliced and served like tomatoes with vinegar and salt. The varieties of the Bell and Bull-Nose type are also used for making mangoes; the large green peppers are cut in half, filled with chow-chow pickles, tied up, and placed in jars or cans containing vinegar, where they remain until wanted for use.

Cardinal.—A variety of recent introduction; pods from 5 to 6 inches long, tapering to a point, color bright cardinal. Sweet when used in the green state. From one plant, 31 peppers were picked which weighed 1.5 pounds; the three best specimens weighed .4 pound.

County Fair.—A variety resembling somewhat the Cardinal; pods larger, 4½ to 5½ inches long, regular in shape, obtusely pointed, of a dark red color; a very showy pepper, used in the natural state and for mangoes. From one plant, 27 pods were picked which weighed 2 pounds; the three best specimens weighed .4 pound.

Black Nubian.—A distinct variety, foliage of a black green color; pods 4½ to 5 inches long, obtusely pointed, of a glossy black color, making quite a pretty contrast with the fiery red and golden colored varieties. This pepper is mild and may be used in the natural state. From one plant, 24 pods were picked which weighed .7 pounds; the three best specimens weighed .3 pound.

Golden Dawn.—Of the Bell or Bull-Nose type, early, pods 3½ to 4 inches long, of a beautiful golden yellow color when ripe; mild, used in the green state and for mangoes. From one plant 22 pods were picked which weighed 1.6 pounds; the three best specimens weighed .4 pound.

Long Red Cayenne.—From this, a representative of *Capsicum annuum*, and also from the shrubby Capsicum, *Capsicum frutescens*, is manufactured the red or cayenne pepper of commerce. Our seed of this variety was not true to name, there being no less than five types varying from the small pyriform shape, not over an inch long, to the long pointed type 5 to 6 inches long, which is the true cayenne; the color is a bright red. From one plant 80 pods were picked which weighed 1.2 pounds; the three best specimens weighed .3 pound.

Mammoth or Sweet Mountain.—A large sweet pepper of the Bell or Bull-Nose type used in the natural state, and also grown largely for mangoes; pods 4½ to 5½ inches long, of a deep red color when ripe. From one plant 13 pods were picked which weighed 1.6 pounds; the three best specimens weighed .8 pound.

Red Cluster.—This is a distinct variety of very showy appearance, producing a profusion of pods which point upward, making a very ornamental plant when the peppers are ripe. Owing to its small size this variety is chiefly grown for pickles. From one plant 460 pods were picked which weighed 1.1 pounds.

Ruby King.—The largest variety of the Bell or Bull-Nose type; pods 5 to 5½ inches long, used in the natural state and also for mangoes. From one plant 22 pods were picked which weighed 2.5 pounds; the three best specimens weighed .9 pound.

SWEET CORN.

While our sweet corn the past season did all that we could expect in the way of making a vigorous growth and producing a large number of ears, clearly showing the comparative earliness and productiveness of the varieties under test, yet by far the greater portion of the crop was destroyed by boll or corn worms. These pests are generally supposed to be more destructive at the south than at the north, but it would be hard to imagine their being more numerous, or doing more damage to the corn crop in any other section of the country, than here during the season of 1893. By actual count from 92½ per cent. to 97 per cent. of the ears had been entered by worms. They have no less than a dozen food plants; attack corn in the growing shoot, the tassel, and the grains in all stages. They seem to prefer sweet corn to the field varieties. There are normally two broods of these worms that feed upon corn, exceptionally three; the eggs are deposited on the leaves of the corn and the newly-hatched larvæ begin feeding at once on the spot of their birth, eating many irregular holes through the leaves. The first brood usually makes its appearance early enough to feed upon the staminate flowers or tassels, before the ears are formed; this first brood did but very slight damage the past season, but the second brood was very destructive. The eggs of the second brood were laid upon the ends of the husks or on the silk, the worms attacking the ears, often cutting several grooves the whole length of the ear, thus rendering it unfit for use; they by no means confine themselves to a single ear, during their work of destruction, but go from one to another. As yet no very effective means have been discovered by which we can combat the boll worm; having so many food plants it is hard to exterminate them. For some sections of the country, plowing fields deep in December and January is recommended, as by turning up the soil at that season many of the early moths will be killed; hand-picking may be practiced where the area is small, as in family gardens, but it is a slow means of getting rid of them, and would be too expensive in large fields; building fires in the fields in early spring will attract many of the early moths, and thus destroy them.

For this latitude, from the 15th to the 20th of May is early enough to make the first planting. By making a succession of plantings of the early, medium, and late sorts, at intervals of about ten days or two weeks, it may be had in the green state until frost. Corn matures more quickly on a sandy loam, but attains a larger size when grown on clay or bottom land; the soil can not be too rich for it.

On May 15th, four varieties of sweet corn were planted in rows 3x3 feet, there being 150 hills of each kind. The ground was cultivated at frequent intervals until the corn was in bloom, after which the ground was not disturbed; water was applied on June 21st and July 8th and 22nd. The first marketable ears pulled were of the Cory Early variety on August 2nd, 77 days from time of planting.

Cory Early.—The earliest variety under test, stalks 4½ to 5 feet high; ears 7 to 8 inches long; mostly eight-rowed, kernels flat, large, creamy white; marketable maturity, August 2nd. This variety ranks second in number of ears produced. Ninety-five per cent. of the ears were injured by worms.

Early Minnesota.—The second variety to mature; stalks 5½ to 6 feet high, ears 8 to 9 inches long, 8 to 10-rowed, mostly eight, rows close; kernels large, whiter than those of Cory Early. Marketable size August 11th, ranking first in number of ears produced; 92½ per cent. of the ears injured by worms.

Crosby's Early.—Third in time of marketable maturity; stalks 6½ to 7½ feet high, ears 7 to 8 inches long, 12 to 14-rowed, rows close; kernels small to medium, roundish, white; marketable size August 16th, ranking third in number of ears produced; 95½ per cent. of ears injured by worms.

Country Gentleman.—A late variety of strong growth, stalks 8 to 10 feet high, ears 8 to 9 inches long, rows irregular, kernels medium size, roundish, white; marketable size, August 22nd. This variety produced the least number of ears; 97 per cent. of the ears injured by worms.

CABBAGE.

When grown for early use seed should be sown in forcing-house or hot-beds from the first to the middle of February. As cabbage plants, if well grown, will stand considerable frost without injury, they may be set in open ground from the 10th to the 15th of April; for the late or winter crop seed should be sown in open ground from the 15th to the 20th of May. Plants will then be ready to transplant to the field from the 25th to the last of June. The cabbage is a very heavy feeder and thrives in a deep, rich, loamy soil.

On April 12th, seeds of the ten varieties named in the accompanying table were sown in flats in the forcing-house; plants were set in garden on June 6th, in rows $2\frac{1}{2}$ feet apart, and 2 feet apart in the rows. Plants were given thorough cultivation with horse cultivator and hand hoes; water was applied on July 5th, 19th, and 31st, and on August 18th. As most of the varieties in our test were of the Flat Dutch type, and there being no very marked difference in habit of growth or form of head of the different kinds, a description of each is not necessary. The two varieties in which there was a readily distinguishable difference from the Flat Dutch type may be mentioned: Burpee's World Beater and Perfection Drumhead Savoy.

Burpee's World Beater.—A late variety, of very large size, producing the largest heads of any under test; spreading in habit of growth; leaves of a dark green color, heads round and solid; this is apparently a good late variety, and will prove a good keeper, as it was the latest to mature, and showed no signs of bursting.

Perfection Drumhead Savoy.—This variety is different in type from any others tested; the stems are short, leaves dark green and very much wrinkled; heads small, round, not so solid as those of the other types owing to the peculiar wrinkling of the leaves. The Savoy class deserves more attention than it receives. They are more tender and of finer flavor than the common cabbage.

The following table shows the number of plants set of each variety; the number of heads of marketable size on August 25th, and also September 20th; the number of marketable heads pulled October 18th; average weight of same, and per cent. of plants set producing salable heads:

VARIETIES.	No. of Plants Set.	No. Heads Marketable Size Aug. 25.	No. Heads Marketable Size Sept. 20.	When Pulled.	No. Marketable Heads.	Average Weight of Heads.	Per Cent. of Plants Set Producing Salable Heads.
Brill's Excelsior Flat Dutch	40	4	19	Oct. 18	34	8.2	85
Burpee's All-Head Early	60	15	50	Oct. 18	57	7.9	95
Burpee's Safe Crop	32	2	18	Oct. 18	28	8.6	87
Burpee's World Beater	18	0	4	Oct. 18	16	10.3	88
Early Flat Dutch	30	4	18	Oct. 18	26	8.0	86
Fottler's Brunswick	34	3	10	Oct. 18	29	8.2	85
Louisville Extra Drumhead	50	5	30	Oct. 18	45	8.6	90
None Such	30	4	18	Oct. 18	25	7.8	83
Premium Flat Dutch	40	4	15	Oct. 18	36	8.5	90
Perfection Drumhead Savoy	30	0	0	Oct. 18	22	3.2	73

CAULIFLOWER.

Sow seed at the time given for sowing cabbage seed. The cauliflower is somewhat more tender than the cabbage, and the plants require more attention in severe weather, in the way of covering sash at night, than do cabbage plants. The kind of soil recommended for the cabbage is equally well suited to the cauliflower. Seed of the five varieties herein described was sown in forcing-house on March 25th, and the plants were transplanted to the garden on June 6th. They were cultivated the same as cabbage and were irrigated on the same dates.

Early Snowball.—The first variety to produce marketable heads, and one of the best sorts tested; dwarf in habit of growth, with short outer leaves; heads large, solid and snowy white; weight of an average specimen, 4 lbs., 4 oz.

Extra Early Dwarf Erfurt.—This was the second variety to attain marketable size; the stalks are short, plant a close compact grower, heads medium size, close and solid; weight of an average specimen, 3 lbs., 3 oz.

Long Island Beauty.—A medium early variety, maturing five or six days later than Early Erfurt; plants are taller than those of the varieties above mentioned; heads large, close, and solid; color not so good as in Early Snowball; weight of an average specimen, 4 lbs.

World-beater.—This is a medium late variety; stems and leaves long, heads of large size though not so solid, or of that snowy white color, as Early Snowball; weight of an average specimen, 4 lbs., 6 oz.

Narrow-leaved Erfurt.—This is a late variety with long narrow leaves; plant a taller grower than Early Erfurt; heads resemble those of that variety, though not so large; weight of an average specimen, 3 lbs.

ONIONS.

Seed should be sown as early in spring as the ground can be worked well, which for this latitude is about the 20th of March. When sown early there is a much better chance of getting a good stand, as at that season the ground is generally quite moist.

On March 28th, seeds of 21 varieties were sown in the garden in rows 18 inches apart. Owing to the very dry spring, and the prevailing high winds during the latter part of March and the month of April, which blew out many of the seeds and young plants, a very poor stand was obtained; with many varieties there was not over 20 per cent. to 40 per cent. of an average stand. As the test was not a satisfactory one, a table showing the productiveness of the different varieties is not necessary; but from the experiment the following points were observed:

1st. The varieties producing the greatest weight of marketable onions were: Giant White Garganus, Prize Taker, Large Red Italian Tripoli, Extra Early Flat Red, White Bermuda, and Yellow Globe Danvers in the order named.

2nd. The varieties ripening first were: Extra Early Flat Red, Queen, Neapolitan, White Bermuda, Large White Italian Tripoli, and Pale Red Bermuda.

3rd. More scullions were produced by the late varieties than by the early.

SUMMARY.

From the variety tests given in the foregoing we may summarize the following points:

TOMATOES.

1st. The five varieties producing the greatest weight of ripe fruit were: Shah, Puritan, Potato-leaf, Table Queen, and Royal Red in the order named.

2nd. Those yielding the most pounds of ripe and green fruit together were: Table Queen, Puritan, The Shah, Potato-leaf, and Large Rose Peach.

3rd. The varieties giving the largest yield of fruit at the first two pickings were: The Shah, Potato-leaf, Aristocrat, Table Queen, and Large Rose Peach.

4th. As the most desirable early varieties for either home use or market we would recommend: Puritan, Potato-leaf, Ignotum, Aristocrat, and Table Queen.

5th. The smoothest varieties and those best suited for canning are: Ignotum, Potato-leaf, Table Queen, and Royal Red.

BEANS.

1st. As a bean for market or home use, of the wax sorts, we would recommend Golden Wax; of the green podded sorts tested, Round Six Weeks proved the earliest and most productive.

2nd. Of the two varieties of bush Limas tested, Burpee's Bush Lima proved to be the more desirable.

EGG-PLANTS.

While New York Improved was the largest variety grown, yet for this locality we believe Black Pekin will give the best results, being earlier, and of finer flavor.

PEPPERS.

Where peppers are grown for market or home use, to be used in the natural state or for mangoes, the Ruby King variety will give the best satisfaction.

SWEET CORN.

Of the early varieties of corn, Cory Early was one week earlier than Early Minnesota, but the latter variety will give more general satisfaction, being more productive, ears larger and of finer appearance.

CABBAGE.

The varieties combining the most desirable features of any in our test were Burpee's All-Head Early, Premium Flat Dutch, and Louisville Extra Drumhead.

CAULIFLOWER.

Of the five varieties of cauliflower grown, Early Snowball gave the best results.

SEEDING, TILLAGE, AND IRRIGATION.

(Arkansas Valley Station, Rocky Ford, Colorado.)

By Fred. A. Huntley.

The profits in crop growing are, as a rule, determined upon the basis of tillage or cultivation without regard to the application of manures or other fertilizers. This is especially true in comparatively new farming sections where the supply of available fertilizers is usually very limited and skill in the management of a natural soil determines largely the extent of production. That good tillage is everywhere the highest essential in successful farming is not to be denied.

All plants have their own peculiar habits. There are certain conditions of climate, soil, and care best adapted to the production of each. When a plant is introduced into a section differing from that of its nativity, it is but natural to enquire into the conditions of culture under which it has been known to thrive. These conditions are learned and applied to a considerable degree by all, but the highest rewards are attained by the best-adapted energies. As localities differ in characteristics of soil and climate, so must the practices of methods differ to suit the requirements of plant culture.

The climate which is now under consideration is very dry and warm during the summer months and mild at other seasons, with an extreme lack of humidity in the atmosphere generally throughout the year. The average rainfall is very slight, as observations for three consecutive years show but 12.06 inches; and coming, as it does, at irregular intervals can not be depended upon materially to benefit crops. The reliable water supply comes through well-developed systems of irrigating canals. The soil of the Arkansas Valley may be described as a sandy loam, containing a small per cent. of clay. The subsoil has nearly the same characteristics as the surface covering, though it is extremely compact in texture. The natural under-drainage needs no improvement.

It is intended by this bulletin to make known the results observed in the general cultivation of farm crops at this Station and for the locality. What follows is by no means claimed to be exhaustive, since it is offered only in the line of progress towards better methods than are in general practice.

CORN CULTURE.

Corn is one of the principal farm crops in the Valley, and in no other section of Colorado are natural conditions found as favorable to its production. Experiments and observations have shown the average yield to be very much below the possibilities, and there is a general demand for better methods and more thorough tillage. The preparation of the soil before planting has, no doubt, more to do with the outcome of the crop than any other operation. It should be borne in mind that our subsoil, though sandy, has a most compact structure. Corn roots have the habit of growing downward as well as branching. They are deep and broad feeders, in consequence of which the soil must be made loose and mellow to a considerable depth to secure full development. Land for corn should be plowed to an average depth of ten inches or more for this and another very important reason. Those familiar with the conditions of irrigation know with what rapidity a compact soil loses moisture. A well-tilled, porous soil collects and retains moisture by a natural law known as capillary attraction. Compact soils have that power to only a very limited extent. A comparative test of deep and shallow plowing was illustrated here in the case of a field of Colorado White field corn. One portion of the field was plowed to an average depth of four and five inches, while an adjacent portion received double the depth of cultivation. The whole planting received uniformly the same culture, including irrigation. A comparison of the yields in measurement upon deep and shallow plowing showed a little over thirty per cent. gain on the greater depth of plowing with grain of superior quality.

Land should always be well irrigated before plowing if not sufficiently moist to leave the work in the best possible condition for after cultivation. Fall plowing, as compared with that done in the spring, has the advantage of exposing the greatest possible amount of surface to the action of prolonged weather changes, which greatly facilitate the breaking up and putting in available form the fertilizing properties of the soil for the food of plants. If done thoroughly it also aids in retaining moisture which comes from natural causes. As irrigation restores the soil to its former compactness, it should never be done upon soils freshly plowed and prepared for planting, unless required to germinate the seed. There are advantages claimed for spring plowing. It enables the farmer to control moisture in making the operations of irrigating, plowing, and planting continuous. Irrigating to germinate seed after planting should never be practiced, since much of the seed becomes ruined, and feeble growth takes place, which can seldom if ever be overcome by cultivation.

It is my opinion that an improvement in planters is desirable to meet our conditions of soil. The ordinary style of two-horse planter with wide wheels, such as is used in the soft soils of other states, does not seem to be just what is wanted here. Wheels for our use should be made with narrower tires, similar to those of press seed-drills, for making the seed-bed more firm. Since we plant corn to a greater depth than is done in moister climates, wide tires do not accomplish the desired purpose of making the soil compact over the seed.

Usually two waterings are sufficient during the growth of a crop, and often one irrigation is preferable. If soil contains sufficient moisture in the spring to start the crop to a thrifty growing condition, and growth seems not to be retarded for the want of moisture, watering can be delayed until the tassels begin to appear, at which time drouth would cause great injury to the crop. The harrow is the best cultivator for corn until it has attained an average height of at least six inches. Continuous surface cultivation saves moisture, and cross-plowing with a two-horse cultivator, work in both directions, is the least that should be done.

The mistake is often made in the use of a large head of water while irrigating, and in attempting to get it properly distributed over large areas and through long rows. Much of the land thus watered becomes too wet, while other portions receive an insufficient supply. In either case the best results can not be expected. Another very serious objection to irrigating with a very large head of water is, that the water contains much insoluble earthy matter which is ever being deposited as sediment. Water-ways become coated and moisture fails to penetrate to the roots of plants along their course. To irrigate properly, furrows must be well made and as nearly free of obstructions as careful methods will permit. The slope of the land will determine the distance it is practicable to run water for uniform results. No greater quantity should be turned into each furrow than will flow with uniform rate. Seepage is slow at best, and it usually takes many hours to secure the proper amount of moisture to the soil to prove of lasting benefit. Some may disagree with the statement that seepage is more effectual and rapid from a small head of water than from a heavy flow. The reason is that water from the Arkansas river is nearly always thick with earthy matter, and the amount of deposit decreases with the volume. We have tested this thoroughly in the garden as well as in the field. It has been found advisable, while irrigating, to expose the smallest amount of surface possible to the flow of water, and thus protect the porous condition of the soil. Another expensive practice is that of allowing a great amount of overflow or waste water to leave the fields and return to the river or lower ditches. Much fertility necessarily goes with it and is forever lost.

Every farmer should practice economy in saving and applying to his land all matter that will eventually decay. The soil, though rich in mineral fertility, is poor in vegetable matter, due to the barrenness of the country before the advent of agriculture. The litter of the farm is slow to decay in a dry climate like ours unless the process is assisted by artificial methods. In view of this fact, a pit was recently dug on the farm of this Station, into which all that will make manure is systematically hauled. Here the process of decay is hastened. The pit is conveniently located where water can be turned into it at any time from a ditch near by.

It may be well to describe here the construction of this excavation for saving fertility. One man and team finished the work in a little more than a day by means of plow and scraper. The pit is 30x70 feet, and four feet deep at the center. The sides and ends were left sloping toward the center to allow easy access with team and wagon for hauling in and out. The usefulness of this arrangement has been so well proven that a companion pit will be dug in the same manner near by, thus rendering more convenient the process of handling the varying stages of decay.

WHEAT CULTURE.

A greater acreage is devoted to wheat culture in this section of country than to any other grain. Both winter and spring varieties are produced with equal success when seasons are equally favorable, but as a rule winter grains have superior advantages in respect to climatic conditions. The year 1892 proved an exceptionally good one for spring grains, by reason of an abundance of early moisture. During the spring months of 1893 but very little precipitation occurred and the irrigating waters were unusually late; all of which resulted more favorably to fall-sown seed. Within these two years, yields per acre at this Station have been as follows: Winter varieties—Clawson, 29 bushels; Turkish, 28½ bushels; Red Russian, 28 bushels. Spring varieties—Sonora, 29 bushels; Amethyst, 29 bushels; Defiance, 24 bushels; Australian Club, 17½ bushels; and Improved Fife, 13½ bushels.

There is usually some speculation going on relative to the cost of producing wheat, but the most convincing arguments that can be advanced are downright facts. Through the last season we kept a careful expense account on raising a field of four and one-half acres of Clawson winter wheat, as given in the following summary:

Labor in irrigating land,	$ 35
Plowing, 3½ days,	7 85
Harrowing, ¼ day,	55
Seed, 22 pecks,	2 75
Vitriolating seed,	20
Drilling seed, 6 hours,	75
Winter irrigating,	35
Spring harrowing,	55
Irrigating,	50
Harvesting,	4 00
Twine,	1 12
Shocking, 5 hours,	80
Stacking, ½ day, two men and team,	1 95
Threshing, 7 cents per bushel,	8 05
Total,	$29 77
Yield, 115 bushels, at 50 cents per bushel,	$57 50
Expenses,	29 77
Net profit,	$27 73
Net profit per acre,	6 16

No estimate is given on cost of keeping water-right in force, or cost of hauling grain to market; but as the straw has both a feeding and manurial value it should be worth at least enough to cover these two items.

It may be well to add that we do not, as a rule, recommend using five pecks of seed to the acre, as was done in the above experiment, but rather a less quantity. Our reason for using that amount of seed in the test was to determine the value of shriveled seed; and since much of the grain seemed to lack germinating power, it appeared advisable to use a larger quantity to offset the possibility of a per cent. of loss. From this shrunken, inferior-looking seed came a product of good quality. It may be argued that the area being small the example is not suited to a large field; yet other fields of wheat grew adjacent, which gave results equally as good. There is no doubt that, as a rule, profits are greater on medium-sized areas than on large ones, but it is also true that small areas well tilled at a profit are preferable to large ones handled at a loss. Better and more thorough methods are needed in the production of all grain crops.

Among the various operations necessary to the production of a wheat crop, deep plowing has here been shown the most essential. In the early stages of the crop there should be a never failing resource of moisture. Such cannot be maintained within compact soils. A porous condition of soil saves moisture, while evaporation soon exhausts the limited supply which compact soils have the power to acquire. Manuring land with any kind of decayed vegetable material increases capillarity or looseness of soil. But since improvement of this character can be furnished only by degrees, deep tillage should supply the requirements for a time at least by making available all the natural resources.

Wheat sown in dry soils can never be made to germinate uniformly even if thoroughly irrigated afterwards. The most perfect requirements of a seed-bed, mellowness and moisture, must be complete before planting to secure uniform advantages for the crop.

Many demonstrations have been made in proof that, as a rule, farmers use too much seed. The best results at this Station have come from the use of about four pecks per acre. The press drill is recommended for advantages over other methods of seeding. By its use the soil is made firm over the seed and rapid and uniform germination insured; while the surrounding soil is left mellow and porous, allowing the young and tender roots to reach in every direction for the available fertility and moisture. The advantages of deep rooting are secured by drilling seed to a depth of at least four inches.

Winter wheat usually requires three irrigations, and spring wheat two after growth has been established. We irrigate winter wheat once during the winter, in January, harrow in February, and irrigate in March or April, as the conditions of the season seem to require. After that, and as soon as the surface becomes sufficiently dry to pulverize without becoming cloddy, it is again harrowed for the second and last time. Wheat is benefitted by harrowing the same as other crops are benefitted by cultivation; and no harm has been found to result from the use of the harrow upon fields after a growth of five and six inches has been established. The final irrigation is required during the stage of forming heads, or not later than the bloom appears. Later watering than this may produce shriveling. While irrigating small grains, water is unavoidably allowed to flow in contact with the stems, by reason of which the application should be made within as short a period of time as possible consistent with thoroughness. Numerous laterals over difficult places facilitate the work.

OAT CULTURE.

The requirements of oat culture do not differ essentially from those of wheat, yet the former grain is found not as well adapted to the various conditions of climate as the latter. Oats attain the highest development in cool climates. They are produced with reasonable success in this valley when the soil is given deep and thorough cultivation. It is important to get the crop started as early in the spring as it is possible to work the soil, after the danger of severe freezing is over. Ripening before the hot weather invariably secures plump grain. The best results at this Station have been an average of 30½ bushels per acre of Excelsior, a white variety. The grain could hardly be surpassed in quality anywhere. The land had been in corn the previous season, which had received good culture, after which thorough and early preparation followed for oats.

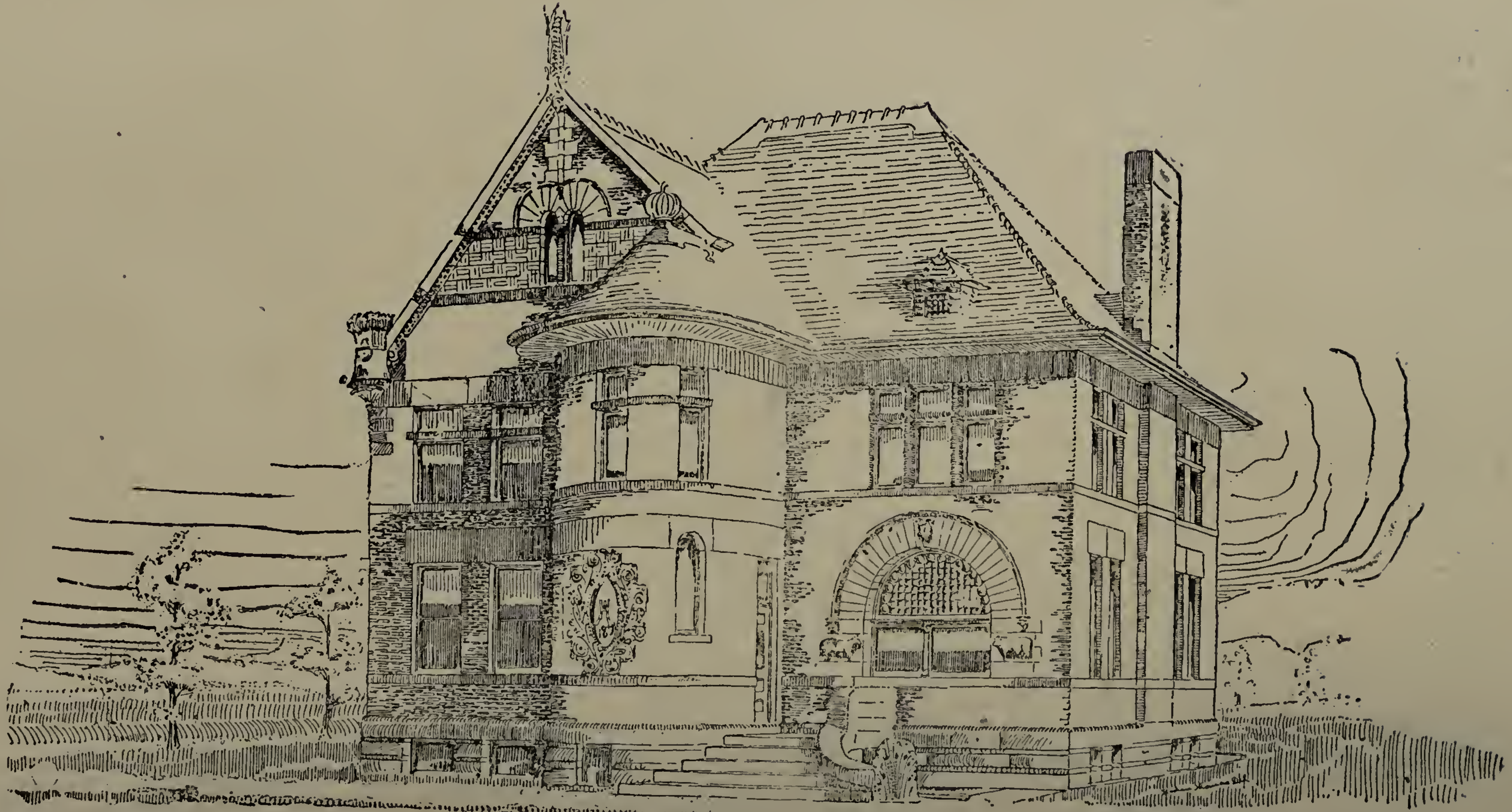
Owing to advantages being claimed for late sowing, to bring the harvest as late as the last of September, I was prompted to visit a number of fields this season, but was disappointed in finding the straw of late grain almost invariably covered with rust, and no indications of improved yields over early sown crops. Some advantages may be developed later in favor of late sowing, but thus far early sowing is advised.

BARLEY CULTURE.

Barley is but little grown as a farm crop in this section of Colorado. Six varieties in test plats at this Station, including both hull and hull-less kinds, have done well in every particular. The culture requirements do not differ essentially from those of wheat, except in the rate of seeding, which is about eight pecks for the hull sorts and a little less quantity for the hull-less.

RYE CULTURE.

The value of winter rye as a quick land renovator seems to be but little understood. When a heavy growth of vegetation can be made, to plow under between regular crops without losing the use of the land for a season, it ought to be encouraged. We have it from experience here that rye can be sown on early fall plowing, which will make two months' pasture and furnish a heavy growth to plow under in the spring. Besides the benefits from green manuring, whatever they may be, a fresh crop of weeds is prevented from going to seed by early plowing, and the necessary spring tillage places moisture beneath the surface for later use. The best yield of rye on these grounds the past season gave 19 bushels per acre. If seed raising is to be the object, about 80 pounds should be sown on an acre, and at least 100 pounds for a matted growth.



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THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

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THE Measurement and Division of Water.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.
AUGUST, 1894.

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ON THE

MEASUREMENT AND DIVISION OF WATER.*

By L. G. CARPENTER.

Questions concerning the measurement and distribution of water probably give rise to more trouble than all others combined in an irrigated country. While frequently the matter in dispute is of small consequence, it is a source of irritation that causes constant annoyance both between canals and consumers, and between neighbors. The problem of a just distribution of water is one of the most important as well as one of the most difficult problems of irrigation.

In passing over the lines of ditches in Colorado and in other states, and in other countries, I have made their methods a special object of observation and inquiry. In general it may be said that the prevailing methods are exceedingly unreliable. In some canals, even the large ones, there is little attempt save by the eye or the judgment of the ditch rider; in others there are nominal measures which frequently are worse than none at all, because while giving no approach to a proper measurement, they give among the consumers and canal officers a false sense of accuracy and stand in the way of a better system. In others the systems are as good as the present conditions will permit. When water has been plentiful in the streams, there has been no necessity for close division or measurement, for there has been water enough to supply the demands of all. But with the greater demand for water, and the need by each farmer of every drop obtainable, there is greater necessity for closer measurement, and many canal organizations are being led to consider more efficient means of measurement and distribution.

The prevention of waste is a matter of public importance. With more land than water, the agricultural future of Colorado depends on the use of her existing water supply to its fullest capacity. The building of storage reservoirs, the stopping of waste, improved methods in irrigation, together

*The first edition of this bulletin was issued in October, 1890, the second edition in July, 1891. In preparing the third edition the opportunity has been taken to condense the bulletin in places, make material additions, add new tables, and practically rewrite the whole bulletin. The changes and additions have been too numerous to call attention to them in detail. Tables V. and VI., in the appendix, are the only ones which appeared in the first edition.

with the changes consequent on irrigation, which make less water necessary, will increase our water supply in effect, if not in amount.

It is safe to say that a good system of measurement will save a large amount of water. Every one knows that in financial affairs a close account is the basis of sound economy. It is also true in water matters. The mere fact of measurement makes users more careful about waste, and in the aggregate the saving is considerable, as some cities which measure water to consumers have found. With water plentiful, the system, or lack of system, works without friction. The practice is to give enough to stop complaint, if there is water enough. But as water becomes scarcer and the demand greater, then the system works gross injustice. If some one gets more than his share, it means that some one else gets less. And this may mean ruin to his crops. In many parts of the state the pressure for water is already being felt. It is only a question of time when the other localities will feel the same pressure, and with time, all will feel the demand more. Hence it is that there will never be an easier time for arranging satisfactory measurements than now; for the demand will not be less, and with time and the increase in value of water then there will be many who will feel that they have rights vested in certain methods of measurement which may be intrinsically unjust.

This bulletin is the result of the consideration of the measuring devices forced upon my attention by various trips over the canals of this state. The study has extended, especially since the first edition, to devices in use in other states and in other countries than our own, in the hope of finding a device which should meet all the desirable conditions. It cannot be said that any are free from objection, but there are some which can be recommended, and, since even on some canals with a presumed system of measure I have found discrepancies amounting to as much as 400 per cent., there is much room for improvement. It may be said, with the present knowledge, there is no need for the variation to be more than 10 or 20 per cent., except in occasional cases, and it is scarcely necessary to except these.

On this subject, as well as on others in the line of irrigation, the experience of Italy is useful. Her physical conditions are not so far different from ours. She has the accumulated experience of six centuries with irrigation; we of scarcely thirty years. While the progress made here by a people who had to rely on themselves for their knowledge of irrigation has been marvelous, it is unquestionably true that we may learn much from her experience. The physical laws governing the flow of water, the principles involved in distribution and measurement are the same here as there. We are finding the necessity of laws and regulations which they long ago found necessary. We shall find it necessary to take other steps which their experience long ago showed desirable.

The Italian modules have been various, but until recently most of them have been based upon one idea—an erroneous one—which has been introduced into Colorado and the other western states in the form of the various miners' inches.

The need for measurement was felt before there was more than the most limited knowledge of hydraulic laws, and the methods of measurement date back, consequently, before the rise of hydraulic science. That they have been used for several centuries with even a fair degree of satisfaction reflects great credit upon Soldati and the magistrates of Milan who so firmly grasped the conditions of the problem. That these measures are known to be incorrect is shown by the fact that all of the large modern canals have adopted other systems. The Cavour Canal, the Canale Casale, the Canale Villorsi have all adopted systems depending upon the weir. The insufficiency of the old measurement is evidenced by the fact that the Italian government required in one of its acts of concession granting water to a new canal, a plan for a new module for the measure and sale of water. That the old measures are still used, and will be used, is due to the fact that in time the individual users have acquired rights in the water which that particular method allows them, and any change which threatens those rights arouses at once intense opposition The same kind of conservatism is shown in Colorado, and the same varied customs are growing up. There are already numerous canals on which there are several different methods of measurement in use and where water is measured out differently to the early users. The changes affect the new users.

The module proposed and adopted by this canal—the Canale Villoresi—will be especially described, because it seems to dispose of some of the difficulties which have made the weir objectionable.

In the measurement of water there are two distinct classes of measuring boxes, different in their object. One is the dividing box, whose object is to give to each consumer some definite portion of the water flowing in the ditch. This box is found especially in the laterals owned in common by two or three neighbors, or in the smaller canals owned and operated by the stockholders. The other class is the measuring box which has in general for an object to give the consumer a certain definite quantity of water, as one cubic foot per second. These need to be adjustable, so that in times of scarcity the amount may be reduced proportionately as the quantity in the canal decreases. To this last class the Italians give the name of *modulo*. The French writers on irrigation, and to a limited extent the English, have adopted the word in the form of *module*, and, as such a word is needed in our irrigation vocabulary, the term is here used. *Module* will therefore be used to designate those boxes or devices, whatever their form, whose object it is to measure the quantity of water delivered, or to give a constant flow. The word *divisor* will be restricted to the first class, whose only object is to divide the water. A module may evidently serve as a divisor, for if the amount to be divided is known it is a simple matter to determine the quantity to which each is entitled and to regulate the module accordingly. There will always be cases where divisors will be by all means the most convenient, but these cases will be mostly in the small ditches from which few take water. In all other cases modules of one kind or another will be found the better.

In the case of divisors it is evident that there is no unit of measure, and that none is needed, as the object is to give the consumer some definite portion of the water flowing in the ditch whether there be much or little.

In the module, on the contrary, some unit is needed.

It is unfortunate that a system has grown up in which the professed unit is the "inch." The word is used in such a multitude of meanings that it is an almost hopeless task to convey an exact idea of quantity by the word. It in effect takes into account only the cross-section of the channel or opening, without regard to the velocity of the water. In the same ditch it is attempted to have the velocity the same or nearly the same through the different openings, by keeping the head the same, but in different ditches the heads vary according to convenience or the notions of the original users. In some ditches the head is four inches, in others six, in some eight, and there are others which allow the opening to extend to the surface of the water and no pressure is used. The whole area of the opening in square inches is then counted as inches of water. Also, in common use, a practice has grown up to call the cross-section of the stream in square inches, without regard to the velocity of the water, as so many "inches." Manifestly there is nothing in common in these different inches, so that the term has no definite meaning. The legal inch" of Colorado, as defined by Section 3472, General Stat-tes, and which was defined in 1868, is as follows:

"Water sold by the inch by any individual or corporation shall be measured as llows, to-wit: Every inch shall be considered equal to an inch square orifice under 5-inch pressure, and a 5-inch pressure shall be from the top of the orifice of the box ut into the banks of the ditch to the surface of the water; said boxes or any slot or perture through which such water shall be measured, shall in all cases be six iches perpendicular, inside measurement, except boxes delivering less than twelve iches, which may be square, with or without slides; all slides for the same shall iove horizontally, and not otherwise; and said box put into the banks of the ditch hall have a descending grade from the water in ditch of not less than one-eighth f an inch to the foot."

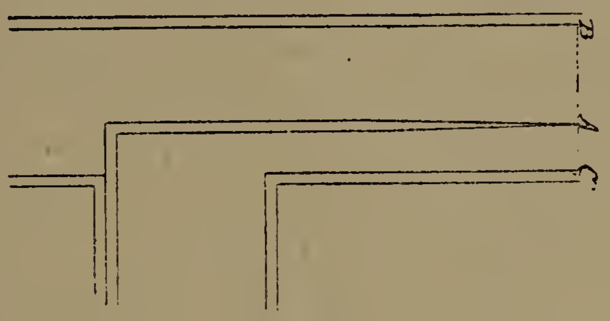
But in addition to the variation in use, there is another undamental error in the method which long ago being recog-iized by the users in Italy caused them to prohibit the use of openings of more than a certain number of oncia. According to this system an opening 6x16, for example, would give 96 'inches;" one 6x8 would give 48. One should discharge twice as much water as the other. As a matter of fact the one dis-charges considerably more than twice the other. This is true, even if the conditions of the head are the same. It was noticed by the users of Italy, so that long ago the number of inches which could be drawn through one opening was limited. If one ob-serves the discharges from an opening under good conditions the reason will be seen. As the water passes out, there is a narrowing up of the stream on top and bottom and sides. As ordinarily placed, those on the sides are the most noticeable. Now the total amount of this narrowing is approximately the same whether the opening is long or short, provided the head is the same. Hence the amount is decreased nearly the same in both cases. But relatively, the loss from the smaller one is greater than from the large one, and the consequence is that the large one discharges more than twice as much as the smaller one. The place where the velocity is the same, with the same head, is not at the opening itself, but where the cross-section of the issuing stream is the smallest. To illustrate further: Suppose that with the statute inch the contraction at each side is one inch; then with the opening six inches high, each area loses 12 inches, reducing the effective area of the one from 48 to 36 square inches and of the other from 96 to 84 square inches, and, leaving other considerations out of account, then the ratio between the two is more nearly that between 84 and 36, or 2.3, than between 96 and 48. In this particular case the larger user receives 2.3 as much as the smaller one, though it is considered as only twice as much. This cause is sufficient to make the "inch" differ by more than 50 per cent. With the indefiniteness of the term as used, it is difficult to determine a clear idea of the quantity involved, unless the statute establishing the ratio between the statute inch and the cubic foot per second in such terms as to make 38.4 statute inches equivalent to one cubic foot per second should be considered as defining the inch. This ratio may be very widely variant if the inch is measured according to statute terms. The cubic foot per second is an absolute unit whose quantity cannot be subject to dispute, though the accuracy of measure may be. The state laws provide that in appropriating water to ditches the quantity shall be estimated in cubic feet per second, or as frequently shorter expressed, as second feet.

DIVISORS.

As ordinarily constructed, the division can rarely be exact, but, frequently, the convenience of an approximate division more than counterbalances any inaccuracy there may be. The larger ditches rarely have occasion to use divisors, for, even if the ditch has to pro rate the water, a better distribution can be effected by means of modules. If the water is to be divided into two equal portions, by placing the two lateral ditches in identical relations to the main ditch, in a straight and uniform channel, the division is exact. Emphasis should be laid on the *identical* relation, for many divisions are seen where the conditions are not the same, as, *e. g.*, one branch continues straight, the other may make an abrupt turn, one may pass through a covered box, etc. In these cases some advantage is given to the ditch having the freer discharge. The effect of these differences is greater than is generally supposed. It is, however, generally easy to meet these conditions if the parties desire. In the same way the water may be subdivided into four, eight or sixteen equal parts. But where it is required to divide the water into two unequal, or into three or more portions, equal or not, the division becomes one of approximation only. The difficulty arises from the fact that the water has not uniform velocity across the whole channel, the center has greater velocity than that near the banks. If, therefore, equal openings be made across the channel, those near the center have the greater discharge. Making the central openings smaller only partially evades the difficulty, for as the relative velocities of the center and sides differ with different depths, this arrangement would still be inexact for any one depth except that for which the opening is made.

In its most common form the divisor consists of a partition dividing the channel into two portions in proportion to the respective claims. This, in effect, assumes that the velocity is uniform across the whole cross-section, which is not the case, even in a uniform channel, and much less so in one irregular or in poor repair. Such a division is to the disadvantage of the smaller consumer.

The nearer the velocity is uniform across the whole channel, the better this method of division, evidently. Accordingly means are frequently taken, by weir-boards or otherwise, with this object in view, but generally with indifferent success. A screen would accomplish this one object better, but the objections to its use are too many in most places to render it practicable.



Fig, 1.—A COMMON FORM OF DIVISOR.

Figure 1 represents one of the most common forms of divisors. The partition board A is movable, and may be placed at different distances from the side C, so that the user can vary the proportion of water which he receives. A cleat of some kind is often used to prevent the board from being moved beyond a certain limit. Where the ditch is wide and shallow, there is sometimes a simple truss used, as in the Lariat ditch, in the San Luis Valley, with a depending cleat. Sometimes a wire or chain restricts the movement. In these cases it is usually assumed that the amount of water going to the side channel is in proportion to the distance the movable partition is from the side, and the ratio is the same to the distance across as the volume is to the volume in the whole ditch. This is not in general true, because the velocity across the cross-section is not uniform.

Sometimes where this is recognized, and it is necessary to make close division, the water is brought to a state of approximate rest, or to a state of approximately equal velocity throughout the channel. In the case of some divisors used on the Farmers' Union Ditch, in the San Luis Valley, a weir-board over which the water drops is placed above the division board. This secures an approximate equality. A fall below the point of division sufficient to prevent the backing up of the water is necessary.

If water is brought to a complete state of rest, or very nearly so, and flows over the weir without lateral contraction, this method will give as satisfactory results as any divisor with which I am acquainted. An increase in the size of the ditch just at the division box will aid in bringing the water to rest. Boxes of this kind were used by Hon. J. Max Clark, of Greeley, as early as 1867.

The divisor which is in use at Elche, in Spain, is one which has developed from their conditions in that province. At Elche there is a peculiar system of water management. The water is owned independently of the land. The amount available is divided into a certain number of shares, and the use of each of these for twenty-four hours is sold each day in the market place to those who want water. In consequence the amount which enters any lateral varies from day to day, and the method of division requires a convenient way of varying the proportion.

Where the division is to be made, the sides and bottom of the canal are made of cut stone for a distance of about fifteen feet. There are two falls in the canal of twelve and sixteen inches respectively, about five feet apart, the upper one being about seven feet from the upper portion of the masonry. The canal for a distance of 150 or 200 feet above has little or no fall, so that the water reaches the first fall with almost no velocity, and passes over undisturbed and perfectly smooth. Furthermore, there is no contraction at the ends, so that the discharge is nearly in proportion to the length.

The arrangement for making the division consists of a partition which is permanent masonry, and divides the canal below the falls into two channels. At the upper end of this partition is a movable piece of wood coming to a point which is pivoted to the end of the partition, and can be held so that its upper end will include any assigned portion of the channel within certain limits. The length of the beak of wood is made so that it reaches to the upper drop when in line with the axis of the partition. The beak is set so as to include the desired portion of the channel and thus remains for twenty-four hours.

At Lorca, for a portion of the area under cultivation, there is a system of sale something like that at Elche, in which the amount which enters any ditch may vary from day to day. A divisor which may be called a needle divisor is used. The same care is used in the preparation of the channel as in the previous one described. A permanent masonry partition is placed in the channel. The proportion which enters the lateral channel is varied by varying the relative width of the main and lateral channels. This is done by inserting or taking out a series of narrow boards placed vertically. These are of uniform width. They are held in place both in top and bottom, and are carefully fitted to prevent leakage. The stream is to be divided so that a certain number of hilas, according to the result of the sale, may enter the channel. No account is taken of the difference introduced by contraction. The discharge is assumed to be proportional to the size of the opening. I have seen a divisor involving the same principle used on a ditch carrying seepage water, near Greeley. The form is not so good as the Elche divisor.

DISTRIBUTION BY TIME.

On small ditches or laterals where the amount of water is not too great for one user to manage, the time method of division may be used and gives a more equitable division than the boxes of the types described, and besides, it accomplishes what is necessary in order to use water economically, it allows of the use of water in large enough quantities during irrigation to make the use much more economical than where used in minute quantities. If water is divided according to the various interests involved, so that each would receive constantly the amount to which he is entitled, and no more, it would often happen that the division would be into such small parts that little good would be done by the small stream of water thus furnished. It thus becomes necessary in almost all localities to exchange water between neighboring users, so that one will use the privileges of several for the time during which he is irrigating, and then the others in like manner will use the water of their neighbor whom they have already accommodated. The time method of division carries this exchange of water to a greater extent and is especially applicable to the small ditches where the amount of water is small. In such case the exchange is systematized, and each one takes the whole stream of water for a time proportionate to his interests in the ditch, and the period is so arranged that the rotation will be completed in some definite time, as a week or two weeks, or such other time as the experience of the locality has shown to be desirable for an irrigation to be repeated. The water will then be given out at night or day according to a schedule, and in order that the inconveniences may be fairly distributed, the period of rotation may be made with a fractional day, so that those who came in the night during the first rotation will come in the day during the second, and vice versa. Thus, suppose the period of rotation be taken as one week, or for reasons above given, 7½ days, and the number of shares be fifteen, of which some own one, others two, and some three shares. In this case each share would give its owner the right to use the water for one half day, or twelve hours; the owner of two shares would be entitled to its use for twenty-four hours, and the owner of three shares to thirty-six hours. Where there are a large number of rights or of users the same method would be carried out but to a greater extent. As carried out in the countries where it is applied, the division may be carried out until the exact number of minutes to which each is entitled to the water is determined. In such case a time table needs to be prepared in advance, usually at the beginning of the season. Each one is furnished with a copy of it, as well as the ditch superintendent and employees, and the water is shut off or turned on the different gates according to schedule. The user must be ready to take it at the proper time or lose the water until his turn at the next rotation.

This method is best applicable evidently in the cases where the amount of water flowing into the lateral is constant. This, under the present conditions of American practice, is rarely the case. The water in the main ditch, and consequently in the smaller laterals, is subject to the fluctuations of the main stream. Where water is distributed from reservoirs, then the flow may be maintained uniform. The necessity for restriction in the use of water to certain assigned times is also distasteful to many. But by common consent, methods are used which are leading to the same system, and with the gradually increasing pressure for the greatest benefit from the amount of water available, there is little doubt that this method will gradually extend in use under the conditions where it is best adapted. With the varying streams and varying flow, with the previously prepared time table, the method is not so equitable as the division of water as it comes. But with the advance of canal administration and with increase in knowledge of the flow of water, it will be possible to adopt a modified time-system of distribution which will be adapted to the varying streams. It is already in ditch administration in Colorado becoming customary to keep records of the amount of water which is taken into the canals. It will become increasingly desirable, and even necessary. For the large ditches taking water from the streams, the amount of water which is taken into the ditch for different depths of water in the ditch, is officially determined by the State Engineer or his deputies. A similar rating of the lateral ditches may be made, or weirs may be used with greater accuracy. As it becomes possible to find men who can use the various methods of measurement to determine the amount of water flowing, it will be possible to use a modified time distribution, so that each will be given the water long enough to give each the same quantity. This would give a short time for the periods when the water is plentiful, and longer times when low. The unit could be varied, so as to bring the irrigations a convenient time apart. The successful operation of such a system would require an intelligent superintendent, and one who had the confidence of the users of the water, or a wide-spread knowledge among the users.

In the distribution of water from small reservoirs, where there are but few interested, and where the different owners do not care to use the water at the same time, some such arrangement is necessary. With the weir measurement it is possible to keep account of the amount used by each person, so that the water may be divided in proportion to the rights of each.

MODULES.

It is not possible to secure a module satisfactory in every respect or to meet all conditions. Where there is fall to spare in the ditch some forms are available which would be excluded if there were no fall to spare.

The features desired in a module may vary under different conditions, so that there are some forms which give excellent satisfaction in some circumstances, which do not in other cases where the conditions emphasize the desirability of some other feature. In the early stage of water measurement, when water is abundant, accuracy is a minor consideration, while with increased demand for water, it is one of the first, if not the first consideration. A second desirable feature, which has been the object toward which many have worked, is a module which is self-regulating and preserves the same discharge of water even with fluctuating depths of water in the canal.

The following may be considered desirable conditions in a module. Most of these conditions were recognized several centuries ago by the magistrates of Milan:

*1. Its discharge should be capable of being converted into absolute measure—as into cubic feet per second.

*2. The ratio indicated by the module between the discharges from two outlets should be the same as the actual ratio.

*3. The same module or box should give the same amount of water wherever placed.

4. It should be capable of being used with large or small canals.

*5. It should be capable of being set to discharge any fraction of its capacity, so as to be capable of distributing water pro rata.

6. Surreptitious attempts to alter its discharge should leave traces easy to recognize.

7. It should be simple enough to be operated by ordinarily intelligent men.

8. Calculation ought not to be required in order to regulate the discharge of different modules, or to determine how much they are discharging.

9. It should occupy but small space.

10. The discharge should not be affected by variations in the level of water in the supplying canal, or, in other words, it should be self-regulating.

*11. Its cost should be small, and it ought not to require much fall.

These conditions are evidently not of equal importance. The most of the conditions have been recognized for several centuries. Those unmarked are essentially the same as those given some centuries ago.

Condition 1, on which depends the accuracy of the measure, becomes day by day increasingly important, and is the one which with the passage of time may be considered the most important. If the first condition is met, Nos. 2, 3, and 4 which are practically included in it are also met.

The question of expense, mentioned in No. 11, is a relative one, and may or may not be of importance. It becomes of less importance as the development of the irrigated section becomes greater and the needs for accuracy become more generally felt. But the requirement that the fall required shall be small, is a physical condition which it is often absolutely necessary that modules for special locations must meet.

Condition 8 becomes of less importance, with the increase in intelligence of those whose duty it is to distribute water, and is not objectionable against such modules as the weir, where tables of discharge may be prepared which enables the discharge to be determined without computation by the user.

No. 10 is the condition which to the early users is almost always the most important. The reason has been partly one of the stage of hydraulic science, in which it has not been known how to measure the quantity of water passing except by passing the water through orifices. In order to make the velocities through these orifices the same, it has been necessary to make the head of the water equal in these different places, and consequently to secure a measure it has been desirable to keep the heads over the openings constant. The condition is less important with us, both because with the growth of hydraulic science the amount of water may be measured with more accuracy than the early users knew how, and because our conditions are different. In our practice it is rarely attempted to make the discharges constant. Instead, as the canals usually have largely different quantities of water during the season, it is far more important that the water shall be cut down in each smaller ditch in the same ratio.

The devices for maintaining a constant flow may be divided into two classes:

1. Those which attempt to maintain the pressure of water above the opening constant, the orifice remaining unchanged.

2. Those which vary the size of the opening with different heads of water, in such manner as to keep the discharge constant.

Nearly all modules are of the first class, as the difficulties are simpler. The module of the Isabella Canal of Spain, described in the latter pages, and an excellent module, is of the second class.

But even if the head may be kept constant, the accuracy of the measure in those of the first class depends upon the kind of opening. The module proper consists of the orifice, the remainder being simply accessory.

The old Italian modules are mostly based on an orifice of a determinate size, the head above the orifice remaining constant. The miners' inch of the west and the statute inch of Colorado are such modules. Some of the Italian modules are circular, but most are rectangular of various dimensions. Those of the same kind had the same height of orifice and the same head. When different quantities of water were to be given, the orifice varied in length. But in all these cases it was assumed that the discharge was in proportion to the length of the opening. The prevailing form of measurement on the older canals of Colorado has essentially the same idea involved. It is generally attempted to deliver water through orifices of the same depths, but with variable widths according to the quantity of water to be furnished. But in cases where the elevation of the surface is such that the ordinary depth can not be given, it is not uncommon to make the depth less but the width greater, keeping the area uniform. Among these Italian modules, the Milanese module, or sometimes called the Soldati module, has been the most celebrated, as it has been the best. This dates from 1585. The canals of the province of Milan had no good system of measure, though having been in operation for several centuries. There was much trouble and complaint. Finally the magistrates of Milan attempted to regulate matters, and called for plans of modules, and gave twelve conditions which a module should satisfy.*

It was in response to this proposal of the Milan rulers that Soldati proposed the module which was adopted and is still in use on the canals of that province.

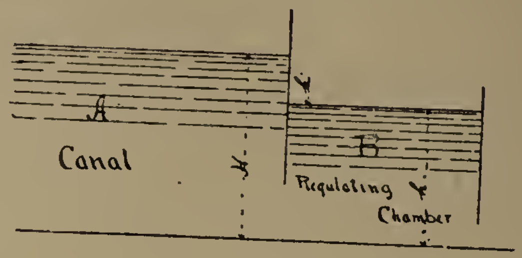


FIGURE 2.

The first thing Soldati considered important was to insure that the water should flow with uniform pressure. This he attempted to do by the following principle:

If two chambers are connected, as in the diagram, the water in the second chamber will be lower than that in the first by an amount depending on the relative size of the orifices. But the depths in the two chambers are in a constant ratio. Thus, if the depth in B is 6 inches, and in A 18 inches, if the water in A becomes twice as deep, that in B will also become twice as deep as before. Under these circumstances, an increase in depth of 18 inches in A causes an increase one-third as much in B.

By means of such a regulating chamber, therefore, the variations in the height of the water in the canal are lessened in the regulating chamber, which is intended to furnish the water under constant pressure. While apparently avoiding the difficulty caused by a varying head, this really does not do so. As a matter of fact the flow *will increase in the same ratio for a given increase in depth of the main channel, whether the orifice comes direct from the main channel or from the regulating chamber, provided it be at the same level.*

The reason for this fact, which is contrary to general opinion of those using water from the ditches under such systems, is this: As the velocity of water flowing from an orifice varies with the square root of the depth, according to the familiar Torricellian principle, the discharge for an opening of constant size will vary with the square root of the

*The history of this event and the trouble is given in Bruschetti's "Storia del Irrigazione del Milanesi," in his complete works. Vol. II., pp. 118-135. It is condensed in Buffon's "Des Canaux d'Irrigation d'Italie Septentrionale." The twelve conditions are included in the unmarked conditions on page 14. It is also given briefly in Smith's "Italian Irrigation;" in "Parrochetti's Manuale Pratico di Idrometria."

epth or pressure. While the variation is not as much, meas-red in inches, in the regulating chamber, as in the main hannel, it is the same relatively, and the discharge, with a ariation of level, will increase in the same ratio as it would ·om an orifice discharging direct from the main canal and ·ithout the regulating chamber. In the latter case, if the rifice gave the same discharge as the one from the regulat-ıg chamber it would be smaller, of course.

It follows from this that the value of this as a regu-ıtor is apparent rather than real, for the amount of water elivered will vary as much as if the opening was in the ca-al and subject to the greater variation of water which there ; in the canal.

It does afford a means of keeping the variation of head bove the orifice within smaller limits, though a larger open-ıg is required, and this is sometimes desirable. But it should e kept clearly in mind *that unless regulated with every variation ı the level of the supplying canal it does not assure a constant low*, which has been its supposed principal merit. In order ıat the discharge shall be in proportion to the size of the penings, which this method implies, it is evidently necessary hat the water shall pass through with the same velocity, hich not only requires that the pressure or head shall be the ame, but also that disturbing influences of other causes, as f velocity in the water from its passage through the first op-ning, waves, etc, shall be eliminated. Accordingly the mod-le consists generally of two parts, that already described for ttempting to maintain a constant pressure, and other appa-atus intended to still the waves in the regulating chamber nd assure that the water shall reach the opening without elocity. A variety of means has been adopted mostly by arying the length and breadth of the regulating chamber. n the case of the Naviglio Grande, the canal where troubles f measurement caused the original introduction of the mod-le, the boxes which I examined when in Italy had also a over for the purpose of stilling the fluctuations of the sur-ace and insuring that the water should leave with the veloc-ty due to the simple pressure.

This method is used with many variations throughout taly. The openings in the different provinces have different izes and shapes, and different pressures are used above the rifice. All are called "oncia" or inches. Some of them are ircular. No less than ten are given in Carton & Marcolon-;o's "Anuale del Ingegnere Agronomo," 1888.

In this State the same principle has been extensively ısed in the Max Clark box, as it is called, named from its introducer. The box has been extensively used in the o portions of the State, and has fulfilled a useful purpose. has the same fault as the Milanese module, added to the that much less pains are usually taken in Colorado to after the details, and to secure the best arrangement possi to prevent the influence of other causes.

As the term "oncia" was given to the Italian uni the term inch has been used throughout this western cou for the corresponding unit. The statutes of Colorado pre scribe that water shall be measured through an orifice inches in height, with a pressure of water of 5 inches abov the opening, and that the number of inches shall be the sam as the number of square inches in the orifice. But the terr is not confined to the statute inch. On some ditches wate is measured with a pressure of only two inches, on other without any, but the same term is used in all.

An inconvenience which was soon discovered in the us of the Milanese module was that the discharge was not i proportion to the nominal discharge. A person, for instance who drew 100 oncia, receives more than ten times as much a one who drew 10 oncia. The difference was so noticeabl that it was not long before the discharge from any one orific was restricted to a certain number of oncia, generally six The oncia varies from 34 to 47 litres per second, according a the orifice discharges one or six oncia. A similar variation i true of the statute inch of this State. The advantage in such methods is entirely in favor of those who draw the larg quantities. The reason for this difference has been show on pages 7 and 8.

There are other causes of variation, as in the distance the opening is above the bottom of the regulating box, in the thickness of the sides, in the manner of its discharge; all o which render this module, excellent as its service has been in the past, inaccurate and unreliable, and is leading to its abandonment.

A module based on an entirely different principle was used on the Marseilles canal in France for a time, and was described in the earlier editions of this bulletin. This module consisted of a hollow vertical cylinder which was kept at a constant distance below the surface of the water by a float The water passed over the edge of the cylinder, and passed out through a channel which connected with the interior of the cylinder. The cylinder passed through a water tight packing. In the previous editions attention was called to the probability that the module would be insensitive. On a perıl visit to the Marseilles canal it was learned that this ule had been abandoned for that reason.

A simpler device for keeping the orifice a certain distance v the surface was tried on the Montrose canal, in the stern part of the State. The orifice rose or fell with the er of the canal, being supported by a float, and was con- ed with the lateral by a pipe and a flexible joint. The le in such an apparatus is to make a joint which shall be er-tight and at the same time flexible enough to be moved y a moderate-sized float when the water rises or falls. If is can be done it would satisfactorily solve the problem of iving a constant flow.

A modified form of the Marseilles module, without the ıore objectionable features has recently been invented by an ustralian. At a competition under the auspices of the Iinister of Water Supply of Victoria this form received the remium of $500. The module consists of a cylinder floating ertically, the water passing from the outside to the interior f the cylinder as in the case of the Marseilles module, but ıe rim of the cylinder is divided into several notches ıstead of one continuous weir. The cylinder is connected ith the channel below by a bellows arrangement of leather hich will open or close as the water varies in depth. The mount of water is varied by varying the depth to which ıe weirs are sunk in the water. The inventor is Chas. A.)'Ebro of Victoria. The durability of the leather may inter- ere with the success of this module.

H. L. Decker of South Fork, Colorado, has arranged a oating module based on the principle of the siphon, which as some good features and would seem to be adapted to give constant discharge. The siphon is arranged to float, so hat the difference between the level of the water in the canal, nd the mouth of the siphon remains the same. There is con- iderable additional apparatus in connection with it for ac- omplishing the object.

The only module of the second class is one which was ırst placed in operation on the Isabella I. canal of Spain, and s due to Senor Ribera. In this one the opening varies in ize as the depth of water changes, being larger when the vater is low, and smaller as the water is deeper. The method ıdopted is to allow the water to pass out through a horizon- al opening in the bottom of the main canal or the head of a ateral. This hole is circular. Through this hole passes a lug of metal, which is smaller than the hole, the water pas- ing between the plug and the outer circumference of the pening. By varying the diameter of the plug at different points, it may be so made that the opening will be reduced in such proportion as the head increases.

This module would seem to be satisfactory. There is little or no friction, but it has the disadvantage of requiring considerable loss of fall. If condition 11 is not important, the module doubtless will be very satisfactory.

For a discharge of 1.44 cubic feet per second, generally estimated in Colorado enough for 80 acres, with a hole 12 inches in diameter, the following would be the diameter of the plug for the given distances from the top of the plug:

Depth.	Diameter in feet.
3 inches	0.53
6 "	0.70
12 "	0.80
2 feet	0.87
4 "	0.91
9 "	0.94

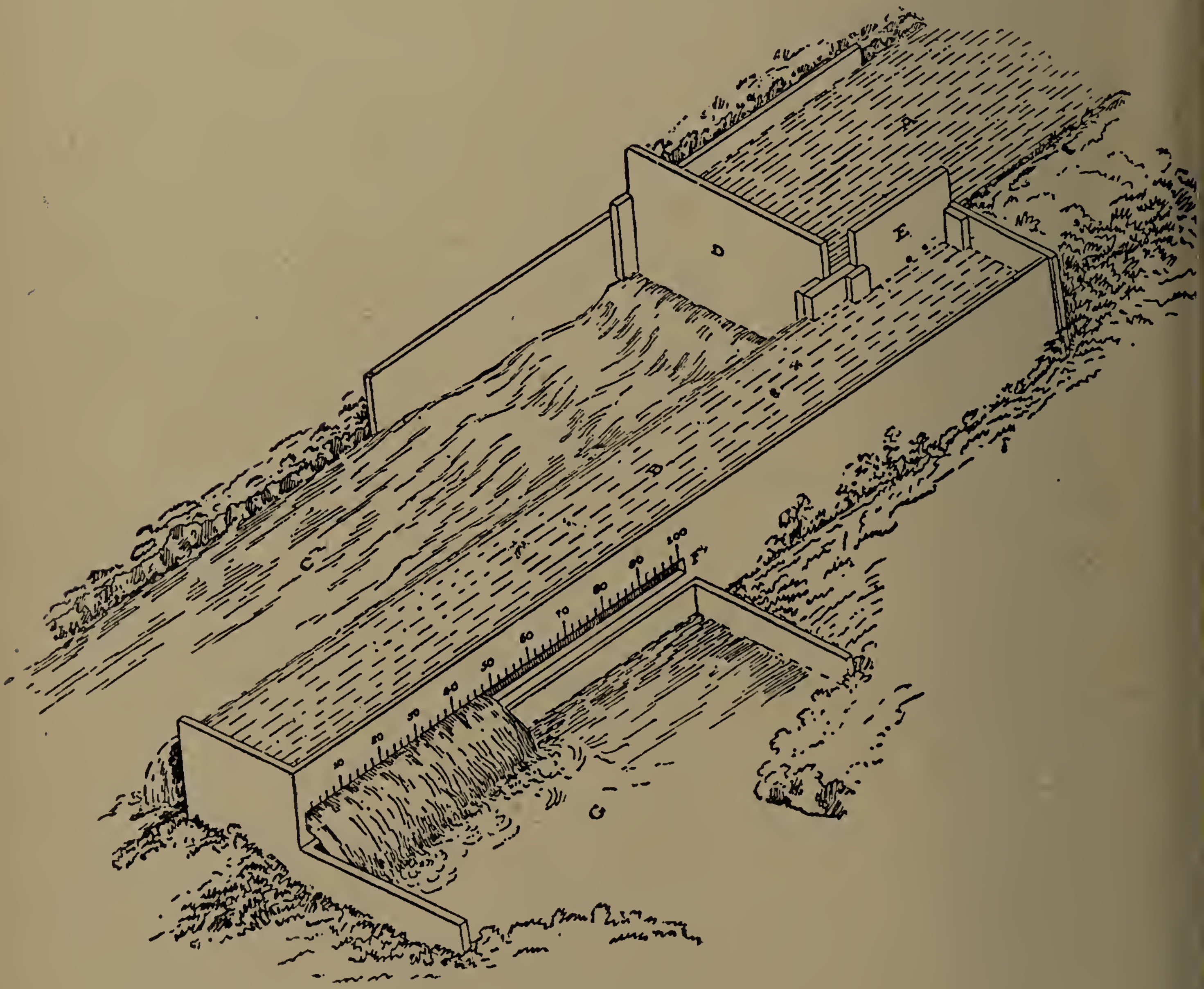


FIGURE 3.

SPILL-BOX OR EXCESS WEIR.

Another means of preserving a constant head is due to A. D. Foote of Idaho, Past President of the American Society of Irrigation Engineers.

A cut of this was given in the *Engineering News* of November, 1886, and it has been more fully described in the Transactions of the Am. Society of Civil Engineers, Vol. XVI.

In Fig 3, A is the main ditch, with a gate forcing a portion of the water through box B. This has a board on the side towards the main ditch, with its upper edge at such a height as to give the required pressure at the orifice. Then if the water be forced through B, the amount in excess of this pressure will spill back into the ditch. If the box B is made long enough, and the spill-board be sharp edged nearly all the excess will spill back into the ditch, thus leaving a constant head at the orifice. Mr. Foote calls this the excess weir. He constructed one for trial purpose. To Mr. W. H. Graves of Monte Vista, is due the credit of its introduction into use on large canals, with the necessary modifications. He terms it the spill-box, a more suggestive name than that proposed

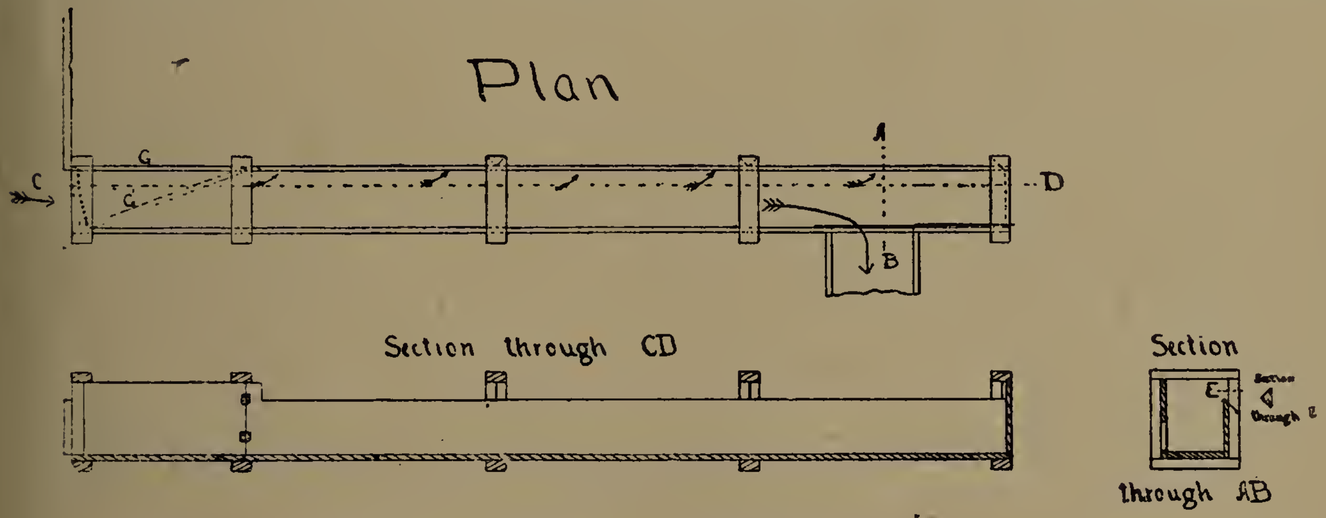


Figure 4—PLANS OF THE SPILL-BOX.

C is the entrance of water from the ditch; G a gate which serves to admit as much water as is desired; B the outlet furnishing water to the user. The small arrows show where the water spills back into the main ditch.

by Mr. Foote. In use, Mr. Graves constructs a weir in the canal, and places the box at one side, always using two, if possible, one at each side, to save fall and expense. The spill-box is about 16 feet long, 14 inches wide, set perfectly level. The crest next the canal is brought to a sharp edge, and so are the 2x4 pieces on that side of the box. The gate for opening the orifice is of galvanized iron, worked by a rod and wing nut from the end of the box, so that it may be adjusted to any desired size of opening, and locked. The side of the opening is protected by strips of galvanized iron, with the double purpose of protecting the orifice from surreptitious enlargement and furnishing a groove for the gate to slide in. Mr. Foote thinks that the main ditch need not lose more than a few inches fall—enough to have the excess spill back. Mr. Graves prefers at least a foot.

These have been introduced on the canals with which Mr. Graves was connected—the Monte Vista or Citizens canal, the Rio Grande or Del Norte, the Grand River and the Montrose, which include the largest canals in the State, and it is now, 1891, being introduced on the North Poudre canal. The farmers whom I questioned in the San Luis Valley expressed themselves as perfectly satisfied with its fairness.

The success of the device for maintaining the head constant is very good, though it cannot be said to be perfect. It may be made much more sensitive. Under normal conditions

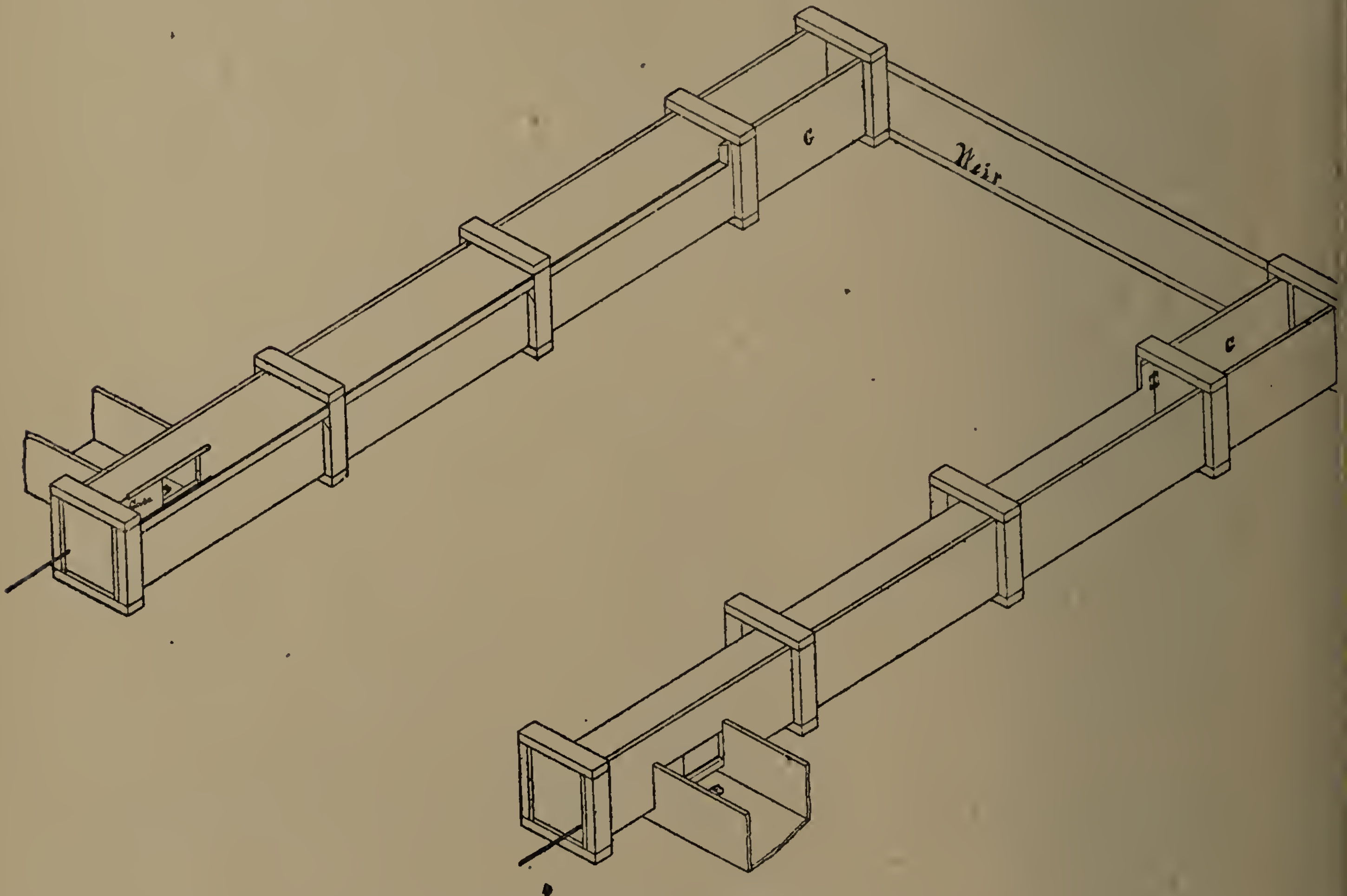


Figure 5—THE SPILL-BOX.

(As usually placed in pairs.)

The weir is placed across the ditch, making the ditch lower below than above, giving apportunity for the water to spill back into the ditch. G is a moveable gate to regulate the amount of water admitted at different stages of water in the canal.

the variations in head will be confined within small limits. As the spill-box is especially a device for keeping the head constant it may be used either with the weir or with the inch system, or with any form of opening. It would be very easily adapted to the Cippoletti form of weir. Unfortunately in its adoption by the companies with which Mr. Graves was connected the inch system of measurement was in use. With a single spill-box, when the opening is of different sizes, there will be caused a velocity of approach in the water which will tend still further to the favor of the larger opening. The effect of this may be lessened by making the width of the box greater for the greater discharges.

By making the box longer, so as to increase the length of the edge over which the water spills the device may be made more sensitive. Mr. J. C. Ulrich, C. E., the successor of Mr. Graves as Chief Engineer of several of the large canals in the San Luis valley, and of the North Poudre Canal, has in some places adopted on the latter canal a form where the box is placed so that it spills on both sides, and the sharp edge is made on both sides of the box.

THE WEIR MODULES.

But of all forms of modules, or that which best satisfies the first condition of accuracy, is the form of opening known as the weir, or overfall (French, *Deversoir;* Italian, *Stramazzo;* German, *Ueberfall*). It is not intrinsically more accurate than many other forms of openings, but as it is so simple that the conditions for accuracy may be readily met, and because there is a vast fund of experimental knowledge regarding its behavior under different conditions, no other form of opening can compare with it in accuracy.

Because of these facts and the growing importance of accuracy, the coming module will be based upon the weir. It is gradually displacing other types. Australia is using it, exclusively, we think; India, to a large extent, and in Italy, the originator of most of our measures, the newer canals are using it to the exclusion of the Milanese module. The old canals will probably continue the use of the old module, for rights have become vested in measurement by them, and consumers are jealous of change. A large portion of the newer canals in Colorado provide that measurement shall be made over a weir. So far as learned no canal has abandoned its use. Cippoletti, who was commissioned by the Canale Villoresi to propose a new module in obedience to the requirement of the Italian government, says in regard to the weir:

"It is indisputably demonstrated that in weirs with complete contraction, constructed and observed with the necessary accuracy, *the coefficient of contraction remains constant*, and Francis' formula guarantees the exactness of the discharge with an error not greater than *one-half of one per cent.* for depths of water from 3 to 24 inches; providing the length of the weir is not less than three—or better yet, four—times the depth of water flowing over it."—[Cippoletti, Canale Villoresi, Modulo per la dispensa delle acqua, Milano, 1886, p. 135.

Two forms will be considered, and tables given for their discharge—the rectangular weir, whose sides are vertical, which is the one ordinarily meant when weir is spoken of, and the one which has been the subject of experiment; and the trapezoidal weir proposed by Cippoletti, after a thorough investigation. Its sides are inclined at a slope of one-fourth horizontal to one vertical.

The most complete experimental investigation of the flow of water over weirs has been made by Americans, and the adopted formula is due to one of them. To the careful experiments of the late Jas. B. Francis, Past President American Society Civil Engineer, Honorary Member American Society Irrigation Engineers, of Lowell, Mass., is due the ordinary form of the equation of the weir, and to his careful work hydraulic science owes much. At Lowell were located a number of manufacturing enterprises drawing their water from the Merrimac river. Their combined capital was over thirteen millions of dollars. It became necessary to determine a more definite measurement of the water, and Francis' experiments were instituted for this purpose. Carried on with all the appliances and conveniences which the capital interested would warrant, the experiments were performed with such care and with such attention to minute sources of error, that they are above criticism.

One difficulty in such experiments is to obtain a suitable basin in which to measure the water. In this case, Francis was fortunate in having one suitable in the Lower Locks, into which the water could be deflected at will after passing the weir. The lock was carefully prepared. Cracks were filled, leaks stopped, even the depressions about nail heads filled up. The remaining leakage was ascertained by exper-

Figure 6.

iment. The slight increase in capacity due to bulging when full was ascertained. The total capacity of the basin when 9½ feet deep was over 12,000 cubic feet.

A preliminary set of experiments was made for determining the proper form of the equation of the weir and after this was determined, the main experiments were devoted to finding the numerical value of the coefficient of the formula. The formula indicated by his experiments has since been standard within the limits indicated by him. If one observes the flow of water through an orifice he will notice that the stream becomes narrower at the opening or is subject to lateral contraction. If over a weir, the sheet of water becomes thinner immediately below the crest, as in Fig. 6, or is subject to a vertical contraction. By taking separate account of these two contractions, Francis succeeded better than previous experimenters in producing a formula which represented the discharge. The form of the equation indicated by theory and agreeing closely with Francis' experiments, is of the form.

$$Q=aLH^{\frac{3}{2}}$$

Where Q=the quantity of water flowing in cubic feet per second, L=the *effective* length of the weir in feet. This is not necessarily the same as the actual length of the weir. It is mentioned more fully on the next page.

H=the depth of water flowing over the weir, in feet. Because of the contraction shown in Figure 6, this must be measured far enough from the weir to be free from its influence. If the water approaches with a current, this depth needs to be increased by a correction indicated by theory. This correction is troublesome to make. In practice it is better to so reduce the velocity of the current that the correction will be so small that it may be neglected. Table II. in the appendix gives the amount of this correction in different cases.

a is a numerical coefficient which is needed to multiply the result obtained by the indicated operations in the measured quantities, in order to give Q the discharge.

From his experiments, an abstract which cannot convey an idea of the care and skill used in the experimentation, Francis adopted the value of 3.33 for *a*; 3⅓ would agree a little more closely, and is slightly more convenient for independent calculation. The value of 3.33 is almost universally adopted.

The formula of Francis then becomes

$$Q=3.33\,LH^{\frac{3}{2}}$$

where the letters mean the same as above and with the same restrictions.

Q represents the discharge in cubic feet per second.

L and H are both measured in feet and decimals.

Sometimes it is convenient to make measurement of the depth in inches. Scales giving decimal parts of feet are not common. In such case the following formula may be used. Q is the discharge in cubic feet per seeond in both cases.

Where depth is measured in inches, and length of *the weir is given in inches*, then

$$Q\text{ (sec. ft.)}=.0798\text{ L (in inches) }H^{\frac{3}{2}}\text{ (in inches.)}$$

Where depth is measured in inches, but the length is *given in feet.*

$$Q\text{ (sec. ft.)}=.006675\text{ L (in feet) }H^{\frac{3}{2}}\text{ (in inches.)}$$

An additional word needs to be said regarding L.

L is the *effective* length of the weir, which in case of the rectangular weirs, is not necessarily the same as the actual length.

ABSTRACT OF FRANCIS' EXPERIMENTS ON WEIRS.

(Depth has in all cases been corrected for velocity. Supply canal 14 feet wide.)

Serial No.	Depth of Water on Weir in feet.	Coefficient for the Experiments	Length of Weir, feet	No. Contractions	COMMENTS
1–4	1.56	3.318	10	2	SERIES A. Crest of weir is 5 feet above bottom of channel of approach
5–10	1.25	3.334	10	2	
11–33	1.00	3.322	10	2	
56–61	0.80	3.325	10	2	
72–78	0.62	3.328	10	2	
36–43	1.06	3.353	10	2	SERIES B. Same as A, except that crest is only 2 feet above bottom of channel.
62–66	0.83	3.340	10	2	
79–84	0.65	3.326	10	2	
44–50	0.98	3.341	10	0	SERIES C. Canal made same width as the weir, suppressing contraction, otherwise as in A.
67–71	0.80	3.339	10	0	
51–55	1.00	3.327	10	0	SERIES D. Water cannot expand after passing weir.
34–5	1.02	3.360	8	4	SERIES E. Water 5 feet deep.
85–8	0.68	3.337	8	4	Water 2 feet deep. In both sets two bays, separated by partition 2 feet wide, giving 4 contractions.

Series C and D correspond to cases of weirs erected in flumes and of same width as flume, C to weir at lower end, D to weir at middle.

Attention has already been called to the contraction of a stream as it passes through the weir or other opening. This will be especially noticed in cases where the opening is smaller than the channel leading to it. The formula giving the discharge really consists of several factors, one of which is the velocity of the water passing the weir, and another the sectional area of the stream where it has this velocity. Now the effect of the contraction is to lessen the area, not of the weir, but of the stream passing through it in which the water has the velocity given by the other factor. In consequence, the *effective* length of the weir is shortened. Hence in this formula, for L is used, not the actual length of the sill, but the *effective* length, which is found by applying a correction for the contraction to the measured length.

The amount of this contraction depends upon the distance that the sides are from the parallel sides of the weir. When close, the contraction is small, but when the distance is two or three times the depth on the weir, there seems to be no further change in the contraction with the increased distance. In such case, the contraction is said to be complete. From the case of complete contraction there may be all degrees of contraction down to no contraction.

The amount of this contraction, when complete, increases with the depth of water flowing over the weir. It is difficult and unreliable to measure the amount directly. But we again have recourse to the experiments of Francis, from which it is determined that with complete contraction, and the same formula, that if an allowance be made, equivalent to a shortening of the weir equal to one-tenth of the depth of the water flowing over it, for each complete contraction, the discharge

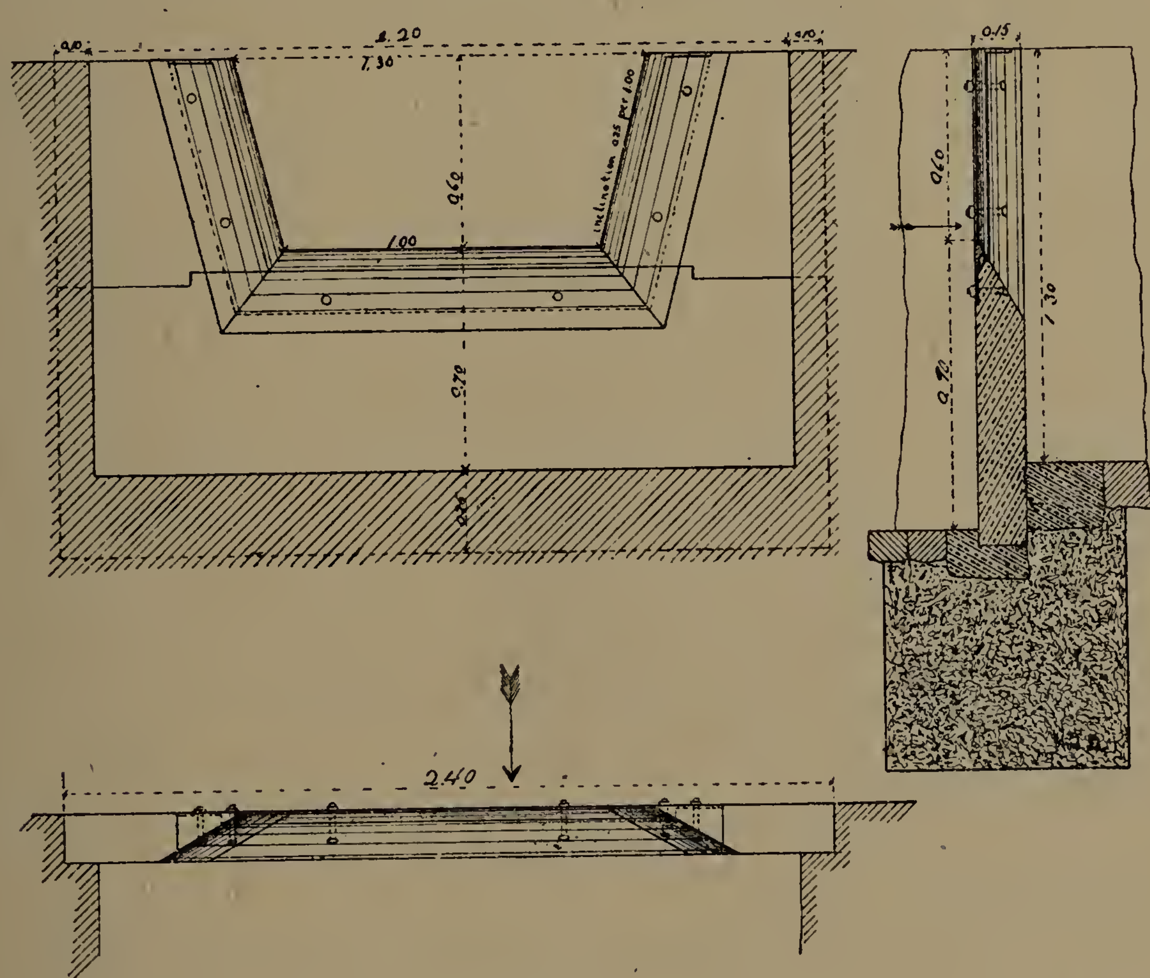


FIGURE 7.

will be given, other conditions being correct, within 1 per cent.

Thus, we may take an example from the abstract of Francis experiments, given on page 26.

In the case where the depth is 1.56 feet, there are two contractions, hence the effective length of the weir, or the length to be taken in the calculation of the discharge, is not ten feet, but ten feet shortened by two (the number of contractions) times one-tenth of 1.56 feet; or .31 feet less than 10 feet. The effective length is accordingly 9.69 feet. With the same weir, but a depth of .80 feet, the effective length, or the value of L to be used in the computation, is .16 less than 10 feet or 9.84 feet.

It is seen that the effective length varies with different depths with the same weir. It is because of this, that of two weirs, one twice as long as the other, of the rectangular pattern, the one will not give exactly twice as much as the other, even for the same depths. But if the two have their effective lengths, so that one is twice the other, then the discharge of one will be twice that of the other.

The Cippoletti weir is a form adopted in order that the effective lengths are constantly the same as the measured length of the weir.

The weir here called the Cippoletti weir because of its originator, is one proposed by Cippoletti to meet the conditions which the Italian government laid upon the company which was given a concession of water for the Canale Villoresi, the last of the great Italian canals. This canal was built a few years since as a "high line" canal to water land above the existing canals. It waters about 125,000 acres, between the Ticino and Adda rivers, just north of the city of Milan. In the act of concession to this canal, the government required the company to propose a module for the measurement and sale of water which should be based upon the theory of the weir with free fall, and that the module should be accurate. The problem was put in the able hands of Cesare Cippoletti, the engineer in charge of construction. The problem Cippoletti proposed to himself, was, while preserving the simple and convenient form of the Francis formula, to determine the form and condition of the weir so that the discharge should be proportional to the length of the weir, and so that no single cause should produce an error of more than one half of 1 per cent.

Taking the experiments made by Francis as a basis, he attempted first to determine a form of the weir in which the contractions at the sides should be automatically overcome.

In the rectangular weir, as already mentioned, the effect of the contraction increases in proportion to the depth. The idea suggested itself to him, that by making the form of the weir so that the area increases by an amount in proportion to the depth on the weir, then if the increase in area can be made so as to exactly balance the loss due to the contraction, the flow through the weir would remain the same as though the weir were rectangular, of the same length of sill, but without contraction. In other words, the effective length would remain the same for all depths. Manifestly, a weir of a trapezoidal shape, like that in Figure 7 presents the condition wherein the increase in area is in proportion to the depth on the weir. This is the fundamental idea in the Cippoletti weir.

This form is equivalent to the rectangular weir, with a triangle added at each end. In order that the flow through the added triangles shall be equal to the amount lost by the contraction, recourse is had to experiments and from calculation, the inclination of the sides is found to be such that a slope of one horizontal to four vertical would be sufficient, provided the coefficient of contraction remains constant. This is not quite an exact supposition, but the difference is insensible.

The experimentation with water so as to make the results worthy of confidence requires such exceptional facilities, and skill in experimentation, the first of which certainly was not accessible to Cippoletti, that he based his confidence in the constancy of the coefficient of contraction upon the constancy shown in the experiments of Francis and other experimenters. The experiments which have been made upon this weir seem to have been made in this country.

Attention was first called to the weir and its adaptability to purposes of irrigation in the first edition of this bulletin in 1890. Experiments had been previously made on weirs of that shape, such as our limited apparatus allowed, which were limited to weirs of 6 and 12 inches in length. Further experiments were made under direction of Professor Church of Cornell University by T. B. McVickers* but the most complete ones have been made by two students, Messrs. A. D. Flinn and Dyer, of the Worcester Polytechnic School of Worcester, Mass., who took the subject for their graduation thesis. These young men were permitted to use the testing apparatus at Holyoke, Mass., erected under the direction of Clemens Herschel, a well known hydraulic engineer. In their case the experiments could only be made by comparison with the flow over a rectangular weir The measurements were made on weirs 3, 4, 5, 6, 7, 8, and 9 feet long. These indicate an error slightly in excess of that expected by Cippoletti, and that the coefficient of contraction is less than .62 which was taken by him in determining the inclination of the sides. But the relation between weirs of different lengths, that their discharge should be in proportion to their length, is closely true. This is the feature for which the weir has been brought forward in the previous editions of this bulletin for irrigation purposes.†

*_Engineering Record_, Aug. 13, 1892.

†Manuscript of experiments furnished by Mr. Flinn. Results to be published Trans-American Society Civil Engineers, 1894.

The weir measurement is accurate, *provided the proper conditions are observed*, but the conditions for the construction of weirs are not generally known, and less generally observed. It should also be understood that it is safe to apply the formula only within the limits of the experiments on which it is based. The results either by the weir or other orifices, are exact only so far as our experimental knowledge goes. The theory of the flow of water under even the simplest conditions is still too incomplete, and the laws too imperfectly understood to allow of passing much beyond the data with which we are possessed. In order that a weir formula should apply beyond these limits, the value of the coefficient a, in the formula would be a varying one. In the Francis formula the coefficient is given a constant value, the disturbing effect of the side contraction being taken into account by varying the value of L. But if the weir be placed so as to meet the following conditions, the formula above given, and the tables attached to this bulletin, may be used with confidence that the result is correct within 1 per cent.

CONDITIONS FOR THE WEIR, EITHER RECTANGULAR OR TRAPEZOIDAL.

In nearly all cases, the weirs placed for measurement, are not placed with sufficient care to make the measurement one of great accuracy. The present demand for water, which is to increase, will gradually require more care in every detail. The weirs commonly used are of timber with board sills and sides, not usually made in a wide enough or deep enough channel.

With the more pressing demand for exact measurement which is coming already in Northern Colorado, companies will soon be justified in constructing permanent weirs, with much care. Under the Canale Villoresi where the Cippoletti weir was first used, all the weirs examined by the writer were construced of cut stone, and the crests and sides were made of iron plates, the whole made with care so as to remain useful for generations to come.

If the following conditions are followed in constructing a weir, whether it be rectangular or trapezoidal, the weir formula may be used with confidence that no single cause will produce an error greater than one half of 1 per cent. The conditions are essentially the same as those either of Francis or of Cippoletti.*

1. That the channel leading to the weir be of constant cross-section, its axis passing through the middle of the weir,

*Canale Villoresi. Modulo per la Dispensa delle Acqua, etc, Milan 1886, published by the Societa Italiana per Condotte d'Acqua.

and perpendicular to it; this straight reach to be of such length that the water flows with uniform velocity, without internal agitation or eddies. This should be not less than fifty or sixty feet, more if possible.

2. Only by making the contraction complete on both sides and bottom can the coefficient *a* in the formula have a value free from uncertainty, and to secure complete contraction, it is necessary:

(*a*) that the opening of the weir be made in a plane surface, perpendicular to the course of the water;

(*b*) that the opening itself have a sharp edge on the upstream face, and its walls cut away so that their thickness at the point of discharge shall not be above 1-10 the depth for depths below 5 inches, nor above ¼ the depth for depths from 5 to 24 inches;

(*c*) that the distance of the sill of the weir from the bottom of the canal be at least three times the depth on the weir;

(*d*) that the distance of the sill of the weir from the sides of the channel, be at least twice the depth of the water flowing over the weir;

(*e*) that the lateral contraction remaining undisturbed, the length of the weir shall be three, or better four, times the depth of the water flowing over;

(*f*) that the depth of water flowing over the weir shall not be less than 3 inches.

3. The velocity of approach must be very small; for weirs three feet long and depth of 12 inches, it ought not to be greater than 6 inches per second; for weirs of six feet long and depth of 24 inches it ought not to be above 8 inches per second. In all these cases the cross-section of the canal of approach ought to be at least seven times that of the weir. Other conditions affecting the velocity of approach are included in *c*, *d*, and *e*, respecting complete contraction.*

4. The layer of falling water should be perfectly free from the walls below the weir, in order that air may freely circulate underneath. For short weirs it is sufficient that the lateral walls of the lower canal be free from the sides of the weir. In such case, when air freely passes underneath, the level of the water in the lower canal has no influence on the discharge of the weir, unless it reaches or exceeds the level of the crest.

5. The depth of the water should be measured with accuracy where the suction of the flow does not affect the

*Table I. will aid in obtaining proper proportion between the channel of approach and the weir.

height and where it is free from influences such as the wind, or the movement of the water, which can affect the true level. The height should be read to within 1-300 of the depth in order that the error may be within one-half of 1 per cent.

6. The weir ought to be constructed with care and carefully located. It should not vary more than 4 degrees from being perpendicular to the channel. Its sill should be horizontal.

The disturbing causes may be divided into three classes; those which always tend to to increase the discharge over the computed amount; those which always tend to decrease the amount; and those which may either increase or decrease the amount, one being as likely to occur as the other, and in the long run tending to balance each other.

The measurement of the depth of water is in general as likely to be too great as too small, with careful measurement, and the errors due to this may be neglected.

The effect of obliquity of the weir, or of eddies is to decrease the flow below the computed amount.

The effect of any velocity of the water as it approaches the weir, of the nearness of the sides or bottom to the weir, incomplete contraction, of a crest not perfectly sharp, of air not having access beneath the sheet of falling water, etc., the effect of each of these is to increase the discharge.

The causes tending to increase the discharge evidently out number those tending to decrease it, and are, all things being taken into account, more difficult to overcome.

It is frequently not possible to meet all the conditions. But the errors due to the weir not being vertical, or horizontal, or perpendicular to the current, or for crest not being sharp, can be obviated by careful construction.

If the weir is not vertical, the discharge is increased or diminished, according as the inclination may be down or up stream. The correction amounts to 4 per cent for inclinations as great as one horizontal to three vertical, or for angles of about 18 degrees.* For less inclinations the correction would be less.

The effect of nearness of the sides in increasing the discharge, amounts to about one per cent. when the distance is equal to the depth of the water on the weir, about ⅓ of one per cent. when the distance is 1½ times the depth, and may be neglected when over twice the depth of water on the weir.

* From experiments made by M. Bazin, Annales des Ponts at Chaussees, Jan. 1890. Translated in Proc. Engrs. Club, of Phila. by Marichal and Trautwine. Also, Trautwines' Engrs. Pocket Book, 16th ed., p. 267 1.

The effect of nearness of floor is to increase the discharge. When the depth below the crest is three times the depth over the weir the increase is insensible; if 2.5 times the depth, is less than one-half of 1 per cent., if 2 times the depth nearly 1 per cent., if equal to the depth is 1.5 per cent. and if but one-half the depth, over 2 per cent. The amount of this varies with other conditions.

An increase of temperature seems to increase the discharge, and the presence of sediment has the same effect through action on the surface tension of the liquid. With large openings the effect of the temperature is less than with small. Under present conditions they need to be neglected. Their influence is small.

The velocity of approach is, all things considered, the most difficult to reduce within reasonable limits, and the errors thus introduced in ordinary measurement are the most considerable. It is not possible to entirely prevent velocity in the approaching water, but by properly proportioning the size of the channel to the opening of the weir, the velocity may be reduced to such limits that its effects may be neglected. A comparison of tables I. and II. for allowing for velocity of approach will show this. As the water for irrigation is liable at times to carry sediment, the space in front of the weir under most conditions is liable to fill up. The water being thus confined to a smaller cross-section, the velocity is augmented, increasing the discharge for the same depth over the weir. It is troublesome to make the computation for the allowance for velocity of approach, the better way being to keep within the bounds indicated by the conditions on page 31, or within limits indicated by study of tables I. and II; but where necessary the following method may be used; with velocities of less than 1.5 feet the results will be correct. For greater velocities it seems probable that the correction is not quite sufficient. It should also be remembered that this correction is only for the additional head due to the velocity:

Let H = the head passing over the weir, measured in quiet water, several feet from the crest.

h = the head which would give the velocity of the water in the channel of approach. This velocity may be found by determining the quantity passing over the weir, by reference to the tables, without correcting for velocity. Then the velocity is

$$v = \frac{Q}{A}$$

Where A is the area of the section of the channel above the weir in square feet, and Q is the quantity in cubic feet per second. Then

$$h = \frac{v^2}{64.4}$$

the denominator being twice the acceleration of gravitation, The correction for velocity is then made by using in the weir formula, $Q = 3.33\ LH^{\frac{3}{2}}$, $H + \frac{3}{2}h$ instead of

H as the depth to be taken. This form of correction is due to Fteley and Stearns.* It gives a much larger correction for velocity than is furnished by the Francis correction, but it agrees much better with measurements I have made for high velocities. The experiments on which it was based were limited to velocities of 2.5 feet per second. Table II. gives the per cent increase in discharge caused by different velocities. It will be seen how great this correction becomes, sometimes causing an increase of several hundred per cent., and, consequently, shows the importance of keeping the velocity within low limits.

To aid in the practical allowance for velocity of approach, two tables have been prepared and are printed as tables I and II of the appendix. Table II shows the increase in per cent. over the quantities given in tables III and IV by various velocities of approach. The increase with a given velocity varies with the depth of water over the weir, being greater for small depths. A velocity of one foot per second increases the discharge over a weir when the water is flowing 3 inches deep, over 14 per cent; if flowing over the weir 1 foot deep, only 3.5 per cent. The table I shows what the average velocity is as the water passes through the weir, or it shows what is the velocity in the channel if the section is the same as that of the weir, as it frequently is. A comparison of the two tables will show the proper section to give the channel in order that the resulting error shall be within reasonable limits.

As the effect of the causes which tend to increase the discharge cannot be entirely eliminated, the tendency is to increase the discharge. In consequence of this, Cippoletti proposed to increase the amount as computed by the Francis formula by 1 per cent. making the formula,

$$Q = 3.36\tfrac{2}{3}\ LH^{\frac{3}{2}}.$$

But as it seems probable that the coefficient of discharge assumed by him was too large, the ordinary formula will be better to use in the dearth of sufficiency of experimental knowledge.

The Cippoletti form of weir because of the reasons already given has the most advantages of any module known to the writer for measurement of water for irrigation purposes. It is reliable to within 2 per cent. with the Francis formula, if placed according to the conditions given, and probably within 1 per cent. The ordinary methods of measuring or guessing at the discharge of water vary from 40 to 400 per cent., as usually used. All that may be said of its advantages, save the one of having the effective length of the sill in proportion to the actual length of the sill is true of the rectangular weir also. It meets most of the conditions for a good module. It lacks means of self-adjustment, or of preserving constant heights of water. Where adapted, the spill-box may be used in connection with it, when that condition would be very nearly met. Several canals have introduced essentially this combination, and so far as reports have reached the writer they have been satisfactory.

SUBMERGED WEIRS.

In some cases the water in the lower canal may be higher

* Trans-Am. Soc. C. Eng. 1884.

than the crest of the weir. If air has free access under the falling sheet it may be as high as the crest, without affecting the discharge; but if higher, the discharge is affected. The form is objectionable. In such cases the discharge may be found approximately.

Let H = the depth of water over the weir, up-stream side, in feet; h = the depth below the weir, above the crest, both measured in still water. The latter should be below the wave which is formed below the weir and measured in feet; $d = \mathrm{H} - h$.

The discharge may be found approximately by considering that the water flows over the weir for the depth, h, as though it came through an orifice of that height and under pressure H — h, and the upper portion of the stream for the remaining depth H — h, or d, flows as over a weir.

The discharge of the weir portion may be computed according to the tables given with this bulletin or by the formula.

The discharge for the opening height, h, may be computed by determining the velocity due to the head, d, in feet per second, which according to the Torricellian theorem, is $\sqrt{2gd}$, where $g = 64.4$. The discharge through a foot length of the lower portion would then be $4.8\, h \sqrt{d}$, approximately. That of the weir, $3.33\, d^{\frac{3}{2}}$. Hence, the total discharge would be, for a portion of length L feet,

$$Q = 3.33\, \mathrm{L}\, d^{\frac{3}{2}} + 4.8\, \mathrm{L} h \sqrt{d}.$$

This is not likely to vary by 5 per cent. if measurements are correctly made. All dimensions are measured in feet; the discharge is given in cubic feet per second.

It is better to avoid the submerged weir, and instead use a flume placed in the ditch, of the same cross-section as the ditch, which should be rated at the different depths in the same manner as the measuring flumes near the heads of the canals in Colorado. The methods of the use of these will be described in a future bulletin.

THE TRIANGULAR WEIR.

The triangular notch or weir, proposed by James Thomson, has been strongly recommended, as it has certain advantages due to the fact that the orifice preserves the same shape for all depths, and the ratio of the area to the weir perimeter remains constant. The discharge depends only on the depth as well as the angle, instead of the width which is usually necessary also. The equation for the flow through such an opening may be found without difficulty to be

$$Q = \tfrac{8}{15}\, m\, \mathrm{T} \sqrt{2g}\, h^{\frac{5}{2}}$$

where m is the coefficient of contraction, T the tangent of one-half the angle, g the acceleration of gravitation and h the depth. Giving m the value 0.62, which is about the average value for such an orifice, and g its value, the formula becomes

$$Q = 2.65\ T h^{\frac{5}{2}}$$

where Q represents the discharge in cubic feet per second, and h is measured in feet. For right angle notches it is then

$$Q = 2.65\ h^{\frac{5}{2}}.$$

EXPLANATION OF TABLES.

Tables I and II in the appendix are for the purpose of correcting to allow for the errors due to velocities in the approaching water without the troublesome calculations indicated.

Table I. is an auxiliary table giving the average velocity through the weir for different velocities over the weir. It may be used to determine the velocity of the water as it approaches the weir, under known conditions, or with the aid of the second table, to determine the proper conditions of the size of the channel, in order to bring the errors within assigned limits. The velocity given is the average velocity in the plane of the weir. If, then, the cross-section of the channel above the weir is no larger than the weir itself, the velocity of the water through the section would be the same as that of the table. If the section is twice that of the weir, then the velocity is one-half that of the table.

Table II is computed from the Fteley formula on page 33, and expresses the increase due to velocity over that given in the tables III–VI. To use, the discharge as given in tables III–VI is determined, and the correction is applied according to the given depth over the weir and the velocity of approach. The correction is expressed in per cent. The formula is based on experiments limited to 2.5 feet per second. For greater velocities, therefore, it is possible that the quantities given are in error.

Example.—What correction to allow for the velocity of 2 feet per second, the water passing over weir 1 foot deep. Find at top the column with depth 1 foot, and at left find line with velocity of 2 feet per second. Follow the line to the right and in the column with depth 1 foot the number 11.3 is found which is the number of per cent. by which the discharge is increased.

Tables III and IV are newly computed for this edition, and give the discharges over weirs with the depths measured in inches and fractions corresponding to the divisions on the rules ordinarily in use. They are computed from modified forms of the Francis formula, the depths being measured in inches.

Table III is computed from the formula, $Q = .006675\ LH^{\frac{3}{2}}$, Q being in cubic feet per second, L and H in inches.

Table IV is computed from $Q = .080107\ LH^{\frac{3}{2}}$, where Q is in cubic feet per second, L is in feet, H is in inches. It is the Francis formula with the units changed.

Tables V and VI were given in previous editions, but the depths being given in decimals of feet were not so convenient for use with scales which most people possessed which are divided into feet, inches and fractions.

In table III the discharge is given for a weir one inch long, forming a portion of a longer weir, and for all depths up to 30 inches, the depths varying by sixteenths of inches. The even inches are given in the left hand column and fractions at the top of the page. The discharge for the corresponding inch and fraction is found at the intersection of the line of the even inch and the column of the fraction. Where there are contractions, the amounts to be subtracted are given in the second column. These are given for intervals of half inches, the quantities there given being for the even inch or half inch of the adjoining column, and for two complete contractions.

Example.—What is the discharge over a weir 45 inches long and with a depth of 11¼ inches with two complete contractions?

Find 11 inches at the left of the page, and the column headed ¼ inch at the head of the page. Follow this column down until it intersects the line of the 11. At the intersection is the discharge, for a portion of the weir 1 inch long, which is .2519 cubic feet per second. Then for a weir 45 inches long it is 45 times as much, or 11.3345 second feet, if without contraction. The second column gives ɪe allowance for contraction for 11 inches depth; the eleventh column for a depth of 11½ inches. or 11¼ inches we then take a value intermediate between those for 11 inches and 11½ inches, ob- ining the correction .567, the amount by which the discharge is reduced. This, then, leaves the otal discharge as 11.335 — .567 = 10.77 second feet.

Table IV is used in exactly the same way. In this table the discharge is iven for a portion of a weir 1 foot long, while No. III gives it for a weir 1 in. long.

These two tables are consequently adapted to weirs of any length, but re- uire multiplication.

Tables V and VI give the discharge for weirs of certain lengths, for different epths, and without multiplication. Where companies adopt weirs for measure- ıent it is far more convenient to adopt certain standard lengths and make all weirs onform thereto.

Table V gives the discharge over rectangular weirs for depths varying by)25 of a foot and for various lengths of weir. These tables give the discharge with wo complete contractions. In case there is no contraction, then the amount in the ight hand column may be added to the amounts given in the table.

The amounts given in the boldface figures are for those cases where the con- itions of depth and length of weir are such as to make the results the most reliable.

Table VI is for rectangular weirs without contraction—which may also be ound from table V, and for the Cippoletti trapezoidal weirs. It will be noticed ıere that the discharges given in the various columns are directly proportional to he length of the weir, while in table V they are not. The amounts are 1 per ent greater than given in table V. The quantities in table V were computed with he constant 3⅓ instead of 3.33 ordinarily used, making the quantities 1-10 of 1 per ent. greater than given by most tables. Table VI, intended for trapezoidal weirs s 1 per cent. greater than corresponding discharges of table V.

Depth in all cases in the following tables is measured in still water. **See ›age 25.**

TABLE I.

Auxiliary Table for Approximating to Velocity of Approach.

Depth of water over weir.		Average velocity in section of weir.	Depth of water over weir.		Average velocity in section of weir.
in ft.	in in.	in ft. per sec.	in ft.	in in.	in ft. per sec.
.25	3	1.665	1.75	21	4.400
.50	6	2.354	2.00	24	4.709
.75	9	2.884	2.25	27	4.995
1.00	12	3.330	2.50	30	5.265
1.25	15	3.723	2.75	33	5.510
1.50	18	4.078	3.00	36	5.765

TABLE II.

Corrections in per cent. for velocity of approach, to be applied to values obtained from Tables III to VI.

Velocity.	Head.*	DEPTH OVER WEIR, IN FEET.											
		.25	.50	.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
.25	.0010	00.8	00.4	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
.50	.0039	03.5	1.8	1.2	0.9	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3
.75	.0087	08.0	4.0	2.6	2.0	1.6	1.3	1.1	1.0	0.9	0.8	0.7	0.7
1.00	.0155	14.3	7.1	4.7	3.5	2.8	2.3	2.0	1.8	1.6	1.4	1.3	1.2
1.25	.0243	22.6	11.1	7.4	5.5	4.4	3.7	3.1	2.7	2.4	2.2	2.0	1.8
1.50	.0350	33.1	16.1	10.7	8.0	6.4	5.3	4.5	4.0	3.5	3.2	2.9	2.6
1.75	.0476	45.7	22.2	14.6	10.9	8.7	7.2	6.2	5.4	4.8	4.3	3.9	3.6
2.00	.0622	60.9	29.2	19.2	14.3	11.4	9.5	8.1	7.1	6.3	5.6	5.1	4.7
2.25	.0787	78.6	37.4	24.5	18.2	14.5	12.0	10.3	9.0	8.0	7.2	6.5	6.0
2.50	.0971	99.1	46.7	30.5	22.6	18.0	14.9	12.7	11.1	9.9	8.9	8.0	7.4
2.75	.1175	121.8	56.9	37.0	27.4	21.8	18.0	15.4	13.4	11.9	10.7	9.7	8.9
3.00	.1398	149.4	69.1	44.8	33.1	26.2	21.7	18.5	16.1	14.3	12.8	11.7	10.7
3.25	.1641	179.6	82.3	53.1	39.1	30.9	25.6	21.8	19.0	16.9	15.1	13.7	12.6
3.50	.1903	213.5	96.9	61.7	45.7	36.1	29.9	25.4	22.2	19.6	17.6	16.0	14.6
3.75	.2185	251.3	113.0	72.3	53.0	41.8	34.5	29.4	25.6	22.6	20.3	18.4	16.8
4.00	.2486	293.1	130.7	82.6	60.9	47.9	39.5	33.6	29.2	25.9	23.2	21.0	19.2

*Head $= \frac{v^2}{64.36}$ v being velocity in feet per second, in first column.

TABLE III.—Discharge Over Weir One Inch Long, in Cubic Feet per Second.

Depth. Inches.	Correction to be s'btracted for 2 side contractions.	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16	Correct'n to be s'btracted for 2 side contract'ns.	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16
3	.0208	.0347	.0358	.0369	.0380	.0391	.0402	.0414	.0425	.0306	.0437	.0449	.0461	.0437	.0485	.0497	.0509	.0522
4	.0427	.0534	.0547	.0559	.0572	.0585	.0598	.0611	.0624	.0574	.0637	.0651	.0664	.0677	.0691	.0705	.0719	.0732
5	0746	.0746	.0760	.0775	.0789	.0803	.0817	.0832	.0846	.0947	.0861	.0876	.0891	.0905	.0920	.0936	.0951	.0966
6	.1177	.0981	.0997	.1012	.1027	.1043	.1059	.1075	.1090	.1438	.1106	.1122	.1138	.1154	.1171	.1187	.1203	.1220
7	.1732	.1236	.1253	.1270	.1286	.1303	.1321	.1337	.1354	.2057	.1371	.1388	.1406	.1423	.1440	.1458	.1475	.1493
8	.2417	.1511	.1528	.1546	.1564	.1582	.1600	.1618	.1636	.2812	.1654	.1673	.1691	.1709	.1728	.1746	.1765	.1784
9	.3244	.1802	.1821	.1840	.1859	.1878	.1897	.1916	.1935	.3714	.1955	.1974	.1993	.2013	.2032	.2052	.2072	.2091
10	.4222	.2111	2131	.2151	.2171	.2191	.2211	.2231	.2251	.4770	.2271	.2292	.2312	.2332	.2353	.2373	.2394	.2415
11	.5358	.2435	2456	.2477	.2498	.2519	.2540	.2561	.2582	.5988	.2603	.2625	.2646	.2667	.2689	.2710	.2732	.2753
12	.6660	.2775	.2797	.2818	.2840	.2862	.2884	.2906	.2928	.7376	.2950	.2972	.2995	.3017	.3039	.3062	.3084	.3106
13	.8135	.3129	.3152	.3174	.3197	.3220	.3243	.3265	.3288	.8940	.3311	.3334	.3357	.3380	.3404	.3427	.3450	.3474
14	.9791	.3497	.3520	.3544	.3567	.3591	.3615	.3638	.3662	1.0689	.3686	.3710	.3734	.3758	.3782	.3806	.3830	.3854
15	1.1634	.3878	.3902	.3927	.3951	.3976	.4000	.4025	.4049	1.2628	.4074	.4098	.4123	.4148	.4173	.4198	.4222	.4247
16	1.3672	.4272	.4297	.4323	.4348	.4373	.4398	.4423	.4449	1.4765	.4474	.4500	.4525	.4551	.4576	.4602	.4628	.4653
17	1.5909	.4679	.4705	.4731	.4757	.4783	.4809	.4835	.4861	1.7105	.4887	.4913	.4940	.4966	.4992	.5019	.5045	.5071
18	1.8353	.5098	.5125	.5151	.5178	.5205	.5231	.5258	.5285	1.9654	.5312	.5339	.5366	.5393	.5420	.5447	.5474	.5501
19	2.1009	.5529	.5556	.5583	.5611	.5638	.5666	.5693	.5721	2.2418	.5748	.5776	.5804	.5831	.5859	.5887	.5915	.5943
20	2.3883	.5971	.5999	.6027	.6055	.6083	.6111	.6140	.6168	2.5404	.6196	.6224	.6253	.6281	.6310	.6338	.6367	.6396
21	2.6982	.6424	.6453	.6482	.6510	.6539	.6568	.6597	.6626	2.8614	.6655	.6684	.6713	.6742	.6771	.6801	.6830	.6859
22	3.0309	.6888	.6918	.6947	.6977	.7006	.7035	.7065	.7095	3.2061	.7125	.7154	.7184	.7214	.7244	.7274	.7304	.7333
23	3.3872	.7363	.7393	.7424	.7454	.7484	.7514	.7544	.7575	3.5743	.7605	.7635	.7666	.7696	.7727	.7757	.7788	.7818
24	3.7675	.7849	.7880	.7910	.7941	.7972	.8003	.8034	.8064	3.9668	.8095	.8126	.8157	.8189	.8220	.8251	.8282	.8313
25	4.1722	.8345	.8376	.8407	.8439	.8470	.8501	.8533	.8564	4.3840	.8659	.8628	.8659	.8691	.8723	.8755	.8786	.8818
26	4.6021	.8850	.8882	.8914	.8946	.8978	.9010	.9042	.9074	4.8265	.9107	.9139	.9171	.9203	.9236	.9268	.9301	.9333
27	5.0574	.9366	.9398	.9431	.9463	.9496	.9529	.9561	.9594	5.2948	.9627	.9660	.9693	.9726	.9759	.9792	.9825	.9858
28	5.5388	.9891	.9924	.9957	.9990	1.0023	1.0057	1.0090	1.0123	5.7894	1.0157	1.0190	1.0224	1.0257	1.0291	1.0324	1.0358	1.0391
29	6.0467	1.0425	1.0459	1.0493	1.0527	1.0560	1.0594	1.0628	1.0662	6.3106	1.0696	1.0730	1.0764	1.0798	1.0832	1.0866	1.0901	1.0935
30	6.5814	1.0969	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

TABLE IV.—Discharge Over Weir One Foot Long, in Cubic Feet per Second.

Depth. Inches.	Correction to be subtracted for 2 side contractions.	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16	Correction to be subtracted for 2 side contractions.	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16
3	.0208	.4163	.4293	.4425	.4559	.4693	.4829	.4967	.5106	.0262	.5245	.5386	.5529	.5672	.5817	.5963	.6110	.6259
4	.0427	.6409	.6559	.6711	.6864	.7019	.7174	.7331	.7483	.0574	.7647	.7807	.7968	.8130	.8233	.8457	.8622	.8789
5	.0746	.8956	.9125	.9294	.9465	.9636	.9809	.9983	1.0157	.0947	1.0333	1.0510	1.0687	1.0866	1.1045	1.1227	1.1407	1.1590
6	.1177	1.1774	1.1958	1.2143	1.2330	1.2517	1.2705	1.2894	1.3084	.1488	1.3275	1.3467	1.3660	1.3853	1.4048	1.4244	1.4440	1.4637
7	.1732	1.4836	1.5035	1.5235	1.5436	1.5638	1.5840	1.6044	1.6221	.2057	1.6454	1.6660	1.6866	1.7074	1.7283	1.7493	1.7703	1.7914
8	.2417	1.8126	1.8339	1.8553	1.8767	1.8982	1.9199	1.9415	1.9633	.2812	1.9852	2.0071	2.0291	2.0512	2.0734	2.0957	2.1180	2.1404
9	.3244	2.1629	2.1855	2.2081	2.2308	2.2536	2.2765	2.2995	2.3225	.3714	2.3456	2.3688	2.3921	2.4154	2.4388	2.4623	2.4859	2.5095
10	.4222	2.5332	2.5570	2.5809	2.6048	2.6288	2.6529	2.6770	2.7013	.4770	2.7256	2.7499	2.7744	2.7989	2.8235	2.8481	2.8729	2.8977
11	.5358	2.9225	2.9475	2.9725	2.9976	3.0227	3.0480	3.0733	3.0986	.5988	3.1240	3.1495	3.1751	3.2008	3.2265	3.2522	3.2781	3.3040
12	.6660	3.3300	3.3560	3.3822	3.4083	3.4346	3.4609	3.4873	3.5137	.7376	3.5403	3.5668	3.5935	3.6202	3.6470	3.6738	3.7008	3.7277
13	.8135	3.7548	3.7819	3.8091	3.8363	3.8636	3.8910	3.9184	3.9459	.8940	3.9735	4.0011	4.0288	4.0565	4.0844	4.1122	4.1402	4.1682
14	.9791	4.1963	4.2244	4.2526	4.2808	4.3092	4.3375	4.3660	4.3945	1.0689	4.4231	4.4517	4.4894	4.5091	4.5379	4.5668	4.5957	4.6247
15	1.1634	4.6558	4.6829	4.7121	4.7413	4.7706	4.8000	4.8294	4.8589	1.2628	4.8884	4.9180	4.9477	4.9774	5.0072	5.0370	5.0669	5.0968
16	1.3672	5.1268	5.1569	5.1870	5.2172	5.2475	5.2778	5.3081	5.3386	1.4765	5.3690	5.3996	5.4302	5.4608	5.4915	5.5223	5.5531	5.5840
17	1.5909	5.6149	5.6459	5.6770	5.7081	5.7392	5.7705	5.8017	5.8331	1.7105	5.8645	5.8959	5.9271	5.9590	5.9906	6.0222	6.0540	6.0857
18	1.8353	6.1176	6.1495	6.1814	6.2134	6.2455	6.2776	6.3097	6.3420	1.9654	6.3742	6.4065	6.4389	6.4714	6.5039	6.5364	6.5690	6.6017
19	2.1009	6.6344	6.6671	6.7000	6.7329	6.7658	6.7987	6.8318	6.8648	2.2418	6.8980	6.9312	6.9644	6.9977	7.0311	7.0645	7.0979	7.1314
20	2.3883	7.1650	7.1986	7.2323	7.2660	7.2997	7.3336	7.3674	7.4014	2.5404	7.4353	7.4694	7.5035	7.5376	7.5718	7.6060	7.6403	7.6746
21	2.6982	7.7090	7.7435	7.7780	7.8125	7.8471	7.8817	7.9164	7.9512	2.8616	7.9860	8.0208	8.0557	8.0907	8.1257	8.1607	8.1958	8.2310
22	3.0309	8.2662	8.3014	8.3367	8.3721	8.4075	8.4429	8.4784	8.5140	3.2061	8.5496	8.5852	8.6209	8.6567	8.6925	8.7283	8.7642	8.8001
23	3.3872	8.8361	8.8722	8.9083	8.9444	8.9806	9.0168	9.0531	9.0894	3.5143	9.1258	9.1623	9.1987	9.2353	9.2718	9.3085	9.3451	9.3818
24	3.7675	9.4186	9.4554	9.4923	9.5292	9.5662	9.6032	9.6402	9.6773	3.9668	9.7145	9.7517	9.7889	9.8262	9.8635	9.9009	9.9384	9.9758
25	4.1722	10.0134	10.0509	10.0886	10.1262	10.1639	10.2017	10.2395	10.2774	4.3840	10.3153	10.3532	10.3912	10.4292	10.4673	10.5055	10.5436	10.5819
26	4.6021	10.6201	10.6584	10.6968	10.7352	10.7737	10.8122	10.8507	10.8893	4.8265	10.9280	10.9666	11.0054	11.0441	11.0830	11.1218	11.1607	11.1997
27	5.0574	11.2387	11.2777	11.3168	11.3560	11.3951	11.4344	11.4736	11.5131	5.2948	11.5523	11.5917	11.6312	11.6707	11.7102	11.7498	11.7894	11.8291
28	5.5388	11.8688	11.9086	11.9484	11.9882	12.0681	12.0681	12.1080	12.1481	5.7894	12.1881	12.2282	12.2684	12.3086	12.3489	12.3891	12.4295	12.4699
29	6.0467	12.5103	12.5507	12.5912	12.6318	12.6724	12.7130	12.7537	12.7944	6.3106	12.8352	12.8760	12.9169	12.9578	12.9987	13.0397	13.0807	13.1218
30	6.5814	13.1629	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

For discharges for depths less than 3 inches, use Tables V or VI. The absolute error will be small.

TABLE V.

Discharge Over Rectangular Weirs, with and without Contraction.

Formula, $D = 3\frac{1}{3}\ (1 - .2\ H)\ H^{\frac{3}{2}}$

For conditions, see page 31.

Depth, H, of Water on crest Measured in Still Water. See Page 25		DISCHARGE IN CUBIC FEET PER SECOND.						
		With Two Complete Contractions.						Correction to be added to each of the preceding to give discharge with no contraction.
In Inches.	In Feet.	1 Foot Long.	1½ Feet Long.	2 Feet Long.	3 Feet Long.	5 Feet Long.	10 Feet Long.	
0.3	.025	.0133	.0200	.0267	.0400	.0677	.1330	.0000
0.6	.050	.0369	.0556	.0743	.1116	.1863	.3716	.0004
0.9	.075	.0674	.1015	.1350	.2040	.3410	.6830	.0010
1.2	.1	.1033	.1560	.2087	.3132	.5240	1.0519	.0021
1.5	.125	.1433	.2175	.2912	.4385	.7332	1.4695	.0037
1.8	.15	.1879	.2847	.3816	.5753	.9627	1.9312	.0058
2.1	.175	.2355	.3575	.4795	.7235	1.2115	2.4315	.0085
2.4	.2	.2861	.4352	.5813	.8824	1.4787	2.9690	.0119
2.7	.225	.3393	.5177	.6956	1.0513	1.7627	3.5412	.0160
3.0	.25	.3959	.6042	.8126	1.2293	2.0227	4.1462	.0208
3.3	.275	.4543	.6946	.9350	1.4157	2.3771	4.7803	.0264
3.6	.3	.5149	.7833	1.0627	1.6104	2.7059	5.4442	.0328
3.9	.325	.5775	.8363	1.1952	1.8129	3.0482	6.1363	.0401
4.2	.35	.6420	.9871	1.3321	2.0223	3.4032	6.8537	.0483
4.5	.375	.7079	1.0909	1.4732	2.2335	3.7691	7.5976	.0574
4.8	.4	....	1.1974	1.6189	2.4623	4.1485	8.3645	.0675
5.1	.425	....	1.3070	1.7680	2.6926	4.5400	9.1565	.0785
5.4	.45	....	1.4189	1.9221	2.9280	4.9404	9.9775	.0906
5.7	.475	....	1.5333	2.0790	3.1708	5.3523	10.8094	.1037
6.0	.5	....	1.6500	2.2392	3.4177	5.7748	11.6672	.1178
6.3	.525	....	1.7689	2.4029	3.6709	6.2069	12.5469	.1331
6.6	.55	....	1.8890	2.5698	3.9295	6.6489	13.4474	.1496
6.9	.575	....	2.0129	2.7395	4.1928	7.0995	14.3663	.1672
7.2	.6	....	2.1378	2.9123	4.4614	7.5596	15.3052	.1859
7.5	.625	....	2.2646	3.0881	4.7351	8.0291	16.2641	.2059
7.8	.65	....	2.3929	3.2665	5.0133	8.5069	17.2409	.2271
8.1	.675	....	2.5234	3.3473	5.2960	8.9930	18.2354	.2495
8.4	.7	....	....	3.6313	5.5836	9.4832	19.2497	.2733
8.7	.725	....	....	3.8170	5.8747	9.9906	20.2796	.2984
9.0	.75	....	....	4.0052	6.1702	10.5007	21.3262	.3218
9.3	.775	....	....	4.1961	6.4704	11.0190	22.3895	.3524
9.6	.8	....	....	4.3888	6.7734	11.5444	23.4704	.3816
9.9	.825	....	....	4.5833	7.0810	12.0769	24.5659	.4121
10.2	.85	....	....	4.7806	7.3929	12.6169	25.6779	.4440
10.5	.875	....	....	4.9792	7.7075	13.1641	26.8056	.4775
10.8	.9	....	....	....	8.0257	13.7177	27.9477	.5123
11.1	.925	....	....	....	8.3509	14.2839	29.1164	.5486
11.4	.95	....	....	....	8.6731	14.8461	30.2786	.5864
11.7	.975	....	....	....	9.0012	15.4192	31.4652	.6258
12.0	1.0	....	....	....	9.3333	16.0000	32.6667	.6667
12.3	1.025	....	....	....	9.6685	16.5869	33.8829	.7091
12.6	1.05	....	....	....	10.0058	17.1789	35.1109	.7531
12.9	1.075	....	....	....	10.3471	17.7777	36.3552	.7988
13.2	1.1	....	....	....	10.6907	18.3825	37.6100	.0849
13.5	1.125	....	....	....	11.0376	18.9926	38.8801	.8949
13.8	1.150	....	....	....	11.3866	19.6080	40.1625	.9455
14.1	1.175	....	....	....	11.7388	20.2298	41.4573	.9977
14.4	1.2	....	....	....	12.0935	20.8569	42.7664	1.0516
14.7	1.225	....	....	....	12.4507	21.4893	44.0866	1.1073
15.0	1.25	....	....	....	12.8109	22.1279	45.4204	1.1646
15.3	1.275	....	....	....	13.1733	22.7713	46.7653	1.2237
15.6	1.3	....	....	....	13.5375	23.4189	48.1224	1.2846
15.9	1.325	....	....	....	13.9067	24.0727	49.4927	1.3473
16.2	1.35	....	....	....	14.2740	24.7308	50.8733	1.4117
16.5	1.375	....	....	....	14.6450	25.3946	52.2671	1.4780
16.8	1.4	....	....	....	....	26.0625	53.6710	1.5460
17.1	1.425	....	....	....	....	26.7355	55.0870	1.6160
17.4	1.45	....	....	....	....	27.4127	56.5132	1.6878
17.7	1.475	....	....	....	....	28.0950	57.9515	1.7615

Discharge Over Rectangular Weirs.—Concluded.

Depth, H, of Water on Crest Measured in still water. In Inches.	In Feet.	Discharge in Cubic Feet per Second. With Two Complete Contractions. 3 Feet Long.	5 Feet Long.	10 Feet Long.	Correction to be added to each of the preceding to give discharge with no contraction.
18.0	1.5	....	28.7814	59.3999	1.8371
18.3	1.525	....	29.4729	60.8604	1.9146
18.6	1.55	....	30.1680	62.3300	1.9940
18.9	1.575	....	30.8681	63.8116	2.0754
19.2	1.6	....	31.5717	65.3022	2.1588
19.5	1.625	....	32.2809	66.8049	2.2441
19.8	1.650	....	32.9935	68.3175	2.3314
20.1	1.675	....	33.7093	69.8393	2.4207
20.4	1.7	....	34.4299	71.3719	2.5121
20.7	1.725	....	35.1546	72.9146	2.6054
21.0	1.750	....	35.8827	74.4672	2.7009
21.3	1.775	....	36.6151	76.0286	2.7984
21.6	1.8	....	37.3510	77.6002	2.8979
21.9	1.825	....	38.0909	79.1814	2.9996
22.2	1.85	....	38.8346	80.7726	3.1034
22.5	1.875	....	39.5812	82.3717	3.2093
22.8	1.9	....	40.3321	83.9816	3.3173
23.1	1.925	....	41.0860	85.6005	3.4276
23.4	1.95	....	41.8436	87.2271	3.5399
23.7	1.975	....	42.6045	88.8635	3.6545
24.	2.0	....	43.3695	90.5061	3.771
27.	2.25	....	....	107.44	5.06
30.	2.50	....	....	125.17	6.59
36.	3.00	....	....	162.81	10.39

TABLE VI.

Discharge Over Cippoletti's Trapezoidal Weir of Various Lengths and with Various Depths, and Over Rectangular Weirs Without Side Contraction.

$$\text{Formula, } D = 3.3\tfrac{2}{3}\, L\, H^{\frac{3}{2}}.$$

For conditions, see page 31.

Depth of Water on Crest. In Inches.	In Feet.	Discharge in Cubic Feet per Second. 1 Foot Long.	1½ Feet Long.	2 Feet Long.	3 Feet Long.	4 Feet Long.	5 Feet Long.	10 Feet Long.
.3	.025	.0135	.0202	.0269	.0404	.0539	.0673	.1347
.6	.05	.0367	.0566	.0754	.1131	.1508	.1885	.3771
.9	.075	.0690	.1035	.1380	.2071	.2761	.3451	.6902
1.2	.10	.1064	.1596	.2128	.3192	.4256	.5319	1.0639
1.5	.125	.1488	.2232	.2976	.4464	.5952	.7440	1.4881
1.8	.15	.1956	.2934	.3912	.5868	.7824	.9780	1.9560
2.1	.175	.2464	.3697	.4929	.7393	.9858	1.2322	2.4644
2.4	.20	.3010	.4515	.6020	.9029	1.2039	1.5049	3.0098
2.7	.225	.3592	.5388	.7184	1.0777	1.4369	1.7961	3.5922
3.0	.25	.4208	.6312	.8417	1.2625	1.6833	2.1041	4.2083
3.3	.275	.4855	.7282	.9709	1.4564	1.9419	2.4273	4.8547
3.6	.30	.5531	.8297	1.1063	1.6594	2.2126	2.7657	5.5314
3.9	.325	.6238	.9358	1.2477	1.8715	2.4954	3.1192	6.2384
4.2	.35	.6972	1.0459	1.3945	2.0917	2.7890	3.4862	6.9724
4.5	.375	.7730	1.1595	1.5460	2.3190	3.0920	3.8649	7.7299
4.8	.40	....	1.2777	1.7035	2.5553	3.4071	4.2588	8.5177
5.1	.425	....	1.3993	1.8658	2.7987	3.7316	4.6645	9.3290
5.4	.45	....	1.5246	2.0328	3.0492	4.0656	5.0820	10.1640
5.7	475	....	1.6534	2.2045	3.3067	4.4089	5.5112	11.0225
6.0	.50	....	1.7854	2.3805	3.5708	4.7610	5.9512	11.9025
6.3	.525	....	1.9210	2.5614	3.8420	5.1227	6.4034	12.8068
6.6	.55	....	2.0599	2.7465	4.1198	5.4930	6.8663	13.7326
6.9	.575	....	2.2018	2.9357	4.4036	5.8715	7.3393	14.6787
7.2	.60	....	2.3472	3.1293	4.6939	6.2585	7.8231	15.6463
7.5	.625	....	2.4955	3.3274	4.9911	6.6548	8.3185	16.6370
7.8	.65	....	2.6462	3.5283	5.2924	7.0565	8.8206	17.6413
8.1	.675	....	2.8007	3.7343	5.6014	7.4686	9.3357	18.6715

Discharge Over Cippoletti Weirs.—Concluded.

Depth of Water on Crest. In Inches.	In Feet.	DISCHARGE IN CUBIC FEET PER SECOND. 2 Feet Long.	3 Feet Long.	4 Feet Long.	5 Feet Long.	7 Feet Long.	10 Feet Long.
8.4	.7	3.9437	5.9156	7.8874	9.8593	13.8030	19.7186
8.7	.725	4.1565	6.2347	8.2930	10.3912	14.5457	20.7824
9.0	.75	4.3733	6.5599	8.7466	10.9332	15.3065	21.8675
9.3	.775	4.5942	6.8912	9.1883	11.4854	16.0796	22.9708
9.6	.80	4.8177	7.2265	9.6354	12.0442	16.8619	24.0885
9.9	.825	5.0453	7.5679	10.0906	12.6132	17.6585	25.2264
10.2	.85	....	7.9154	10.5538	13.1923	18.4692	26.3846
10.5	.875	....	8.2669	11.0225	13.7781	19.2893	27.5562
10.8	.90	....	8.6234	11.4978	14.3723	20.1212	28.7446
11.1	.925	....	8.9850	11.9800	14.9749	20.9649	29.9499
11.4	.95	....	9.3516	12.4688	15.5860	21.8204	31.1720
11.7	.975	....	9.7233	12.9644	16.2054	22.6876	32.4019
12.0	1.00	....	10.1000	13.5667	16.8333	23.5667	33.6667
12.3	1.025	....	10.4808	13.9744	17.4679	24.4551	34.9359
12.6	1.05	....	10.8666	14.4888	18.1110	25.3554	36.2220
12.9	1.075	....	11.2575	15.0100	18.7624	26.2674	37.5249
13.2	1.10	....	11.6524	15.5365	19.4206	27.1888	38.8412
13.5	1.125	....	12.0513	16.0684	20.0855	28.1198	40.1711
13.8	1.150	....	12.4553	16.6071	20.7588	29.0624	41.5177
14.1	1.175	....	12.8644	17.1525	21.4406	30.0168	42.8812
14.4	1.2	....	13.2764	17.7019	22.1274	30.9784	44.2548
14.7	1.225	....	13.6936	18.2581	22.8226	31.9517	45.6453
15.0	1.25	....	14.1148	18.8197	23.5246	32.9344	47.0492
15.3	1.275	....	14.5410	19.3880	24.2349	33.9289	48.9699
15.6	1.3	....	....	19.9603	24.9503	34.9305	49.9007
15.9	1.325	....	....	20.5394	25.6742	35.9439	51.3484
16.2	1.35	....	....	21.1238	26.4047	36.9666	52.8095
16.4	1.375	....	....	21.7123	26.1404	37.9966	54.2808
16.8	1.4	....	....	22.3075	27.8844	39.0382	55.7688
17.1	1.425	....	....	22.9082	28.6352	40.0893	57.2704
17.4	1.45	....	....	23.5128	29.3910	41.1474	58.7820
17.7	1.475	....	....	24.1242	30.1552	42.2173	60.3105
18.0	1.5	....	....	24.7396	30.9245	43.2943	61.8490
18.3	1.525	....	....	25.3604	31.7005	44.3808	63.4011
18.6	1.55	....	....	25.9866	32.4833	45.4766	64.9666
18.9	1.575	....	....	26.6182	33.2727	46.5818	66.5455
19.2	1.6	....	....	....	34.0685	47.6959	68.1370
19.5	1.625	....	....	....	34.8702	48.8183	69.7405
19.8	1.65	....	....	....	35.6782	49.9495	71.3565
20.1	1.675	....	....	....	36.4913	51.0878	72.9826
20.4	1.7	....	....	....	37.3111	52.2355	74.6222
20.7	1.725	....	....	....	38.1376	53.3926	76.2752
21.0	1.75	....	....	....	38.9691	54.5568	77.9383
21.3	1.775	....	....	....	39.8074	55.7304	79.6149
21.6	1.8	....	....	....	40.6515	56.9121	83.3030
21.9	1.825	....	....	....	41.5009	58.1013	83.0018
22.2	1.85	....	....	....	42.3577	59.3008	84.7154
22.5	1.875	....	....	....	43.2179	60.5031	86.4358
22.8	1.9	....	....	....	....	61.7211	88.1730
23.1	1.925	....	....	....	....	62.9442	89.9203
23.4	1.95	....	....	....	....	64.1720	91.6743
23.7	1.975	....	....	....	....	65.4116	93.4452
24.0	2.0	....	....	....	....	66.6560	95.2228
25.5	2.125	....	....	....	....	72.999	104.289
27.0	2.25	....	....	....	....	79.541	113.63
28.8	2.4	....	....	....	....	87.619	125.18
30.0	2.5	....	....	....	....	93.156	133.07

SOME PHYSICAL CONSTANTS USEFUL IN CONNECTION WITH THE PRECEDING TABLES.

1 cu. ft. water weighs 62.416 lbs. at 32 degrees F.
1 cu. ft. water weighs 62.424 lbs. at 39.3 degrees F.
1 cu. ft. water weighs 62.408 lbs. at 50 degrees F.
1 cu. ft. water weighs 62.300 lbs. at 70 degrees F.
1 cu. ft. = 7.48052 U. S. gallons.
1 acre ft. = an acre 1 ft. deep = 43,560 cu. ft.
= 325,851.45 gallons.
1,000,000 U. S. gallons = 133,680.6 cu. ft.
= 3.07 acre ft.
1,000,000 cu. ft. = 22.9568 acre feet.
= 11.574 cu. ft. per sec. for 24 hrs.

1 cu. ft. per sec. = 448.8312 gals. per min.
= 86,400 cu. ft. in 24 hrs. (Nearly 2 acre feet.)
= 2 acre ft. in 24 hrs., 12 min.
= 1,000,000 cu. ft. in 11.574 days.
= 1,000,000 gals. in 1.5472 days.
1 cu. ft. per sec. = 38.4 Colorado statute inches.
= 50 California statute inches.
1.44 cu. ft. per sec. covers 80 acres 6 in. deep in 14 days.

The State Agricultural College.

THE AGRICULTURAL EXPERIMENT STATION.

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Approved by the Station Council.

ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

SEPTEMBER, 1894.

The Russian Thistle.

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The Russian Thistle.

By Charles S. Crandall.

The list of Colorado weeds, already a formidable one, has recently received an addition, a new-comer which at once falls into the category of worst weeds and which we deem worthy of special mention. We refer to the Russian thistle, or Russian cactus. These two names for the plant are in common use wherever it is known and are too well established to admit of being changed; they are, however, misapplied, because the plant is neither a thistle nor a cactus. The species of which the plant to be considered is a variety is the saltwort, common along the Atlantic coast and reported from a number of stations inland as far west as Nebraska. It is an introduced plant of weedy character, but during its century or more of existence on American soil has never developed as a serious farm or garden pest.

Saltwort, or Russian saltwort, would be correct as common names for our plant, but following custom we will call it Russian thistle.

Botanically the plant is known as *Salsola kali tragus* (L.) Moq. It belongs to the goosefoot family—*Chenopodiaceæ*—and is closely related to several of our most common weeds, among them being the common pigweed, *Chenopodium album* L.; the winged pigweed, *Cycloloma platyphyllum* Moq.; the sea-blite, *Suæda depressa* Watson, which in company with its variety, *erecta*, is so common on lands moist from seepage; the greasewood, *Sarcobatus maximiliani* Nees., and several species of the genus *Atriplex*. There should also be mentioned as relatives of the Russian thistle three members of the amaranth family, *Amaranthus retroflexus* L.; *Amaranthus blitoides* Watson; *Amaranthus albus* L.; the latter is our common tumble-weed, and has often been mistaken for the Russian thistle.

ORIGIN AND HISTORY.

The following concerning the origin and history of the Russian thistle, as given by Mr. L. H. Dewey, in bulletin No. 15, from the Division of Botany of the U. S. Department of Agriculture, will be of interest:

"Nearly a century and a half ago this plant was mentioned by Linnæus as growing in eastern Europe, and many botanical writers have since described it among the plants of that region.. The species *Salsola kali*, or some of its varieties, is found in most of the provinces of eastern Russia and western Siberia. The variety *tragus* seems to have developed on the plains of southeastern Russia, where the conditions are very similar to those of the great Plains region of the United States. For many years it has been a destructive weed in the barley, wheat, and flax regions of southeastern Russia, and the cultivation of crops has been abandoned over large areas in some of the provinces near the Caspian Sea. No effectual methods of exterminating the weed are known in Russia. Sheep, pasturing on the young plants, aid materially in keeping the thistle in check, but it is continually growing more troublesome and extending to new territory.

"The plant was first introduced into the United States in 1873 or 1874, in flaxseed brought from Russia and sown near Scotland, Bonhomme County, S. Dak. The land there is somewhat hilly, and corn is the chief crop raised, so that, owing to the wooded ravines and the standing cornstalks, the Russian thistle was at first slow in spreading. In 1877 it first appeared in Yankton County, east of Bonhomme, and five years later it had spread to the counties to the north and west of Bonhomme. It continued gradually to cover new territory until 1888, when it had infested most of the counties between the Missouri and James rivers south of the Huron, Pierre and Deadwood Division of the Chicago & Northwestern Railway. The strong winds during the winter of 1887-88, followed by the dry summer of 1888, and possibly a fresh importation of seed into the flax fields of Faulk or McPherson Counties, caused the weed to spread, within two years, to nearly all the remaining counties between the Missouri and James rivers in South Dakota, and to infest the southern tier of counties in North Dakota. At about the same time it invaded northern Iowa and northeastern Nebraska."

No definite date can be assigned for the introduction of the Russian thistle into Colorado. We have authentic information of its existence here in 1892, but it was undoubtedly introduced earlier, and possibly several years earlier. It has attracted no notice and received no attention until within the present year. During the last three months a large number of inquiries have been received by this department, most of them accompanied by specimens of the plant.

From the remoteness of the localities reporting the plant, it is apparent that it has not spread from one point of infection, and the manner of its introduction is a matter of speculation. It is said to have been introduced into Morgan County by a colony of Russians, who brought it as an impurity in seed. At Denver, LaSalle, and Longmont, plants were first discovered upon railroad property, and the development and distribution point to the railroad lines as points of infection, and to passing trains as the means of introduction.

Railroads, as is well known, are very efficient agents in aiding the distribution of plants; trains, and especially freight trains, passing through a district where any particular plant abounds afford convenient lodging places, on the trucks, or among the cargo of open cars, for plants, or parts of plants, or seeds, which are thus transported long distances. The bedding used in stock-cars may abound in weed seeds; it may be carried back and forth, to be finally thrown out at some point far removed from the point of shipment. New plants, strangers in the locality, make their appearance, they multiply and spread, or die out, according as the conditions are favorable or unfavorable to their growth. It is probable that several localities reporting the presence of the Russian thistle owe its introduction to the agency above mentioned.

The Russian thistle is in itself a good traveler, being one of the most perfect tumble-weeds known, but it is not probable that it came to us unassisted, because of the distance from previously infected sections, and the fact that there are intermediate areas from which the plant has not been reported. From the information now at hand, it appears that seventeen counties in Colorado are infested with the plant in greater or less degree; these are Weld, Logan, Phillips, Yuma, Washington, Morgan, Boulder, Jefferson, Arapahoe, Elbert, Lincoln, Kit Carson, Fremont, Pueblo, Otero, Bent, and Prowers. It is very probable that it exists in four other counties, namely: Larimer, Sedgwick, Cheyenne, and Kiowa, but we have as yet no information to confirm this suspicion.

The counties known to be infested are all agricultural counties, and a glance at the list will at once show what a wide distribution the plant already has; it is so widely distributed and has obtained so strong a foothold that it is a serious menace to our agricultural interests. The presence of the plant in Weld County was brought to our notice in a letter from Hon. J. S. Newell, of the Board of County Commissioners. We visited LaSalle, the locality indicated, and traveled over the infested area; from inquiries made it appears that the plant was first noticed in the fall of 1892, near the Union Pacific tracks; no one who saw it knew what it was and no attention was given to it. In 1893 it appeared in quantity along the bank of the canal, and many plants were seen in adjoining fields. This present season it spread still further; the canal bank was occupied for a half mile east from the point of infection; the lateral ditches were lined with it, affording a striking illustration of the efficacy of the irrigating ditch as an agency in the dissemination of weed seeds; an area of waste land adjoining the main canal was covered with the plant, and numerous specimens were seen in neighboring fields of potatoes and corn.

Mr. Newell had previously visited this locality, and I found the farmers advised as to the nature of the plant. A knowledge of the damage inflicted in other states, and a present forcible illustration of the ability of the plant to spread, quickly awakened them to the impending danger, and all were resolving to at once engage in a war of extermination. But here arose a question: the right-of-way along the railroad and along the canal was infested; would the railroad and canal corporations take care of the weeds on their property? The opinion seemed to prevail that they would not, and the farmers were awake to the fact that it would give them no permanent relief to exterminate the weed from their farms if the plants on neighboring territory were allowed to ripen and produce their seed. They could care for their own farms, but were neither able nor willing to do more. Immediate action was necessary, because seed would soon be forming. Mr. Newell and his colleagues in this case solved the problem; the County Commissioners of Weld County employed a dozen men and set them at work, under instructions to continue as long as a plant could be found. That the work was thoroughly done I can testify from personal inspection, and I desire to hold up this prompt action of the Commissioners as a shining example that may well be followed by other counties. This energetic action at LaSalle does not, however, free Weld County from the weed; knowledge of its presence came late, and mischief had already been done. Later reports show the plant present on farms several miles south and east of LaSalle, and also northeast on Crow Creek; the presence of the plant on Crow Creek traces directly, as I am credibly informed, to alfalfa hay hauled from near LaSalle in the fall of 1893.

At Longmont the Russian thistle was first noticed this summer in three small areas near the Union Pacific depot; these plants, I am informed, have been pulled and burned under the direction of the Street Commissioner. Later the plant is reported as present on several farms near Longmont; but the warning has come in time, and as there appear to be no extended areas covered, we may reasonably look for its complete extermination from this locality.

In Arapahoe County the Russian thistle appears to be quite well distributed over the eastern portion, and it is very abundant in the suburbs on all sides of Denver. We have seen the plant in quantity along the tracks of the Kansas Pacific Railroad from York street east; on the numerous vacant lots, the roadsides, and ditch banks in the district lying east of Gaylord street, between 28th and 40th avenues; in City Park; on Capitol Hill, and in several places south of the city. On Gaylord street, along the tracks and about the terminus of the cable line, it is especially abundant.

For our information regarding the Russian thistle in the Arkansas Valley we are indebted to Mr. F. A. Huntley, Superintendent of the Experiment Station at Rocky Ford, in Otero County. Mr. Huntley writes, under date of September 25th:

"So far as known the first specimens seen in the Arkansas Valley were discovered last year in the vicinity of Fowler, in the western part of this county. That they were there last year has been conclusively proven. It is numerous in the vicinity of Pueblo, then beginning near Nepesta, about 26 miles west of Rocky Ford, and extending east as far as 10 miles east of La Junta, making a continuous infested area of about four miles wide by 45 miles long, not counting Pueblo. A county organization has been formed and its members, over 100, are pledged to put forth every effort possible towards the destruction of this pest. Frank Bingham is the President of this society and F. A. Huntley Secretary. The people here are fully awake to the importance of destroying the Russian thistle. The railroads have been doing good work."

Accompanying Mr. Huntley's letter, were letters from officials of the Atchison, Topeka & Santa Fe, and the Missouri Pacific Railroad Companies, advising him that instructions had been issued to section men to cut and burn all Russian thistles found on the right-of-way. These letters manifest a cordial desire to co-operate with the farmers, and it would seem that everything possible is being done to eradicate the plant from the Arkansas Valley, or at least from Otero County.

Fig. 1.—Twig from plant of compact growth, enlarged 1½ ttmes.

Two practical questions appear in most of the letters of inquiry received by this department: First, How can the Russian thistle be distinguished from other plants? Second, How can it be exterminated? In those localities where the plant is abundant, farmers have learned, or will learn this fall by personal contact, the answer to the first question. But there are yet many who have not seen the plant to know it, and it will not be out of place to dwell briefly upon its characteristics. As is the case with most of our weeds, the Russian thistle varies greatly, according to the conditions which surround it. Isolation, rich soil, and plenty of water induce large plants; crowding by other plants, poor soil, and extreme drouth produce small plants. With variations in size are also variations in habit of growth; two plants may have the same dimensions as to height and spread, and yet be very different in general aspect; the one grown under favorable conditions will be oval, or possibly almost globular in form, with a thick and matted appearance due to the develop ment of a great number of branches ; the other, grown under adver circumstances, will present an open, straggling appearance, because the branches are fewer in number, farther apart, and usually very short. The matter of color seems largely dependant upon w plants upon ditch banks, or in other moist situations, have a green color, which they retain until quite late in the season ; deprived of water are early tinged with red, and this color d as the season advances.

The Russian thistle is an annual. It comes from se year, produces seed in its turn, and then dies. The young s are smooth and succulent, showing none of the characters which mark the mature plant. The early leaves are slender and thread-like, from one to two inches long, each tipped with a spine; on either side, at the base of each leaf, is a short spine, and above the leaves appear branches, which at first seem to be clusters of spines and short leaves. These branches are near or remote, long or short, according to circumstances; on vigorous plants the branching continues until growth ceases and even the late branches may be from three to six inches in length. On dwarfed specimens the late branches remain quite short, an inch or less long. On all plants the leaves produced late in the season are very short, commonly but little longer than the spines, so that the branches appear to bear spines only, and these in clusters of three. [See Fig. 1.] As the plant approaches maturity, these spines become more rigid, imparting that character which evidently suggested the application of the name thistle. The long leaves produced early in the season wither and usually fall away as the plant nears maturity, so that many plants appear to be almost leafless. Immediately above, and close down in the angle, between the clusters of spines and the stem, is borne a single flower. [See Fig. 2.] The number of flowers on a plant is, however, large, because the clusters of spines are near together. We have counted thirty-five on a branch three inches in length, and the average of several branches counted was nine to the inch. The flowers are inconspicuous and vary in appearance on different plants ; sometimes they are pale red, but oftener green or greenish. As the fruit begins to mature, the floral envelope surrounding each flower enlarges somewhat and spreads out until it often measures a quarter of an inch across. The fruit which is held within this floral envelope is small, with rough exterior, and of a light-

FIG. 2.—Single flower enlarged 3 times. The flower rests in the axil of the leaf, between the divergent bracts; the stem is shown below the flower only

grey color when ripe; the outer covering removed shows the seed in spiral form. The root system of the plant is small, giving it but a slight hold on the ground; it can be easily pulled at any time. When the plant dies in the fall the wind may turn it out entire, or break it off at the surface. It is then ready to travel where the winds may take it, distributing its seed as it goes. For further and more minute details of structure, the following technical description given by Mr. L. H. Dewey, in bulletin No. 15, from the Division of Botany of the U. S. Department of Agriculture, may be consulted:

"Technical Description.—*Salsola kali tragus* (L.) Moq. in DC. Prod., XIII., [illegible] (1849). A herbaceous annual, diffusely branching from the base, 0.5 to 1 m. (1½ to 3 feet) high and twice as broad, smooth or slightly puberulent; tap root dull white, slightly twisted near the crown; leaves alternate, sessile; those of the young plant deciduous, succulent, linear or subterete, 3 to 6 cm. (1 to 2 inches) long, spine-pointed and with narrow, denticulate, membranaceous margins near the base; leaves of the mature plant persistent, each subtending two leaf-like bracts and a flower at intervals of 2 to 10 mm. (about one-twelfth to five-twelfths of an inch), rigid, narrowly ovate, often denticulate near the base, spine-pointed, usually striped with red like the branches, 6 to 10 mm. (three-twelfths to five-twelfths of an inch) long; bracts divergent, like the leaves of the mature plant in size and form; flowers solitary and sessile, perfect, apetalous, about 10 mm. (five-twelfths of an inch) in diameter; calyx membranaceous, persistent, inclosing the depressed fruit, usually rose-colored, gamosepalous, cleft nearly to the base into five unequal divisions about 4 mm. (one-sixth of an inch) long, the upper one broadest, bearing on each margin near the base a minute tuft of very slender coiled hairs, the two nearest the subtending leaf next in size, and the lateral ones narrow, each with a beak-like connivent apex, and bearing midway on the back a membranaceous, striate, erose-margined horizontal wing about 2 mm. (one-twelfth of an inch) long, the upper and two lower wings much broader than the lateral ones; stamens 5, about equaling the calyx lobes; pistil simple; styles 2, slender, about 1 mm. (one twenty-fifth of an inch) in diameter, dull gray or green, exalbuminous, the thin seed coat closely covering the spirally-coiled embryo; embryo, green, slender, about 12 mm. (one half inch) long when uncoiled, with two linear subterete cotyledons. The plant flowers in July or August and the seeds mature in September and October. At maturity the action of the wind causes the root to break with a somewhat spiral fracture at the surface of the frozen ground, and the plant is blown about as a tumble-weed. The mature flower with the inclosed seed is held in place in the axils of the bracts by the two minute tufts of coiled hairs, preventing the seeds from falling all at once when the plant begins to roll.

The variety *tragus* differs from the typical form of *Salsola kali*, which is common along the Atlantic coast, in the following characters: The leaves of the mature plant are very little longer than the leaf-like bracts which they subtend, while in the typical form of the species they are generally two to four times as long. The calyx is membranaceous and nearly always bright rose-colored, and the wings on the backs of the calyx lobes are much larger than the ascending lobes, while in the typical form the calyx is coriaceous and usually dull white or only slightly rose-colored, and the wings are thick, comparatively narrow, and less prominent than the ascending lobes. The species itself is less bushy in habit and less rigid at maturity. It has been known along the Atlantic coast from Massachusetts to Georgia for nearly a century, and has never developed into a troublesome weed."

Three of our native weeds have been mistaken for Russian thistle. These plants do, in some degree, resemble the thistle, but the leaf and spine characters of the latter can hardly fail to readily separate it from the others. The plant bearing the strongest resemblance is the common tumble-weed, *Amaranthus albus* L. [Plate V.]; its habit of growth is much the same, but its flat leaves, which may always be found, at least towards the base of the plant, together with the lighter color and early maturity, will serve to distinguish it. The winged pigweed, *Cycloloma platyphyllum* Moq. [Plate VI.], bears resemblance to the Russian thistle only in its compact, globular form of growth; its leaves are flat, its branches slender; it has no spines, and the whole plant is light green in color; these characters should separate it without difficulty. The third plant is the sea-blite, *Suæda depressa* Watson; the large forms of this species, seen at a little distance, show rather a striking resemblance to the Russian thistle, but, as in the other cases, the leaves and spines serve as a ready means of recognition. The sea-blite is not at all spiny, and its leaves, while of the same general shape, are larger and thicker than in the Russian thistle.

How can the Russian thistle be held in check or eradicated? The plant, being an annual, is perpetuated from season to season only through the seed. The crop of any year depends entirely upon the seed produced the previous year. It will, therefore, be apparent that effort must be directed towards preventing the formation and dissemination of seed. It is only a question of how this can best be accomplished. There is no probability that the plant will die out of itself; the growth and multiplication within the short time the plant has been with us shows that our climatic conditions are favorable to its development, and makes it plain that nothing but active and persistent warfare will rid us of it. Work should be commenced at once and continued as long as plants can be found. Later than September 1st, all plants pulled should be burned, in order to insure the complete destruction of such mature seeds as they may bear. Every plant destroyed in the fall will lessen by so much the work that must be done another season. For spring-sown grain the ground should be prepared and the seed sown as early as possible; having the ground occupied by a crop will, in a measure, check the growth of the weed. Infested grain fields should be harvested early, because the earlier the weed is cut the more succulent it is and the less trouble it will give in handling the grain. Plowing immediately after harvest is recommended as a further means of destruction. Where hoed crops are to occupy the ground there need be no trouble, if reasonable attention is given to cultivation. Clean culture should be given until the first of August, or later, if possible. Weeds springing up after that date will not usually mature seed, and hence are only bad in their effect on the present crop.

Any thrifty farmer can, by a little extra effort, free his cultivated land from the Russian thistle, but, if he stops at this, he must repeat the same effort every year. The borders of fields, fence corners, ditch banks, and waste places which are sure to be found on every farm must, so far as weeds are concerned, receive the same attention he would bestow upon his clultivated land; if they are neglected they will harbor a sufficient crop of weeds to again seed his fields, and he makes no progress toward their extermination. Attention to the outside localities enumerated is one of the greatest factors in the problem of weed extermination; very many farmers do not seem to appreciate its importance, as is apparent from the too common sight of well-tilled fields bordered by rank growth of a variety of weeds. In some cases there is a possible reason for the neglect in the want of co-operation on the part of the owners of adjoining property. If a farmer is so unfortunate as to be surrounded by unoccupied lands owned by non-residents, or if his neighbors are of the careless, shiftless class, he is quite likely to confine his own labor to the land he occupies with crops, and considers himself fortunate if he can keep these clean. Co-operation is in many things an advantage; in the matter of weeds it is an absolute necessity. Individual effort amounts to nothing. The residents of a neighborhood must be of one mind, and must act in concert, in order that lasting good may be accomplished. A very few years of concerted, well-directed action will solve the weed problem for any district; but can this voluntary united action be brought about? It may be possible in some districts, but observation and experience indicate that there are many difficulties in the way; difficulties that in some cases would be insurmountable. There are in every irrigated valley tracts of non-resident land; there are areas on occupied farms lying above the ditches, areas useless for cropping but abundantly able to produce weeds; there are railway and canal lines, each with its more or less broad right-of-way. In the aggregate, a considerable area where weeds are, as a rule, totally neglected. It is difficult, if not impossible, to secure the voluntary co-operation of all corporation or non-resident land owners in the destruction of weeds—a matter involving labor or the expenditure of money; but perfectly effective warfare against weeds cannot be carried on until all lands involved are looked after with equal care. There would be manifest injustice in asking or expecting farmers to keep the unoccupied lands of their neighbors free from weeds, and it seems equally unjust to require them to combat on their own lands the weeds which periodically come to them from the neglected lands around them.

Some, at least, of the railway companies operating in Colorado are ready and willing to co-operate in a war against weeds. We have already referred to the action of the Atchison, Topeka & Santa Fe and the Missouri Pacific Companies in the Arkansas Valley, and we are informed that the Burlington & Missouri River Company has been taking active measures against the Russian thistle on its line. A railway company, viewing a right-of-way from a business standpoint, would desire it kept clean and made as attractive as possible, but there is no encouragement to pay particular attention to weeds if the line must pass through fields that are entirely neglected. To demand of a corporation the extermination of weeds on a right-of-way without extending the demand to all bordering lands, would be as unjust as to require a single farmer to keep his land free from weeds while his neighbors were allowed to neglect theirs.

We have but one thing to suggest as a remedy that may give equal justice to all, and that is the enaction of a weed law which shall make the destruction of at least the most obnoxious weeds compulsory upon all land-owners. We are well aware that the mere enactment of such a law would accomplish nothing; its existence on the statute books would be of no use, unless it were backed up and supported by a public sentiment strong enough to demand its rigid enforcement. At the last session of our Legislature a bill providing for the destruction of weeds was introduced and its passage ably advocated by some of the members; it, however, failed to become a law, and the sentiment which prompted the bill has until recently remained dormant.

The interest lately awakened in the Russian thistle, and the activity which the people of infested districts have shown in efforts towards its extermination, has so developed the sentiment in favor of a weed law, that we believe there would now be no difficulty in passing such a law, and in securing its proper enforcement. Many States have weed laws which are more or less effective, according as public sentiment demands their enforcement. Only two States, the Dakotas, legislate distinctively against the Russian thistle. The South Dakota law provides for the destruction of all noxious weeds, with specific mention of Russian thistle, Canada thistle, and cockle burr. The North Dakota law applies to six species only, namely: "Canada thistle, cockle burr, mustard, wild-oats, French weeds (*avena fatua*), and Russian thistle (*Salsola kali tragus*)." The Wisconsin law covers eleven species; the Nebraska law only one, the Canada thistle.

A law for Colorado should be comprehensive; it should include those weeds which are at present giving serious trouble, and be so worded that amendments to cover new introductions are not necessary. The weed question is of vital importance to the farmers of Colorado, and any measure that affords promise of relief should be earnestly supported.

PLATE I.—Russian Thistle—*Salsola kali tragus* (L.) Moq. Twig from plant of open, straggling growth ; enlarged $1\frac{1}{2}$ times.

PLATE II.—Russian Thistle—*Salsola kali tragus* (L.) Moq. Compact form from Rocky Ford.
Negative by F. A. Huntley.

PLATE V.—*Amaranthus albus* L. Common tumble-weed. Spread, 3 feet ; height, 1 foot and 8 inches.

PLATE VI.—*Cycloloma platyphyllum* Moq. Winged pigweed. Spread, 2 feet and 4 inches; height, 1 foot and 6 inches.

PLATE III.—Russian Thistle—*Salsola kali tragus* (L.) Moq. Plant of compact form from City Park, Denver. Diameter at the ground, 6 feet and 6 inches; height, 2 feet and 4 inches.

PLATE IV.—Russian Thistle—*Salsola kali tragus* (L.) Moq Plant of open, straggling habit. The most common form on dry soils. Spread, 2 feet and 6 inches; height, 1 foot and 5 inches.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN No. 29.

Strawberries and Grapes.

Approved by the Station Council.

ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

NOVEMBER, 1894.

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Strawberries and Grapes.

By M. J. Huffington.

STRAWBERRIES.

The strawberry is the most delicious and wholesome of all berries, and is more universally cultivated in our gardens than any other fruit. It is a native of the temperate climates of both hemisheres, though the species found in different parts of the world are of distinct habit, and have each, through cultivation, given rise to different classes. In no other fruit, perhaps, has there been greater improvements made over the wild types, by the untiring efforts of the horticulturist, than the strawberry. The great superiority of our varieties of the present time, over those of the original forms, from which they have sprung, is in the size of fruit, greatly increased productiveness, and keeping qualities. Although this fruit has been brought up to such a degree of excellence by man, through cultivation, cross-fertilization, and selection, as regards size and productiveness, yet quality and flavor have not been improved upon, as some would expect, but rather have deteriorated, and in some cases have been almost entirely lost. Some of our mammoth berries, beautiful indeed to the eye, are deficient in flavor, and are often really insipid; but there is a peculiar, pleasant, sprightly flavor about the strawberry, in its native wilds, that will satisfy the most fastidious taste. Perfection, we know, is never attained, yet we believe a berry nearer the ideal will some day be originated—such a one as this, as large as any one of the largest at the present time, productive, a good shipper, and equal in flavor to the wild form. What can be more interesting work, to the true lover of horticulture, than that of originating new varieties of fruit, and especially is this true of the strawberry. Aside from the pleasure derived from such work, it is highly important that there should be, from time to time, worthy new candidates for admission to the already long list. All varieties of strawberries are constantly changing, just as with the potato and all plants propagated by any other method except from seed — the only source from which a new life can be generated. Hence the need of new varieties—seedlings, to take the place of those that were once popular, but have run down, or have degenerated until they are no longer profitable. The strawberry being so generally liked, of easy culture, and coming into bearing so soon after planting, everyone possessing a piece of land, if only a town lot, should grow sufficient of this wholesome and popular fruit for his own family, at least. A bed 150 feet long and 18 inches wide will furnish berries in abundance for an ordinary family. By planting an early, a medium, and a late variety, the strawberry season may be extended over a period of four or five weeks.

SOIL.

While the strawberry will grow and succeed fairly well on a variety of soils, it reaches its highest degree of perfection when grown on a rich, sandy loam. Light or sandy soils give earlier fruit, but the crop is generally heavier from land partaking of a clayey nature. A southern slope will produce earlier fruit, a northern the reverse, but land level, or nearly so, is more desirable, and especially where irrigation is practiced. It is always best to set strawberries on clean land—land that has been in some cultivated crop the previous year. Sod ground is not desirable, because it is often infested with the white grub, which in many places is so destructive to strawberry plants. Formerly, it was believed that strawberries flourished best and were most productive when grown on moderately poor soil, and that they must not be manured heavily; but now we know that the plant is a very heavy feeder, and that the crops we get are just in proportion to the amount of plant food we supply them.

MANURES.

The best results are obtained from the use of commercial fertilizers; those high in potash and bone phosphate are the best. Hardwood ashes used as a top dressing are also beneficial. Ordinary barnyard manure contains the seeds of numerous troublesome weeds, which to keep under subjection requires a great amount of labor and expense. In the use of chemical manures, many of these noxious weeds are avoided, and the plants are furnished with just the proper elements for the production of fruit. It has been noted that where mineral manures have been used, the strawberry grub did but little damage. Nitrate of soda applied in early spring, as a top dressing, has been found to greatly increase the yield of fruit. In this State, where commercial fertilizers are high and but little used, well-rotted barnyard manure will have to suffice. If it has been composted and turned several times, all the better, as in the process of fermentation many weed seeds are destroyed. The land should be manured and plowed several months before the time for setting plants, in order that the manure may become well incorporated with the soil; before planting, plow again, sub-soiling if possible, then harrow until the surface is smooth and fine.

TIME TO PLANT.

In regions where the rainfall is ample, beds are set in early spring, and from the last of August to the middle of September, though by far the greater part are planted in March and April. Under irrigation, plants may be set at any time from March to October, but even here, where water can generally be had when needed, if a plantation of any size is to be made, we would recommend spring as the best season to set. It is reasonable that all perennials will bear transplanting better early in spring, while in a dormant state, than during the growing period. In March and April the ground is generally quite moist, often to such an extent that it is not necessary to irrigate at time of planting, an item worth considering when a large patch is to be set. In early spring, the weather being cool, the plants never wilt, as they often do when set in summer, but soon take root and grow; furthermore, plants are much stronger and better rooted in the spring than in the summer. For summer or fall planting, it is generally difficult to get enough plants that are well rooted, without a great loss, as many at that time are not sufficiently established to support themselves when severed from the older plants, and, as a result, are lost. Of course, pot-grown plants can be procured, but these will be found to be quite expensive when several thousand are required. There are two systems of cultivation practiced in strawberry culture, the matted row and the hill, but the former method is more generally adhered to. Where matted rows are desired, rows are marked off $3\frac{1}{2}$ to 4 feet apart, and the plants set in the rows 18 to 24 inches apart, requiring 5,500 to 8,700 plants to set an acre. All runners should be cut or pinched off until the first week in July, as the parent plants will be stronger if not allowed to spend their energies in producing runners before they are well established. With such varieties as Crescent and Warfield, rapid plant producers, it would be well to keep the runners cut a week longer. An ideal matted row is one in which the plants are evenly distributed, 4 or 5 inches apart, in beds 18 to 24 inches wide. In hill culture, which is the more intensive method, plants are set 12 inches apart, in rows $2\frac{1}{2}$ to 3 feet apart, requiring 12,000 to 14,000 plants to the acre. No runners are allowed to form at any time, and, as a result, remarkably strong, healthy plants, with numerous well-developed fruit crowns, are obtained. Picking is more easily done when grown in hills Both systems have strong advocates. Some varieties succeed best when grown in hills, others do best in matted rows. It would be well for growers to test the two systems for themselves.

METHODS OF PLANTING.

In the East, where large areas are devoted to growing this fruit, lists or ridges are made with a one-horse plow, by two furrows being thrown together; the top of this ridge is smoothed off with a small spiked harrow, then follows a man with a stick about four feet long and two or three inches in diameter, sharpened to a point at the lower end; by thrusting this down, a hole is made to receive the plant; with a little practice, one can make the holes very rapidly, nearly as fast as a person can walk; then, with one to drop, and another to set, the work of planting goes on finely. Here, where level culture is necessary, rows are laid off with any convenient marker; a man with a good sharp spade thrusts it down to a depth of 5 or 6 inches, pressing the handle from him, thus making an opening, into which a helper places a plant, the roots being spread out in fan shape; the soil is then well firmed about it. Care should be exercised that the plants are not set either too deep, or too shallow; the crowns should be just above ground; if the bud is covered the plant will likely die, and the same will follow if any roots are exposed. After a few rows are set, shallow furrows should be run on each side of the row of plants, and as close as possible without covering any; water is then run through the furrows slowly until the space between is thoroughly soaked. Surface irrigation, or flooding, is never advisable, as the ground will bake and crack, causing many plants to die. Cultivation should commence in about two weeks after planting, and should be frequent and thorough. Keep the middles mellow with cultivator; directly around the plants the ground should not be hoed deeply. As to the number of times strawberries should be irrigated, it depends upon the season, and the kind of soil on which they are grown. Light, sandy soils require more water than stiff or clayey. Ordinarily, they should be irrigated every two weeks, and should be cultivated and hoed after each watering, as soon as the soil is in condition to work. Cultivation should continue until frost. Late in the fall, just before freezing, plants should be well irrigated.

MULCHING.

Mulching, in some cases, is an advantage, while in others it proves a detriment. It has been clearly demonstrated that mulching retards ripening from a week to ten days, and as early fruit generally commands the highest price, a week in time of ripening often makes a great difference in the growers' returns; and again, unless the mulch is free from weed seeds, it will be the means of giving much extra work the following season, in the way of hoeing. The points in favor of mulching are: That by retarding plant growth there is less danger of the blooms being killed by late spring frosts; and when all the covering is not lifted from the beds it serves to keep the berries clean and free from grit, also helps to retain moisture. Where one is growing berries for market, it would be well to cover a part of his patch, and leave uncovered a portion. If mulching is to be done, during November or December is the proper time; the materials should be straw or light manure; the plants should not be covered too deep; the mulch should not be removed in spring until after plant growth starts, but it is not safe to let it remain on until the plants begin to bleach. After the covering is removed, they should be irrigated frequently until the fruiting season is over. The strawberry is a heavy drinker, and during the fruiting period should not be allowed to suffer for water. On light or sandy soils they require irrigating twice a week, while on clayey land once a week will be sufficient.

PICKING THE FRUIT.

When the berries are to be shipped, they should be picked every day, and should not be thorougly ripe, as they will reach market in poor condition if allowed to ripen on the vines before being picked. Each berry should be picked with a stem from one-half to three-quarters of an inch long, as the fruit keeps much fresher and better in every way if the cap, or calyx, is undisturbed. We believe if growers would grade their berries they would be handsomely paid for the extra labor. After fruiting, the beds should be barred off—*i. e.*, a furrow thrown from each side of the row; the plants should then be hoed, and where very thick, some should be cut out. After hoeing, the middles should be kept well cultivated. It is not advisable to let a bed fruit more than two years—three at the very outside Some of the most successful growers consider that one year is long enough for a bed to stand, but for the ordinary cultivator, we would not recommend such a system. A new patch should be set every year, so there will always be one at its best.

Strawberry growers under irrigation possess a great advantage over their fellows outside the irrigated districts, for drouth often cuts short the finest of prospects. In this State there is no better field in fruit culture for intensive work than that of strawberry-growing. With a proper soil, good varieties, and a reasonable amount of attention, strawberries are among the most profitable of small fruits grown.

SELECTION OF VARIETIES.

The selection of varieties is a matter of the greatest importance to the grower of strawberries for market. If the bulk of the crop will have to be shipped, the grower should be sure that he plants varieties that are good carriers. For home use, or market close at hand, it is not so important that a berry should be a good shipper—but a variety possesing this quality in connection with other good qualities is all the more desirable. With beginners, the mistake is often made of planting too many sorts, and frequently those that have not been thoroughly tested in that particular section. But few varieties succeed equally well in all parts of the country, hence the amateur should first ascertain from neighbors those varieties that are grown successfully in his vicinity. Plant these first as your mainstay, and if you want to experiment in a small way testing varieties, all right, but go cautiously on novelties; they are expensive, and often many of them are not any better than the standard sorts. Try a few of the novelties at first, and if better results are obtained from these than from the old varieties, then will be time to plant more largely of the new kinds. In order to keep a variety from degenerating, as far as lies within the cultivator's power, much care should be exercised in the selection of plants for setting new beds. Some persons think that old plants taken from old beds are just as good as young plants taken from new beds, provided the old black root is broken off; but such a practice is wrong, and to it is often traceable the fact that a variety has run out. Only young, strong plants, with well-developed roots, from beds that have never fruited, should be used.

PISTILLATE AND BI-SEXUAL VARIETIES.

In the accompanying table, those varieties marked "H" are perfect flowering kinds, having both stamens and pistils, and are capable of fertilizing themselves. Those varieties marked "P" have pistils only, or the stamens are so poorly developed that they have to be planted with or near a variety that has a perfect flower in order to insure fruitfulness. Some of our best and most productive varieties are pistillate, and when these are grown, success or failure, to a large degree, depends on the sort used as a pollenizer. In selecting a variety for a pollenizer it is not enough that it has a bi-sexual flower, for many of the sorts termed perfect flowering have such weak stamens that they can not more than fertilize themselves. A pollenizer should have a large bloom, strong, well-formed anthers, which, as a rule, will be prolific in pollen. Time of blooming is also another important consideration in choosing a variety for a pollenizer; both kinds should bloom at or very near the same time; if there is much difference in their blooming periods, small, ill-shaped berries from the pistillate sort will be the result. There is a diversity of opinion among growers as to what proportion of a patch should be of a bi-sexual variety; some claim that one row in four or five is all that is necessary, while others say the best results are obtained from planting half and half. We believe the latter proportion will prove the more satisfactory.

VARIETY TEST FOR 1894.

The soil on which our plants were grown is a heavy, adhesive, bottom land, hard to cultivate, unless taken just at the right time. Plants received good attention during the summer of 1893, and most of them made a good growth. They were irrigated last on October 20th, and mulched with old wheat straw on October 27th;

the covering was allowed to remain on until April 21st, at which time plant growth had commenced; cultivation was then given, after which water was applied as often as required. The accompanying table gives the date of blooming and date of first ripe fruit of each variety:

	Sex.	*Date of First Bloom.*	*Date of First Ripe Fruit.*
Atlantic	H.	May 14	June 18
Belle of La Crosse	P.	" 13	" 17
Bomba	H.	" 16	" 13
Boynton	P.	" 12	" 11
Bubach	P.	" 10	" 12
Captian Jack	H.	" 11	" 12
Cornelia	H.	" 16	" 17
Crawford	H.	" 17	" 14
Crescent	P.	" 9	" 8
Crystal City	H.	" 4	" 5
Cumberland	H.	" 14	" 14
Downing	H.	" 14	" 13
Edgar Queen	P.	" 18	" 20
Edward's Favorite	H.	" 13	" 15
Eureka	P.	" 16	" 18
Gandy	H.	" 14	" 21
Glendale	H.	" 14	" 17
Haverland	P.	" 9	" 11
Ironclad	H.	" 9	" 11
Jessie	H.	" 14	" 11
Jewel	P.	" 14	" 17
Jumbo	H.	" 16	" 15
Lady Rusk	P.	" 14	" 12
Lida	H.	" 13	" 14
Loudon	H.	" 14	" 15
Louise	H.	" 14	" 13
Manchester	P.	" 9	" 15
Ontario	H.	" 16	" 13
Parker Earle	H.	" 9	" 14
Pearl	H.	" 14	" 11
Shuster's Gem	P.	" 14	" 13
Summit	H.	" 8	" 15
Thompson	P.	" 14	" 13
Van Deman	H.	" 12	" 9
Warfield	P.	" 14	" 11
Westlawn	P.	" 14	" 14
Wilson	H.	" 9	" 12
Woolverton	H.	" 18	" 14

Atlantic.—A late variety, not proving very vigorous here. Plants of medium size, leaf stalks long and only fairly strong, leaflets long ovate, light green, trusses long, berry of medium size, regularly conical, colors evenly, firm and of fair flavor. The variety cannot be recommended for general culture, as there are others so much better.

Belle of LaCrosse.—Plants vigorous, leaf stalks long and strong, leaflets of medium size, broad ovate, trusses of medium length and strong. A late variety, productive, berry of medium size and regularly sub-conical, color a light scarlet, of fair quality for home use, but too soft for market.

Bomba.—A variety closely resembling Wilson, both in habit of plant and appearance of fruit. Leaf stalks strong and of medium length, leaflets large, broad ovate, trusses short and stout, blossoms large, stameus well developed. A second early berry of good color and very firm, but is not up to the standard for productiveness.

Boynton.—A variety resembling Crescent in foliage and fruit. Plant vigorous, produces runners freely, early in ripening and productive. Berries of good size, regular in shape and of good color; altogether, we consider this a decided improvement on Crescent.

Bubach.—This variety, which is such a favorite in many sections, proved an entire failure on our heavy land; but grown by parties near here, on a sandy loam, it was a success. Its season is medium early, the plants are productive and the berries large. We would say to all, do not plant the Bubach on heavy land.

Captain Jack.—A well-known standard variety in many sections. Ripens second early; the plant is a strong, healthy grower with very dark-green foliage; flowers strongly staminate; the variety is extensively used as a pollenizer for pistillate sorts. It is fairly productive, berries of medium size, conical, of an attractive red, firm and a good shipper.

Cornelia.—A late variety of the old Glendale type, possessing only ordinary vigor. Leaf stalks long, erect, leaflets medium size, long ovate, light green, trusses long. Berry of medium size, conical, of poor color, too soft to ship; the variety possesses no special merits which would recommend it to the public.

Crawford.—A poor grower, makes but few plants, seems to lack vigor. Leaf stalks short and strong, leaflets large, broad ovate, dark green; trusses short and stout, stamens well developed. Berry large, conical, firm, seeds very numerous, not productive; the variety can not be recommended.

Crystal City.—This was the first variety to ripen. Plants very vigorous and healthy, but is not productive, fruit small and too soft for shipment; of no value here.

Crescent.—This well known and at one time the most popular variety in cultivation, is being supplanted by some of the newer sorts possessing superior merits, chief among which may be mentioned Warfield. Crescent is second early in time of ripening, plant remarkably vigorous, will grow in a great variety of soils, is productive and a fair shipper. The chief objection to it is that the berries run down so very small after the first few pickings.

Cumberland.—An old variety highly esteemed for family use or near markets, but not firm enough for distant shipping. A close grower, leaf stalks short and stout, leaflets large, broad ovate, of a dull green, trusses short. Berries medium large, sub-conical, remarkably regular in form and holding their size throughout the season, color light pink, of a mild, pleasant flavor. The variety is not as productive as some, but for home use is a favorite wherever grown.

Downing.—Another of the old sorts, which, like the Cumberland, is desirable only for home use, on account of its poor shipping qualities. Here the plant lacks vigor and productiveness. It is medium in time of ripening, fruit small, conical, regular, color attractive, flavor good.

Edgar Queen.—A late variety of strong, vigorous growth; leaf stalks long, leaflets large, long to broad ovate, light in color, trusses long and strong, productive, berries of large size, somewhat lobed, holds its size well, but is not firm enough for market.

Edward's Favorite.—This variety is said to be a seedling of old Jucunda, which it closely resembles both in plant and fruit. Plant remarkably strong and healthy, produces runners freely, medium in time of ripening. Berries of large size, conical, very even, holding the same throughout the season, of a bright, attractive color, appearing as though they had been varnished, seeds golden and prominent, flavor good. While not so productive as some, this is one of the best varieties tested. We think it would prove a good shipper.

Eureka.—A late variety of strong growth, late in blooming, leaf stalks long, leaflets large, broad ovate, medium light in color, trusses long and strong, productive, berries of the Bubach type, large, sometimes irregular, colors evenly, a light scarlet, of fair flavor, but too soft for shipping.

Haverland.—This is a second early variety, vigorous and productive, but desirable only for home use, the fruit being too soft for shipping. Leaf stalks long and fairly strong, leaflets medium size, long ovate, light green, trusses long, fruit rests on the ground, berries of medium size, conical, slightly necked, color a light scarlet, flavor good, a fine variety for home use.

Gandy.—One of the latest to ripen. Were this variety productive it would stand without a peer as a late sort; plant of medium vigor, makes but few runners, leaf stalks medium long, strong, leaflets long ovate, trusses long. Berries uniformly large, of a bright scarlet, with a very large green calyx, which remains fresh for a long time after being picked, giving the fruit an attractive appearance in market; the regular even size is held throughout the season; the variety is a good shipper.

Glendale.—A late variety with apparently tender foliage for this climate. Plants are tall and of only medium vigor, leaf stalks long, leaflets long ovate, light green, trusses long and strong, productive, berries of medium size, conical, of poor color, many having white sides and tips.

Ironclad.—A second early variety resembling Wilson. Plants strong and healthy, but do not produce runners freely, a close grower, leaf stalks short, leaflets medium large, broad ovate, dark green, smooth and glossy, trusses short and strong, stamens well developed. The berries are of medium size, rich dark red, very firm, but not up to the standard for productiveness.

Jessie.—This is a variety of the Sharpless type, medium early in ripening, plant vigorous, leaf stalks long and stout, leaflets large, broad ovate, trusses short and strong, strongly staminate, makes but few plants. Berries large, conical, of uniform size, of better color than Sharpless and firmer. This is a fine variety, good as a pollenizer.

Jewel.—A late variety of no special value. Plant easily affected by heat, foliage very tender, leaf stalks long, leaflets large, long ovate, trusses long, fruit at the very top of the fruit stalks, berries medium large, resembling the Cumberland in shape and color, with a peculiar spicy flavor. The variety can not be recommended.

Jumbo.—Another variety of the Sharpless class, plants large, strong and fairly productive for a large sort, medium in time of ripening, leaf stalks strong, leaflets large, broad ovate, light green, trusses short and very strong, flowers large, with well developed stamens, a good pollenizer. The berries are large to very large, compressed conical, tips and under sides do not color well until fully ripe, fairly firm for so large a berry. This variety is worthy of trial.

Lady Rusk.—Plant and fruit both resemble Crescent, although the fruit is inclined to be more irregular in shape, plant healthy, and produces runners freely, only fairly productive, second early in ripening, color like that of Crescent, fairly firm, worthy of trial.

Lida.—A strong growing variety with large leaves and strong leaf stalks and trusses, produces plants freely which are evenly distributed in the row, medium in ripening, berries large, of uniform size throughout the season, sub-conical, very much like Manchester in color and shape. The variety is hardly productive enough for a market berry, but is desirable for home use.

Loudon.—This variety makes a strong, vigorous growth, leaf stalks of medium length and stout, leaflets large, long ovate, trusses short and strong, blossoms large, stamens well developed, would be a good variety to use as a pollenizer, productive, ripens in mid-season, berries of good size and color, quite firm.

Louisa.—A medium variety in time of ripening, plants healthy and productive, leaf stalks short and strong, leaflets of medium size, broad ovate, medium green, trusses short and stout, berries of large size, regular, conical, flavor good, firm.

Manchester.—A popular mid-season variety, inclined to rust badly in some sections, although entirely free from it here. Plant and fruit closely resemble Lida. This is a good variety for home use or near market, but will not stand much handling.

Ontario.—Another variety of the Sharpless type. The plants are large and strong, with stout leaf stalks and large, broad ovate leaflets, and strong trusses. Foliage light green, blooms very large with strong stamens, does not make many plants. The berries are large, somewhat irregular in shape, like Sharpless, but colors better than that variety, sweet and of fine flavor. The variety is below the standard of productiveness.

Parker Earle—For productiveness this variety stands far ahead of any we had under test the past season. We never saw plants more heavily loaded with fruit, the most of which was brought to perfect maturity. To give an idea of the immense productiveness of the variety, a row 100 feet long and 18 inches wide produced 65 boxes of berries; at this rate an acre would have yielded 12,800 boxes, a remarkable crop under the average cultivation. The soil on which Parker Earle was grown is a very heavy bottom land, and it remains to be seen how the variety will succeed on lighter soils and on heavy soils in different seasons. The plants are remarkably strong and vigorous, make sufficient runners to form an even bed 18 inches wide. The berries are large, conical, regular in size, of an attractive scarlet, slightly necked, calyx reflexed, quality good. This promises to be a good market berry.

Pearl.—A productive early variety ripening with Crescent. The plant is of strong growth and produces sufficient runners. Leaf stalks short and stout, leaflets large, broad ovate, trusses short and strong, berries large, regular, evenly colored, slightly necked, of a bright scarlet, flavor equal to any in the list, a good variety.

Shuster's Gem.—This variety is a cross between Crescent and Sharpless. The plant is moderately vigorous, with light green leaflets of medium size, and strong trusses. It is quite productive, berries of large size, conical, of a light scarlet, flavor good; too soft for market, but desirable for home use.

Summit.—In foliage and fruit this variety closely resembles Lida. It produces uniformly large fine berries, sub-conical, light scarlet and of good flavor. This is another variety that is desirable only for home use.

Thompson.—There were only a few plants of this variety, but these made a favorable showing; plant and fruit of the Crescent type, second early in time of ripening, berry of good size and color, firm, worthy of further trial.

Van Deman.—In this variety our expectations were not realized; as so many favorable reports were heard of it from all parts of the country, and having grown it in Maryland, when first introduced, with the most satisfactory results, one could not help feeling a special interest in the variety. The plant is strong and healthy, with a fine, dark green foliage, but here it was not productive. The first two or three pickings gave berries of good size, sub-conical, of an attractive color, fairly firm and of good quality; but afterwards the fruit was of small size. On a different soil we hope the variety will do better.

Warfield.—This is undoubtedly one of our very best all-purpose berries. The plant is of medium size, very vigorous, producing as many if not more runners than Crescent. The foliage is strong and dark green, trusses short and stout, a second early variety, very productive; berries of large regular size, conical, slightly necked, of a rich dark red, firm, and a good shipper. Like the Wilson, it is a little acid. Of all the varieties tested, for a profitable market berry, the Warfield stands at the head.

West Lawn.—A strong, vigorous variety, with long leaf stalks and long ovate, light green leaflets, trusses long and strong, holding the fruit well up from the ground, medium in time of ripening, berries of good size, regular, sub-conical, of a dull scarlet. The tips are inclined to remain green, which feature, with many, would condemn the variety.

Wilson.—No other variety of strawberry has been so widely disseminated and was held in popular favor so long as the Wilson. For more than twenty years it stood pre-eminently as a productive market berry, but now we are sorry to say that this once grand berry has certainly run down, until it is no longer productive, and the fruit is of inferior size after the first few pickings. The plant is a a strong, close grower, with large, dark leaves, flowers strongly staminate, prolific in pollen, berries of medium size, conical, dark red and very firm, one of the best shippers grown.

Wolverton.—A productive variety, ripening in mid-season, that gives promise of becoming a valuable berry, both for home use and for shipping, being a late bloomer it is not likely to be killed by late spring frosts. The plant is a close grower, strong and healthy, leaflets large, long ovate, light green, trusses very strong, berries large, conical, regular in size, color a bright, attractive red, flavor good. We believe this variety will be liked by all who grow it.

SUMMARY.

From the variety test carried on at this station, and from observations made on beds of growers in this vicinity, the following may be summarized:

1st. For an extra early berry, either for home use or market, Mitchell's Early is desirable. The plant is bi-sexual, prolific in pollen and a good pollenizer. The variety does far better the second and third years than the first.

2nd. The most productive sorts were, Parker Earle, Warfield, Boynton, Edward's Favorite, Wolverton, and Pearl.

3rd. The most attractive berry in appearance and also possessing the best flavor, was Edward's Favorite.

4th. For market we would recommend Warfield, Parker Earle, Edward's Favorite, Boynton, and Wolverton. Were but one variety selected we would say, Warfield, fertilized with Edward's Favorite or Parker Earle.

5th. Varieties prolific in pollen and good for pollenizers are Captain Jack, Edward's Favorite, Jessie, Mitchell's Early, Loudon, Parker Earle, Pearl, Van Deman, and Wolverton.

GRAPES.

Commercial grape-growing in Eastern and Northern Colorado does not offer the prospective planter any inducement; the unfavorable conditions attending the successful and profitable growing of the grape here, are these: East of the range, all varieties must be protected in winter by a covering of earth two or three inches deep, and the same removed in spring, all of which adds to the cost of production; and furthermore, the yield obtained here is not as large as it is in the grape-growing regions of the East. At the present time the prices realized are so very low that local growers can not compete with the grape belts of the east, where the fruit is grown by the hundreds of tons and shipped in car-load lots to our Western markets, where it sells at retail for 25 to 30 cents per 10-pound basket. Were the yield here as large as it is in the East, and could covering be dispensed with, thus lessening the cost of production, the problem of profitable grape-growing here might assume a different aspect.

West of the range, the conditions are different, and altogether favorable to successful grape-growing on a large scale. The vines require no protection whatever; the yield is large, and fungus diseases are entirely unknown. There is no reason why Western Colorado should not some day be reckoned among the foremost of the grape producing sections of the country. The conditions as regards soil and climate are certainly most excellent, and what is now necessary in order to prosecute the business on a large scale is proper shipping facilities at reasonable rates. While we do not believe that grape-growing can be carried on profitably on an extensive scale in Northern and Eastern Colorado, we do not mean to discourage the planting of the vine, but would not recommend it as a money crop. To all home owners, we would urge the importance of planting the grape for their own use. A few dozen vines, well cared for, in a few years will be the source of much enjoyment and satisfaction to any family; and when the vines are once well established they will last almost a lifetime. Where one is near a town of any size, a vineyard of a few hundred vines may be made to pay, provided the right sorts are planted; early varieties are the ones to plant for profit, the earlier the better; very early grapes of only medium quality are generally more profitable than later ones of good quality; but a variety possessing extreme earliness in connection with good quality, is what we need. Generally, in the markets of the West, dark grapes sell better than the light ones, while in the East the reverse is the case. With grapes, as with all other fruits when grown for market, too many varieties should not be planted.

SOIL.

Grapes succeed best on a warm, well-drained soil, sloping towards the south. The spring is the best season for planting; vines are usually set 6 to 8 feet apart, in rows 8 feet apart; at these distances, requiring 680 and 900 vines, respectively, to set an acre. One and two-year old vines are generally planted; two-year old vines cost from one-third to one-half more than one-year old vines, but they are stronger, and, as a rule, will give fruit earlier. When ready to plant, ample holes should be dug to receive the vines; if the roots are very long, say from 18 to 24 inches, they should be shortened, and spread out in all directions, not more than 6 or 8 inches from the surface, in order that they may get more warmth, and also have a richer soil in which to grow; broken or ground bones, old shoes, rich earth, or any fertilizing material, mixed with the soil when filling in, will be of much benefit. The grape, like the majority of plants, does best when well fed.

After vines are set they should be cut back to within two or three buds of the old wood. For the first two years the method of pruning is practically the same for any system of training that is to be adopted later. The first fall after planting pruning consists in cutting back nearly to the ground again, leaving only a spur of three or four buds; the second season two canes should be allowed to grow; on good soil and under proper cultivation, strong growing varieties should make a growth of five or six feet the second season; if so, one branch should be cut back to within three buds again, and the other, which is intended to bear, should be cut back to within three or four feet. If vines are not strong enough to produce a good growth of wood, they are too weak to bear fruit; as they grow older and are stronger three to five canes may be left to fruit—those that start within a foot or two of the root are preferable; these shoots are trained out in fan shape on trellis or to posts. This mode of training and trimming is known as the fan system. The following is a plan of trellis which is much used: Durable posts are set 16 to 18 feet apart, and to these wires are tightly stretched and fastened; the lowest wire should be a foot or more from the ground, the next 10 or 12 inches above, and the other two each 12 to 16 inches apart; by increasing the distance between the wires three may be made to answer. A system of training and pruning, after the second year, different from the fan system, and one that is generally liked, especially for small vineyards, is as follows: The two canes that have been formed the third year are cut off within three or four feet of the base, and spread out horizontally to form the arms; all shoots nearer than one foot of each other are rubbed off; each shoot should be tied to the second wire as soon as it has grown sufficiently to reach it. If properly trained, each arm ought to produce four or five strong shoots, which are trained to the wires in a vertical position. At four years of age each shoot should yield two or three bunches of fruit. After growing one season each horizontal shoot should be cut down to one or two good buds, these grow and form the bearing wood for next year, and so, from year to year, this method of pruning and training may be practiced with little deviation. Pruning may be done at any time after the leaves fall until the sap starts in the spring.

NOTES ON STATION VINEYARD FOR 1893 AND 1894.

The Station vineyard, which contains 260 vines, representing seventy-five varieties, is on a clay loam, gently sloping towards the south. The rows are 8 feet apart, and the vines 8 feet apart in the rows. A trellis of two wires is used for training. Between the first and middle of November the vines are pruned, laid down and covered with earth to a depth of 2 or 3 inches. Generally, about the first of May, the covering is removed, the vines again tied to the wires and the surface leveled, after which water is applied. One or two irrigations, for such soil, followed by good cultivation until the middle or last of July, is all that is necessary. In the following descriptions of varieties, and from the value placed on each, it should be borne in mind that of many of the kinds only one plant was set, and it is well known that individuals of a variety often differ, so that with some of the sorts, had there been more than one vine planted, the results obtained might have been more satisfactory. In giving the season of ripening of a variety, the Concord has been used for comparison, for the reason that it is more generally known than any variety in cultivation.

BLACK VARIETIES.

Aminia (*Roger's No. 39—Hybrid*).—Vine a good strong grower, shoots 5 to 6 feet, wood stocky, season after Concord, medium productive, bunches of good size, compact, berry large, black, skin thick and tough, flavor poor.

August Giant (*Labrusca-Vinifera—Roger's Hybrid*).—Vine an ordinary grower, shoots 2 to 3 feet in length, early in time of ripening —a few days later than Moore's Early, and a week or more in advance of Concord; bunch of good size, rather loose, berry medium, round, black, with a blue bloom, and of fair quality. The variety is fairly productive, and worthy of trial.

Black Eagle (*Labrusca X. Vinifera—Concord Hybrid*).—A variety ripening with Concord, and quite productive. The vine did not make as good growth in 1894 as in 1893; shoots not over 1 foot long, slender, bunch long, loose, berry some smaller than Concord, black with a deep bloom, sweet and of good quality. Concord is preferable.

Cambridge (*Labrusca*).—A variety ripening with Concord. Vine a good grower, shoots 3 to 5 feet long, wood stocky, productive, bunch small to medium size, loose, berry smaller than Concord, skin thin, pulp melting, hardly equal to Concord in flavor. Worthy of trial.

Champion (*Labrusca*).—Only an ordinary grower, shoots 2 to 3 feet, rather slender, productive, one of the very first to ripen, bunch of medium size, compact, berry smaller than Concord, a dull bluish black, inferior to Concord in flavor, though a profitable early market grape.

Concord (*Labrusca*).—A variety universally known and liked. Here the vine makes a good growth, some shoots 5 to 6 feet long, wood stocky, productive, but hardly early enough for this section; often it barely escapes frost; bunch large, quite compact, frequently shouldered, berry large with a good bloom, flavor good, the standard late black grape for home use and market.

Cottage (*Labrusca*).—Vine an ordinary grower, some shoots 2 feet long, wood slender, fruit ripens four or five days earlier than Concord, fairly productive, bunch of medium size, berry some smaller than Concord, black with a deep bloom. Concord is the more desirable, though Cottage is worthy of trial.

Creveling (*Labrusca X. Vinifera—Concord Hybrid*).—A second early variety, ripening considerable in advance of Concord. The vine is a good grower and productive, shoots 2 feet and over, bunch of medium length, rather loose, berry smaller than Concord, black with a deep blue bloom, sweet and melting, not equal to Concord as an all-purpose grape, but on account of its earliness, will prove satisfactory where the season is short.

Early Victor (*Labrusca*).—This is a second early variety, vine a good grower, shoots 4 to 5 feet long, wood stocky, bunch small, compact, berry small to medium, inferior to Concord in flavor. The chief merit of the variety is its earliness, ripening two weeks before Concord.

Essex (*Roger's Hybrid No. 41*).—This is a rank-growing variety, shoots 6 to 8 feet, wood stocky. It ripens after Concord and is too late for this part of the State; bunch of good size, fairly compact, berry very large, very dark red or black. Where the season is longer this would be a desirable variety.

Herbert (*Roger's Hybrid No. 44—Labrusca X. Vinifera*).— The past season the vine of this variety made a small growth; some shoots 2 feet long, wood slender. Its season is some later than Concord; bunch of medium size, berry large, black, quality good. So far the variety has not proved productive.

Janesville (*Labrusca X.*).—This is one of the hardiest if not the most hardy variety we have tested. The vine makes a good growth —5 to 6 feet—which is well ripened. Its season is very early, bunches of medium size, compact, occasionally shouldered, berry smaller than Concord, black with a good bloom, very productive, and were it not for the very poor flavor would be a desirable sort. It is fine for preserves and jellies, and in trying localities, for home use, it will prove good.

Merrimac (*Labrusca X. Vinifera—Roger's Hybrid*).—This is a remarkably strong growing variety, shoots 6 to 8 feet, wood stocky. It is productive, and ripens a little later than Concord, bunch of medium length, loose, berry large, skin thick, quality good; too late for this section.

Moore's Early (*Labrusca*).—This variety makes but little growth, some shoots 3 feet long. So far it has not been productive. It is early in ripening, and the best in quality of the early varieties, bunch of medium size, generally loose and ill shaped—so many of the berries drop, thus making a straggling bunch; occasionally there is a fairly compact bunch, berry some larger than Concord. Were this variety more productive, it would be one of the very best early black grapes; at any rate, it is worthy of trial.

Montefiore (*Riparia X. Labrusca*).—This variety makes an ordinary growth, some shoots 4 to 5 feet, fairly stocky. Its season is later than Concord, bunch small and loose, berry of medium size and of fair quality, rather late for this section.

Norwood (*Hybrid*).—This is a good grower, shoots 3 to 4 feet, stocky. The season is a little before Concord, bunch of medium size, fairly compact; berry large, resembling Concord in appearance and flavor; the variety is productive and of merit here.

Oriental (*Hybrid*).—This variety is a fairly good grower, ripening four or five days after Moore's Early. It is quite productive, bunch of medium size, berry large, very dark red or black, flavor somewhat like the Agawam. The variety is worthy of planting.

Rochester (*Labrusca*).—For the last two years this variety has made a small, weak growth; the vine seems to lack vigor here.

There were a few small, poor-shaped bunches; berry small, black, sweet, pulp melting. In other sections the variety might prove a success.

Senasqua (*Hybrid*).—This variety makes a fair growth, shoots 2 to 3 feet, wood stocky, ripens after Concord, bunch long, loose, berry large, thick skinned; too late here.

Telegraph (*Labrusca*).—Vine a fairly good grower, shoots 4 to 5 feet, stocky. Its season is second early, ripening a few days after Moore's Early, bunch of medium size, compact, berry smaller than Concord, black with a deep bloom, sweet and of fair flavor, though inferior to Concord; a good variety for home use, where the season is short.

Wilder (*Roger's No. 4—Labrusca X. Vinifera—Roger's Hybrid*).—Vine a slow, weak grower, shoots not over 1 foot long, wood slender. Its season is a few days later than Concord, bunch of good size, berry large, black; so far it has not been productive.

Worden (*Labrusca*).—A valuable grape of the Concord class, and nearly identical with that variety, but ripens four or five days earlier. The vine is a good grower, shoots 4 to 5 feet, wood close-jointed and stocky, productive, bunch of good size, quite compact, often shouldered, berry large, black with a deep blue bloom, quality good; altogether, the Worden is preferable to Concord.

RED VARIETIES.

Agawam (*Roger's No. 15—Labrusca X. Vinifera—Roger's Hybrid*).—By many this is considered one of the best of Roger's hybrids. Here the variety succeeds very well; it is a strong, stocky grower, shoots 2 to 3 feet, ripens a few days after Concord; bunch long, loose, berry large, round, red, quality good. The variety is fairly productive, and should be included in every collection.

Amber (*Riparia X. Labrusca*).—A medium variety in time of ripening. It is a strong grower, some shoots 8 feet long, stocky, farly productive, bunch long, loose, berry smaller than Concord, sweet, and of good quality. There are others of the class in the list more desirable.

Amber Queen (*Labrusca X. Vinifera*).—This is a second early variety, ripening a few days after Moore's Early; vine a good grower, some shoots 5 feet, stocky, bunch small, berry smaller than Concord, red or amber, skin thin and tender, sweet and of good quality. This variety is worthy of a place in any collection, but would not recommend it as a profitable sort for market.

Brighton (*Labrusca X. Vinifera —Concord Hybrid*).—A second early variety, ripening a few days after Moore's Early, and has proved here to be one of the very best red grapes among the varieties under test. The vine is a good grower, ripens its wood well, and is productive, bunches long, quite compact, berries some smaller than Concord, round, dark purple, sweet, and of good quality. A sort that will give general satisfaction.

Barry (*Roger's No. 43—Hybrid*).—Vine a good strong grower, shoots 4 to 5 feet long, quite productive, ripens about with Concord, bunch long, compact, berry large, red, thick skin, pulp melting, of a very pleasant flavor. The variety is worthy of trial.

Dracut Amber (*Labrusca*).—This is a poor-growing, unproductive variety, ripening with Concord, bunch of medium length, rather loose, berry smaller than Concord, dark amber, sweet with a very pleasant flavor, pulp meaty; the berries will dry upon the vines before dropping. The variety does not possess any desirable qualities that would recommend it to the public.

Delaware (*Labrusca* X. *Vinifera*).—The vine of this variety has made a poor, slender growth the past two seasons, some shoots 2 feet and over, bunch small, fairly compact, berries small, red, of fine flavor, but so far has not proved productive; worthy of a place in any collection.

Iona (*Labrusca X. Vinifera*)—This has been a poor, weak grower here, some shoots 2 feet long, but slender. Its season is after Concord, bunch of medium size, loose, berry small, red, sweet, and of good flavor. The variety is not desirable for this part of the State, on account of its lateness.

Norfolk (*Labrusca*).—This is a remarkably strong growing variety, shoots 6 to 8 feet, very stocky, productive, ripens with Concord, bunch of good size and fairly compact, berry large, red, and of good flavor; worthy of trial.

Perkins (*Labrusca*).—A variety ripening with Concord; this year the vine made a poor, weak growth, and produced only a few ill-shaped bunches. The berries are smaller than Concord, red or amber, with thick skin. The variety can not be recommended.

Ulster Prolific (*Labrusca X. Vinifera*).—A variety ripening after Concord, vine a moderate grower, shoots 2 to 3 feet, bunches of medium size, loose, berry smaller than Concord, red, flavor good. The variety is too late for this part of the State.

Vergennes (*Labrusca*).—Vine a poor grower, not productive, bunches small, loose, berry smaller than Concord, red or amber, sweet, and of good flavor. Its season is a little later than Concord, which makes it too late for this part of the State.

Woodruff Red (*Labrusca*).—This is only an ordinary grower, but quite productive, ripening after Concord. The season here is not long enough for its perfect maturity; bunches large, compact, berry about the size of Concord, light red, and of a very pleasant flavor. This variety will no doubt prove valuable where the season is longer.

WHITE OR GREEN GRAPES.

Eldorado (*Hybrid*).—A variety ripening three or four days after Moore's Early. The vine is a remarkably strong, stocky grower, bunches long, somewhat loose, berry about the size of Concord, of a greenish color with a golden tinge, skin thin, pulp melting, sweet and of good quality. The variety is productive, and altogether a desirable light grape either for home use or for market.

Elvira (*Riparia X. Labrusca*).—A remarkably strong, vigorous grower, and very productive, some shoots 8 to 10 feet long. It ripens with Concord; bunches short and very compact, berry smaller than Concord, greenish white, sweet, though of poor flavor. For jellies and preserves the fruit is all right, but for market it has no value.

Empire State (*Riparia X. ?*).—This variety has made a poor, slender growth, some shoots 2 feet long. Its season is about with Concord. The few bunches obtained were small and straggling, berry smaller than Concord, white, and of good flavor. While the variety has not done well here, in more favorable localities, it might prove good.

F. B. Hayes (*Labrusca*).—A variety ripening a few days before Concord, vine a poor grower, and so far has been unproductive; bunches small and loose, berry small, straw-color, sweet, and of fine flavor. There are other white grapes in the list much better.

Grein's Golden (*Riparia X. ?*)—The vine a strong grower, and fairly productive; bunches long and loose, berry about the size of Concord, of a rich golden color, skin thin, pulp melting, quite acid. Here the season is too short for the fruit to ripen; further south it might be of value.

Jessica (*Hybrid*).—This variety has made but little growth the past two seasons—seems to lack vigor. Its season is several days earlier than Concord; bunches small, loose, berry small, straw-color, sweet, and of good quallty. Here the variety has proved unproductive, and has not shown any desirable qualities that would entitle it to a place as a sort worthy of cultivation.

Lady Washington (*Hybrid.*)—This variety has proved one of the very best light grapes, so far, tested at this Station. The vine is a remarkably strong, healthy grower, producing shoots 8 to 9 feet long, and ripening its wood well. It is very productive, in season a few days later than Concord, bunches very large and showy, generally shouldered, berries a little smaller than Concord, color between a straw-color and a golden, quality good. Here the season is sometimes rather short for the perfect development of the fruit, but where the season is longer it will prove a most valuable white grape.

Martha (*Labrusca*).—An ordinary grower and not very productive, shoots 2 to 3 feet long. It ripens with Concord; bunches of medium size and fairly compact and holding the fruit well, berry smaller than Concord, greenish, sweet, with a rather flat flavor, For home use the variety will give satisfaction, but is not productive enough for a market sort.

Moore'e Diamond (*Labrusca X.*)—A variety ripening in mid-season, vine a good grower and ripens its wood well, shoots 4 to 5 feet long. So far it has not proved very productive; bunches long and loose, berry smaller than Concord, color a greenish-white with a tinge of yellow when fully ripe, skin thin, pulp melting, of fine quality. This is a desirable variety for home us, and were it more productive would be a profitable market sort.

Niagara (*Labrusca*).—This widely disseminated variety which has succeeded well over a broad range of country, has been a failure here. Only one vine was planted, and that has been a poor grower, producing only a few ill-shaped bunches. Its season is a little after Concord. It approaches nearer to a white grape than any we have, and is of good quality. As but one vine was planted, it is hardly fair to pass judgment on the adaptability of the variety to this part of the State; on the western slope it succeeds well.

Prentiss (*Labrusca*).—A poor growing variety, ripening after Concord; so far, it has not been productive. The past two years it has produced only a few poor bunches, berry small, greedish-white, of a pleasant flavor. The variety has not proved at all a desirable sort.

Transparent (*Riparia X*).—A variety ripening a week or more after Concord. The vine makes a fine growth, shoots 6 to 10 feet long, bunches of medium size, loose, berry smaller than Concord, color between straw-color and golden; where the season is longer it would, no doubt, be good.

Triumph (*Labrusca X. Vinifera*).—This is a fair growing variety, but is decidly too late for this section—its season being much later than that of Concord. The bunches are of good size and fairly compact, berry smaller than Concord, greenish-white. It might be of value for the South.

The following varieties are not desirable table sorts, but in many sections are highly esteemed as wine grapes:

Clinton (*Riparia*).
Cynthiana (*Æstivalis*).
Marion (*Riparia*).
Norton's Virginia (*Æstivalis*).
Taylor's Bullet (*Riparia X.*).
Pearl (*Riparia X.*).
Noah (*Riparia X.*).

Those varieties that have not fruited sufficiently to warrant a report are:

Eaton (*Labrusca*).
Eumelan (*Æstivalis*).
Isabella (*Labrusca*).
Jefferson (*Hybrid*).
Poughkeepsie (*Labrusca X. Vinifera*).

In giving the class or classes from which a variety originated, *Labrusca* represents the Northern Fox grape; *Riparia*, the Winter, or Frost grape; *Æstivalis*, the Wild Summer grape; *Vinifera*, the Wine grape of Europe.

By far the greater number of our valuable American grapes are from the *Labrusca* class, which succeeds over a wider range of country than any of the others. Varieties of the *Riparia* and *Æstivalis* class seem better adapted to the South and Southwest, and it is from these two classes that the majority of our native American wine grapes have originated. Roger's hybrids, all of which possess foreign blood, are from *Vinifera* crossed with our native species, or their descendants. Most of the Roger's family are fine, showy grapes, and where mildew and rot are not prevalent, succeed well.

SUMMARY.

The following varieties may be recommended for the northern and eastern portions of the State. In each class ripening in the order named :

Black Varieties.—Champion, Moore's Early, August Giant, Oriental, Worden.

Red Varieties—Brighton, Norfolk, Delaware, and Agawam.

White Varieties.—Eldorado, Moore's Diamond, Martha, and Lady Washington.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 30.

I—FARM NOTES FOR 1894.

Home Station, Fort Collins, Colorado.

II—NOTES ON TOMATOES.

Home Station, Fort Collins, Colorado.

Approved by the Station Council,

ALSTON ELLIS, President.

FORT COLLINS, COLORADO,

FEBRUARY, 1895.

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Farm Notes For 1894.

BY W. W. COOKE AND F. L. WATROUS.

WHEAT.

Several varieties of wheat were sown in small plats on April 2d. They were irrigated May 23d and June 20th, and harvested August 11th.

The Polish wheat was sown March 15th, irrigated May 15th and June 22d, and harvested August 8th.

Polish wheat is more commonly known in this State under the name of Mammoth Spring Rye, but the latter name is misleading. It is a true wheat, but of a different species from ordinary wheat. The Polish wheat was grown this year, under bad conditions of land and water and the yield of twenty-five bushels to the acre was much more than ordinary wheat would have been under the same conditions. It is a very hard wheat and when fed whole to our sheep was largely passed undigested. It does not make good flour but, when cracked, is an excellent stock food.

Variety.	Area of Plat in Acres.	Yield per Plat in Bushels.	Yield per Acre in Bushels.
Saskatchewan Fife	0.25	6.	24
Velvet Chaff Blue Stem	0.25	5.	20
Marvel	0.25	4.5	18
Belotourka	0.0067	0.11	17
Dur de Medeah	0.0067	0.13	20
Polish	12.00	304.	25

OATS.

Last season was especially favorable for oats. Copious rains came at just the right time to make the heads fill well and the oat crop of the Poudre Valley has never before been equalled. Nearly all the kinds raised on the farm did well and most of them very well. The three-acre plot of Silesian oats was a red clover sod plowed in the fall after being irrigated, but nevertheless it was so dry in the spring that after being sown April 6th it had to be irrigated May 17th to make the seed germinate. When it did come, it made an almost perfect stand.

All the other varieties were sown on unfertilized land that had been cropped with grain the previous year. The oats were sown March 30th, irrigated May 25th and June 20th, and harvested August 11th.

Variety.	Area of Plat in Acres.	Yield per Plat in Bushels.	Yield per Acre in Bushels.
Calgary Gray	0.10	6.5	65
White Scotch	0.33	12.	36
Badger Queen	0.10	5.	50
White Russian	0.25	15.	60
Yellow French	0.25	16.	64
Negro Wonder	0.33	18.	54
American Banner	0.33	22.	66
Red Rust Proof	0.33	16.	48
Race Horse	0.20	10.	50
Great Northern	0.33	20.	60
White Bonanza	0.40	16.	40
Lincoln	0.40	16.	40
Irish	0.40	16.	40
Silesian and Excelsior	1.00	48.	48
Excelsior	4.00	24.1	60
Silesian	3.00	22.5	75
Totals and Averages	11.75	70.2	59.75

BARLEY.

While Colorado is not particularly adapted to barley and comparatively little of it is raised, yet the fine crops that are sometimes grown show what may be done with good conditions and good seed.

Barley grows in Colorado with a very short straw, but the heads and the grain compare well with the growths of any country. All the varieties grown the past season were in small test plats. They were sown April 2d and May 12th; the first sowing irrigated May 23d and June 16th, and the last irrigated June 25th, and harvested August 1st to 12th.

The Nepaul and Black barleys are hulless i. e., in threshing, they separate from the hull like wheat. The rest of the kinds retain the hulls in threshing. The California barley deserves special notice for its drouth resisting qualities and its productiveness. It is the only cereal that withstood the severe drouth of last season at the Cheyenne Wells sub-station and the yield of fifty bushels to the acre that we obtained here was re-cleaned, fine seed weighing fifty-six pounds to the bushel. The California barley was sown May 12th, irrigated June 25th, and harvested August 12th.

Variety.	Area of Plat in Acres.	Yield per Plat in Bushels	Yield per Acre in Bushels.
Champion	0.17	8.5	51
Nepaul	0.17	8.5	27
Black	0.17	4.0	24
Manshury	0.33	11.5	34
New Zealand	0.014	0.75	51
California	0.50	25.0	50
Italie	0.0067	0.15	23
Celeste Petite	0.0067	0.17	23

RYE.

A sixth of an acre of Prolific Spring Rye yielded four bushels, or twenty-four bushels per acre. It was sown, irrigated and harvested at the same times named in connection with the wheat.

BUCKWHEAT.

The farmers of Colorado seem to raise but very little buckwheat, and apparently the reason is not that buckwheat will not grow, but that it shells and wastes so in harvesting.

The small plats raised on the farm this season were cut by hand with great care, carried in a canvas to avoid loss and threshed by hand, and yet it is probable that the amount saved represented not much more than two-thirds of the seed grown by the plants.

Two distinct kinds of buckwheat were grown. The Asiatic and the Angled are like the ordinary Silver-hull or Japanese buckwheat. While the other two varieties have a smaller berry shaped more like a kernel of wheat or rye from which it gets its name of rye-buckwheat. This kind is new to Colorado but has been long raised in New England under the name of India wheat or Nigger wheat. Its special characteristic is that it will grow on soil too poor to raise anything else. All varieties made a rank, vigorous growth, but owing to the losses in harvesting it is doubtful whether any of them would prove profitable on land rich enough to grow other grains.

Some second sowing, made in the middle of summer, proved a complete failure. The varieties reported on below were sown in drills May 25th, irrigated June 28th, and harvested August 20th.

Variety.	Area of Plat in Acres.	Yield per Plat in Bushels.	Yield per Acre in Bushels.
Tartarian	0.0067	0.17	26
Rye-Buckwheat	0.0067	0.18	28
Aangled	0.0067	0.16	24
Asiatic	0.0222	0.16	7

MILLET.

Millet was grown as an early crop for seed and as a late crop for hay. In both cases it did not make a satisfactory growth. Although an abundance of good seed was used on land in good condition and that raised large crops of other grains on neighboring plats, yet the stand of the millet was poor and the growth not vigorous.

The millets grown were of two classes, those with the solid, round head, represented by the Hungarian and California and those with the loose head comprising the remainder of the varieties. These latter varieties are called "broom corn millets" from the resemblance of the head to broom corn and the four varieties grown are apparently the same millet, modified slightly by different conditions of soil and climate.

Variety.	Area of Plat in Acres.	Yield per Plat in Pounds.	Yield per Acre in Pounds.
Hungarian	0.033	15	450
California	0.055	11	220
Manitoba	0.055	30	549
Russian	0.007	5	755
Hog Millet	0.180	124	704
Red French	0.100	74	740

BEETS.

Both stock and sugar beets were grown both with and without irrigation. What is called in the table "west field" is a piece of low land that is coming into alkali from a ditch on the upper side. It was raw sod broken in the spring of 1893 and re-plowed six inches deep in the spring of 1894. It was so filled with alkali that scarcely anything would grow on it and yet, under these very bad conditions, we obtained a crop of about thirteen tons per acre of beets.

The "east field" is a piece of land that used to be a cattail swamp but has been reclaimed by tile draining.

The beets were planted with an ordinary Buckeye grain drill, two out of each three holes being stopped up, making the rows twenty-four inches apart. They were sown in the west field May 21st, cultivated June 9th, 27th, and July 2d, and thinned July 14th. Those in the east field were sown May [illegible] ultivated June 6th, 18th, and 27th, thinned July 3d, and [illegible]gated August 2d. The west field was not irrigated. All the kinds were stored in the root cellar and have kept remarkably well. They are being fed to steers, sheep, hogs, cows, and horses with satisfactory results, especially in the case of the hogs.

Variety.	Area of Plat in Acres.	Yield per Plat in Pounds.	Yield per Acre in Tons.
WEST FIELD:			
Yellow Globe Mangel	0.80	19879	12.4
Red Mangel.................	0.60	19413	16.2
Mette Sugar................	0.48	9069	9.4
EAST FIELD:			
Mette Sugar	1.33	33372	12.7
Lane's Sugar...............	0.58	21663	18.8
No. 4 Sugar................	0.17	4360	12.6
Total and Average..........	3.96	108116	13.6

POTATOES.

The principal work done with potatoes was the testing of the effect of commercial fertilizers on their growth and the results are printed in full, not because they show any large advantage to have come from the use of the fertilizer but because they show in a striking manner what may be expected from such work under irrigation. The fertilizers used were "tankage" and "bone meal," both made by the Armour Packing Company, Kansas City, Missouri. They both consist of the refuse from slaughter and rendering houses, dried and ground. but not dissolved with acid, so that the fertilizing elements exist in a form not soluble in water. The tankage is the richer in nitrogen, the bone meal in phosphoric acid. Neither contains but a small amount of potash. They constitute the only forms of commercial fertilizers that are now for sale in Colorado markets.

The fertilizer was sown in the drill at the rate of 400 pounds per acre and intermediate plats left without fertilization. The arrangement of plats and yields are given in the following lists:

Variety.	Fertilizer.	Yield of larger Potatoes per Plat in lbs.	Yield of small Potatoes per Plat in lbs.
Early Ohio	None	16	22
" "	Tankage	28	16
" "	Bone Meal	22	26
" "	None	16	17
" "	Tankage	9	10
" "	Bone Meal	18	13
	None	13	14
Rose Seedling	None	30	38
" "	Tankage	39	41
" "	Bone Meal	26	30
" "	None	24	28
" "	Tankage	30	39
" "	Bone Meal	28	33
" "	None	38	45
Average of all Plats		24	26
Average of Plats with no Fertilizer		23	27
Average of Plats with Tankage		26	26
Average of Plats with Bone Meal		23	25

The point that shows most clearly is the great difference between neighboring and similarly treated plats. This can always be expected in irrigated ground. The yield depends very largely on the moisture of the ground and even under the best of irrigation this is much more irregular than where water is supplied by rain.

The second point is that the differences between plats similarly treated are greater than between the average of plats differently treated. This shows the necessity in work of this kind of having duplicate plats.

The fertilizer has on the average, increased the yield but it has not had the large and decided effect that is produced by a soluble fertilizer used in a country where the soil is moist in early summer. Both bone meal and tankage require moisture to allow the acids of the soil to act on them and make them soluble and under Colorado conditions, where there is but little rain and no irrigation water is applied until the middle of summer it is not surprising that they do not prove successful.

NON-SACCHARINE SORGHUMS.

In the eastern part of Colorado and the western portions of Nebraska and Kansas, the non-saccharine sorghums, such as Kaffir Corn, Jerusalem Corn, Milo Maize, etc., have come to be largely grown because they require so little water to make a reasonable crop.

A test was made at the College farm to see whether they would yield enough more under irrigation to prove a profitable crop.

Several varieties were sown May 17th in drills thirty-six inches apart on seepage ground near a ditch where they had an abundance of water all the season. They were cultivated and hand hoed. On August 18th, notes were taken of their stage of growth as follows:

Yellow Milo Maize. Three feet high, leafy, stocky, most advanced stems, just heading at four feet.

White Milo Maize. Much the same. Not quite so full of heads.

Evergreen Broom Corn Five to eight feet high; good stand and heavy yield; heads just beginning to show blossoms.

Japan Broom Corn. Same as the Evergreen but more leafy and not so far advanced.

African Millet. Two and a half to three feet high, very few heads, rather uneven, but pretty good stand.

Jerusalem Corn. Three and a half feet high, a few heads, the most advanced turning down, not yet in blossom.

Red Kaffir Corn. Fairly heavy growth, three to three and a half feet high, no heads showing even in the stalk.

White Kaffir Corn. About like the last.

The sorghums were harvested at various times from September 16th to 27th. They were put in the silo, heads and stalks. Each of them, even the broom corn, made excellent ensilage.

Yellow Milo Maize. This made the heaviest growth, ripened earliest, and produced the most seed of all varieties, though none of the plats had what would be considered a good yield of grain. The whole plant weighed 19.3 tons per acre, containing 30 per cent. of dry matter or 5.8 tons of dry matter per acre. This 19.3 tons was divided into fifteen tons of stalks and 4.3 tons of heads. The heads contained thirty-four per cent. of dry matter or 1.46 tons of dry matter per acre, and yielded twenty-seven bushels of seed per acre.

African Millet. This seems to be practically the same thing as the White Milo Maize. It produced at the rate of 18.4 tons per acre, divided into 2.7 tons of heads and 15.7 tons of stalks and leaves.

Red Kaffir Corn. Only a few heads, just going out of blossom; stalks short, averaging scarcely three feet high, heads quite large but few. Whole crop, seventeen tons per acre.

White Milo Maize. This gave a total crop at the rate of eighteen tons to the acre, containing 29 per cent. of dry matter, or 5.2 tons of dry matter per acre.

Egyptian Corn. The poorest stand of all, with a few scattering but large heads. The whole crop yielded at the rate of eleven tons to the acre, containing 37.5 per cent. of dry matter, or 4.1 tons of dry matter per acre.

The two Broom Corns did not ripen the brush very well, but they grew an enormous amount of fodder per acre. If this had been dried and fed to stock, it would have been poorly eaten, but being preserved wet in the silo it was eaten readily. The Evergreen Broom Corn yielded twenty tons of fodder per acre, and the Japanese twenty-two tons per acre. They averaged 38.5 per cent. of dry matter, or over seven tons of dry matter per acre.

Such material, with 32 to 38 per cent. of dry matter, is as dry as it is safe to put in the silo.

FORAGE PLANTS.

During the season of 1894, nearly seventy-five varieties of forage crops were grown in large and small plats on the College farm. Many of them need continued tests to furnish a basis for an intelligent judgment.

Flat Pea. (Lathyrus sylvestris). A great many letters have come to the Station asking about this new forage plant. It has not been tried sufficiently yet to show whether it will ever return a profitable crop, but it is certain that it never will be largely grown in Colorado. It needs to be planted in well prepared soil, carefully hand weeded and cultivated a whole season, and then transplanted the next season to its permanent place. The crop the second year is not enough to pay expenses. So that it is not until the third year, after an investment of as much money as several years' crops will be worth, and the loss of the use of the land for two years, that the crop begins to make any return. There has nothing yet come to light in its history at this Station or at any other to indicate that when fully set and grown, it is even as good as alfalfa.

We have a considerable quantity of it sown at the College, but it has not made so large a root growth as it should under the favorable conditions surrounding it.

Sacaline. (Polygonum sachalinense). This plant is getting an immense amount of advertising at the present time and many inquiries have come to the Station concerning it.

Roots and seed were imported from France by this Station during 1894, and were tried under various conditions. The seed failed entirely to grow, though tried in field culture, garden plats, and by greenhouse methods. Some roots started in the greenhouse during the latter part of winter, were well grown when set out in rich ground the first week in May. They were near a hydrant, where they could be watered abundantly and seemed in vigor all the summer. But the amount of growth was disappointing. The most vigorous plant did not grow two feet tall. For a few days during the hottest part of the summer, the plants seemed to make a vigorous growth, but with the first chilly nights the growth ceased. They blossomed but ripened no seed. The climate is apparently not warm enough for the plant to make a profitable growth.

Rape. For many years rape has been grown in France and Germany for the oil contained in its seeds, and in England as a forage crop. Within the past five years, it has been introduced into Canada, and a few experimental patches have been grown in the United States. The most flattering accounts of it from either England or Canada, do not credit it with a vigor of growth equal to that it displayed on the College Farm the past season. An excellent crop in Canada is considered to be from nine to thirteen tons per acre. Of all the plats grown on the farm none yielded so low as the higher of these numbers. It was sown at different times and by different methods, and several varieties, and the smallest yield of all was twenty-two tons to the acre. One plat doubled this and a spot of special luxuriance gave a yield of fifteen pounds from four square feet or at the rate of seventy-five tons per acre.

There would seem to be no question about the plant's being adapted to Colorado soil and climate, the points now to be worked up are the best methods of planting, harvesting, and feeding. On these the Station is planning to do considerable work, the present season.

For the benefit of those not familiar with the plant, we may say that it looks and grows like a rutabaga turnip with an extra large top and a small tough root. The top is the part eaten. It is sown in drills or broadcast, any time from April 20th to August 5th. The seed is very cheap, costing less than twenty-five cents to seed an acre. The plant is ready to pasture or to harvest at sixty days from planting. Two crops can be grown on the same ground the same season. It takes a hard freeze to injure it. It cannot be dried for hay, but is pastured or cut for a soiling crop or for ensilage. It is just about as watery as sugar beets and much the same composition as alfalfa. It will bloat an animal if given in too large quantities the first day. By feeding some dry fodder in connection with the rape, it is easy to prevent the bloating, and after the first few days all danger is past. The rape grew well for us last summer on ground so alkaline that even sugar beets could not succeed.

Its best use at present seems to be for sheep pasture in summer and early fall. If ensilage ever is adopted in Colorado this plant will rival corn as an ensilage crop.

CORN.

During the season of 1894, many varieties of corn were raised on the farm. The particular object in view was the comparison of the large southern corns, with the smaller varieties in common use. This was the first time that large fodder corn had been raised on the College Farm and almost the first ever seen in this vicinity. All the varieties were planted the same day, May 15th, with a hand planter, in hills three feet apart each way, allowing about five kernels to the hill. They were harrowed June 4th, and during the next three weeks were cultivated three times both ways, and the weeds in the hills cut out with hoes. They were irrigated July 2nd, and afterwards cultivated again both ways. Half of each variety was on land freshly manured with stable manure, the other half on fairly good land, the second year from red clover sod. Both fields turned out to be very uneven in character and drainage, so much so that it was deemed best in making comparisons to select one hundred hills of each variety, taken half from the manured and half from the other piece and selected to give as nearly as possible a correct comparison of the different varieties. The yields given in the following tables are calculated from these hundred hills, and represent what any farmer can fairly expect to obtain on medium land, well cultivated and irrigated. These yields are on the average a little less than the crops we obtained the same season from our fields that were planted entirely to large fodder corn, i. e., the land selected for the variety test was not quite so good as the average of our tillable soil.

The varieties were harvested September 25th, after several moderate frosts. Notes were taken on the growth from time to time.

Each variety will be described by itself, and then the large and small varieties compared.

Samples of each variety were taken at the time of havesting to determine the amount of water and dry matter in the crop. The ears were spread out to dry in the corn house for three months and then shelled and weighed.

Both flint and dent varieties were raised, and both small and large kinds of each. The flint corn varied from the little Wills' Gehu Seventy-Day Corn with some ripe ears at three feet high, to the Giant Long White Flint that at eight feet high had not even by harvest time grown an ear fit to roast. Equal differences existed in the dent corns, the earliest and smallest being represented by the Wisconsin Yellow Dent, while the Brazilian Flour Corn represents the other extreme of no ears at all when killed by frost.

SMALL FLINT CORN.

Golden Dew Drop. This is one of the smaller flint corns, showing the first tassels August 1st, and the first roasting ear, August 25th.

On August 18th it was low and leafy, four to five feet high, small stalks, not well eared, ears just showing cob.

September 25th it was scarcely ripe. Total crop, 8.4 tons per acre, containing 31.57 per cent. of dry matter, or *2.65* tons of dry matter per acre. The green ears weighed 4,820 pounds, dried down to 2,772 pounds of ear corn, and *34.4* bushels of shelled corn per acre.

Wills' 70-Day Gehu. This is smallest and earliest of all the varieties grown. First tassels appeared July 22d, and by August 14th, some of the ears were ready to roast. On August 18th, only five feet high, very many suckers, heavily eared, some ears being within six inches of the ground; extra good stand, no replanting, very irregular in ripening; most advanced ears already glazing; many ears only showing cob, most of the ears in full milk. Average per hill, thirteen stalks, six tassels and six ears.

September 16th; ripe and dry. Total crop, 7.1 tons per acre, containing 32.76 per cent. dry matter, or *2.33* tons of dry matter per acre. The ears at harvesting weighed 4,900 pounds, dried down to 2,694 pounds of ear corn, and *37.8* bushels of shelled corn per acre.

King Philip. A red flint corn very early for its size showing tassel July 29th. On August 18th, extra good growth, eight to nine feet high, well eared, very small stalks, almost half the ears at the boiling stage, and a few beginning to glaze. The average hill contained ten stalks, five tassels, and four ears. The ears did not set well, nor fill out, and the yield of shelled corn was much less than would have been expected from its condition in August.

September 16th; ripe and dry. Total crop 9.6 tons per acre, containing 25.06 per cent. of dry matter, or *2.41* tons of dry matter per acre. The ears at harvesting weighed 3,600 pounds per acre, and dried down to 1,639 pounds ear corn, and *18.9* bushels shelled corn per acre.

Sanford. A white flint, with very long ears, medium early. Is almost sweet and makes a nice table corn. It showed the first tassel August 3d: August 18th, very leafy, seven to nine feet high, considerable replanting, only medium earing, small stalks heavily suckered. The average hill contained nine stalks, five tassels, and three ears.

September 25th, well ripened but poorly eared and badly eaten by worms. Total crop, 11.7 tons per acre, containing 32.07 per cent. dry matter, or *3.75* tons of dry matter per acre. The green ears weighed 5,302 pounds per acre, and dried down to 2,651 pounds ear corn, and *32.3* bushels shelled corn per acre.

Longfellow. A medium yellow flint corn, that is much grown in some parts of the country. First tassel August 1st, and first roasting ear August 28th. On August 18th, fully tasseled at six to seven feet. Ears low, some only one foot from the ground; well eared, ears showing cob. The average hill contained ten stalks, five tassels, and three and one-half ears, thus being heavily suckered.

September 25th; ears well ripened, but not well filled; rather poor as a whole, but some nice ears. Total crop, 9.8 tons per acre, containing 31.03 per cent. of dry matter, or *3.04* tons of dry matter per acre. The ears at harvesting weighed 3,856 pounds per acre, which dried down to 1,928 pounds of ear corn, and *23.7* bushels of shelled corn per acre.

Minnesota King. This can be classed as either a flint or a dent corn, as part of the kernels are dented and others are typical flint shape. On August 18th, poor stand with some replanting, irregular, tasseled at six to eight feet high; the first tassels having appeared July 29th. Well eared, ears long, almost to roasting stage, only a few suckers. The average hill contained three stalks, three tassels, and two ears.

September 25th. Ears fully ripe and all the kernels apparently true flint. Total crop, 7.1 tons per acre, containing 28.30 per cent. of dry matter, or *2.01* tons of dry matter per acre. The green ears weighed 2,892 pounds per acre, and dried down to 1,687 pounds of ear corn, and *21.05* bushels of shelled corn per acre. This is probably not a fair exhibition of the general character of the corn.

LARGE FLINT CORN.

Thorburn's White Flint. One of the late flints that will not ripen in this State. The first tassels did not appear, until August 7th. On August 18th, quite low, many tassels at three feet. About half tasseled, leafy, and some suckers six to eight feet high.

September 25th; fairly well eared, but no ears beyond roasting, ears long and slim. Total crop, 9.3 tons per acre, containing 26.35 per cent. dry matter, or *2.45* tons of dry matter per acre.

Giant Long White Flint. Much like the last, but showing the first tassels six days earlier. On August 18th, small stalks, with a few ears, showing cob, fairly good stand by some replanting. The average hill contained nine stalks, four tassels, and three ears.

September 25th. No boiling ears, large, long cobs. Total crop, *10.2* tons per acre, containing 25.23 per cent. dry matter, or *2.57* tons dry matter per acre.

SMALL DENT CORN.

Queen of the Field. A medium sized yellow dent corn showing the first tassel July 28th, and the first roasting ear August 22d. On August 18th, all tasseled, stalks small, six to eight feet high, fairly eared, and showing kernels; corn worm already working badly. Average per hill, four stalks, three tassels, and two ears.

September 25th, ears fairly ripened. Total crop, *11.4* tons per acre, containing 32.2 per cent. of dry matter, or *3.67* tons of dry matter per acre. The green ears weighed 6,266 pounds per acre, dried down to 2,531 pounds ear corn, and

30.1 bushels shelled corn per acre.

Huron. Quite like the last and ripening at the same time. On August 18th, stalks quite slim, seven feet high, ear medium, extra good stand; average per hill, five and one half stalks, five tassels, and three and one-half ears.

September 25th; ears fairly ripened. Total crop 9.2 tons per acre, containing 32.2 per cent. of dry matter, or *2.96* tons of dry matter per acre. The green ears weighed 5,423 pounds per acre, dried down to 2,892 pounds of ear corn and *43.0* bushels shelled corn per acre.

White Pearl. A medium sized white dent corn, showing the first tassel July 28th, and the first roasting ear August 22nd. On August 18th, halfway between the two last; ears quite large and chunky, the most advanced almost to roasting; average per hill, four stalks, three tassels, and two ears.

September 25th, ears nearly ripe. Total crop, 10.7 tons per acre, containing 31.27 per cent. of dry matter, or 3.35 tons of dry matter per acre. The green ears weighed 6,869 pounds per acre, dried down to 3,133 pounds of ear corn, and *43.0* bushels of shelled corn per acre.

Wisconsin Yellow Dent. As small as most of the flint corns showing first tassel August 4th, and first roasting ear August 25th. On August 18th, it was fully tasseled at six to seven feet high, very small stalk and, not many ears, the ears just showing cob, extra good stand without replanting. The average hill contained five stalks, three tassels, and two ears.

September 25th. Corn well ripened and ears well filled out. Total crop 10.8 tons per acre, containing 31.03 per cent. of dry matter or *3.35* tons of dry matter per acre. The green ears weighed 5,905 pounds per acre, and dried to 2,772 pounds of ear corn and *38.7* bushels of shelled corn per acre. This indicates a rather small proportion of cob to shelled corn for Colorado.

Pride of the North. A standard dent corn that has been long raised in Colorado. It was one of the first to show tassel July 28th, and to show a roasting ear August 24th. On August 18th, seven feet high, all tasseled, well eared showing kernels, but no roasting ears. The average hill contained five stalks, three tassels, and three ears.

September 25th. Total crop 12.4 tons per acre, containing 35.88 per cent. of dry matter or *4.45* tons of dry matter per acre. The ears at harvest were nearly ripe and weighed 5,784 pounds per acre. They dried to 2,531 pounds ear corn and *32.3* bushels shelled corn per acre.

Stewart's California Yellow. A medium dent corn, one of the best. On August 18th, stalks medium, well leafed, tasseling at seven to eight feet, showing silk on one-fourth of the stalks, extra stand with but little replanting. It is a good looking corn now, and looks good for much more growth.

September 25th. Ears fairly well ripened. Total crop, 11.2 tons per acre, containing 33.98 per cent. of dry matter, or *3.81* tons of dry matter per acre. The green ears weighed 6,250 pounds per acre, and dried down to 3,374 pounds of ear corn, and *34.4* bushels of shelled corn per acre.

LARGE DENT CORN.

Mastodon. A large, late ensilage corn, showing no tassel until August 8th. On August 18th, nine to eleven feet high, about the best in the field at this date. Very leafy, a little silk, showing a fair stand, with some replanting; a few suckers.

September 25th. Fairly eared, in roasting stage; very large, heavy ears but not many of them. Total crop, 12.5 tons per acre, containing 23.91 per cent. of dry matter, or *2.79* tons of dry matter per acre.

Chester County Mammoth. One of the standard large, late corns, showing the first tassel August 10th. On August 18th, fairly good stand, with little replanting, extra good growth, nine to ten feet high; heavily eared for an ensilage corn. Ears in silk.

September 25th. Full roasting stage, fairly well eared, large, nice ears, but none ready to glaze. Total crop 10.6 tons per acre, containing 27.42 per cent. of dry matter, or *2.91* tons of dry matter per acre.

Red Cob. This is an excellent corn, but the seed planted on this part of the farm, proved poor. The Red Cob was used as the principal field corn on the farm and gave good results, but the seed used for the main crop was from a different source. On August 18th, poor stand, with much replanting, badly mixed seed, tasseling very low, four to six feet high, to top of tassel, very unsatisfactory looking; only a few large stalks. In the main crop at harvest time many stalks were found with the bottom of the ear seven feet from the ground.

September 25th. Ears large, a few in the roasting stage. Total crop, 11.6 tons per acre, containing 25.43 per cent. dry matter, or *2.96* tons dry matter per acre.

Champaign County Prolific. Ripening about the same time as the Red Cob and showing no tassel till August 5th. On August 18th, a good stand after much replanting, stalks about medium, seven to ten feet high, no ears.

September 25th. A few ears, and those, in the roasting stage or earlier, about one tenth beginning to glaze. Total crop, 11.5 tons per acre, containing 24.95 per cent. of dry matter or *2.87* tons of dry matter per acre.

Leaming. One of the best of the medium late fodder corns showing the first tassel August 9th. On August 18th, tasseling at eight to nine feet, leafy, vigorous, not large stalks, showing a few ears and some silk, no boiling ears. The average hill contained four stalks, three tassels, and one ear. There were no suckers; the extra stalks seemed to be from replanting.

September 25th. Well eared, part of the field almost ripe, but the ears not well filled out, the end third almost bare of corn, badly eaten by worms. Total crop, 15.4 tons per acre; containing 29.31 per cent. dry matter or *4.51* tons of dry matter per acre.

Giant Fodder. One of the latest corns grown. On August 18th, the tassels were just showing on the most advanced; no ears or silk; quite leafy with long, broad leaves; medium stalks for so large a corn, seven to eight feet high, an extra good stand.

September 25th. Ears large, a few just showing kernels. Total crop, 17.5 tons per acre; containing 23.06 per cent. dry matter, or *4.04* tons dry matter per acre.

Virginia Mammoth. A large, late white corn, rather late for Colorado. On August 18th, no ears, scarcely tasseled, and seven to eight feet high; at this date a pretty fair corn.

September 25. No ears but an occasional nubbin. Total crop, 10.4 tons per acre, containing 22.16 per cent. of dry matter, or *2.30* tons of dry matter per acre

Brazilian Flour Corn. The latest variety of all, and also the variety that produced the largest growth of stalk and the most dry matter. On August 18th, seven to eight feet high, all leaves, many suckers, no tassels, will make an extra heavy yield. The first tassel did not appear until August 24th.

September 25th. No ears and scarcely any tassels. Total crop, 18.6 tons per acre, containing 24.87 per cent. of dry matter, or *4.63* tons of dry matter per acre.

In order to give a better idea of the comparative yield of the different varieties, there are given in the tables below, the total yield of the crop for each variety, the amount of dry matter contained, and the yield of shelled corn:

Variety.	Total Crop per Acre in Tons.	Total Dry Matter per Acre in Tons.	Shelled Corn per Acre in Bushels.
SMALL FLINT CORN:			
Golden Dew Drop	8.4	2.65	34.4
Will's 70-Day Gehu	7.1	2.33	37.8
King Philip	9.6	2.41	18.9
Sanford	11.7	3.75	32.3
Longfellow	9.8	3.04	23.7
Minnesota King	7.1	2.01	21.5
Average	8.95	2.70	28.1
LARGE FLINT CORN:			
Thorburn's White Flint	9.3	2.45	none
Giant Long White Flint	10.2	2.57	"
Average	9.75	2.51	"
SMALL DENT CORN:			
Queen of the Field	11.4	3.67	30.1
Huron	9.2	2.96	43.0
White Pearl	10.7	3.35	43.0
Wisconsin Yellow Dent	10.8	3.35	38.7
Pride of the North	12.4	4.45	32.3
Stewart's California Yellow	11.2	3.81	34.4
Average	10.95	3.60	36.9
LARGE DENT CORN:			
Mastodon	12.5	2.79	none
Chester County Mammoth	10.6	2.91	"
Red Cob	11.6	2.96	"
Champaign County Prolific	11.5	2.87	"
Leaming	15.4	4.51	"
Giant Fodder	17.5	4.04	"
Virginia Mammoth	10.4	2.30	"
Brazilian Flour Corn	18.6	4.63	"
Average	13.51	3.38	"

The average of all the varieties is 11.2 tons of total crop, containing 3.09 tons of dry matter. Those varieties that ripened, averaged thirty-five bushels of shelled corn per acre.

It is evident on the whole, that the dent corns were more productive than the flint, in total crop, in dry matter, and in shelled corn. When a comparison is made between the small and large kinds of each, the difference is not so great. The large, late flint corns are, evidently, not so well adapted to Colorado conditions as the smaller and earlier kinds, but the choice among the dents is not so apparent. Most of them have done well and some of them very well. Any corn that produces four tons of dry matter per acre has made an excellent growth. According to the figures given above the small dent corns average a trifle more dry matter per acre than the large and later varieties. There has always been a dispute among farmers as to whether this dry matter from mature and immature corn had an equal feeding value, pound for pound. The careful experiments made by the Maine Experiment Station through a series of years seem to show conclusively that the dry matter of the mature corn has the higher feeding value. For every one hundred pounds of dry matter in ripe corn they found seventy-three pounds digestible, while from an equal weight of immature corn, but sixty-five pounds were digested.

If we use these figures we find that of the 3.60 tons of dry matter per acre, yielded on the average by the small dent corns, 2.63 tons are digestible, while of the 3.38 tons yielded by the large dents, 2.20 tons are digestible, showing a difference of 0.43 tons, or sixteen per cent. in favor of the smaller varieties.

The Brazilian Flour corn gave the greatest yield of dry matter per acre. If we consider sixty-five per cent. of this as digestible, we get 3.01 tons of digestible matter per acre. The Pride of the North gave 4.45 tons of dry matter per acre, being the largest yield of the small dents. If seventy-three per cent. of this is digestible, it would give 3.25 tons of digestible matter. Thus, the Pride of the North had more feeding value in its crop, and this crop could be harvested with the labor of handling six tons less weight than the Brazilian Flour Corn. It has the added advantage that if used for ensilage, it will occupy less space and usually keep better and be less acid.

The question as to whether it is better to raise the large or medium dents will have to be settled largely by the conditions of climate. These experiments show that the Poudre Valley is at the extreme northern limit of latitude, at this altitude, for making a profitable growth of the larger varieties. At a lower altitude, or farther south, the larger varieties would do much better, while the smaller varieties would not show a proportional gain. If the results of this season's growth, fairly represent average conditions of this vicinity, the farmer who raises corn for fodder or for ensilage, would better plant about half and half of the medium and large varieties of dent corn. He will then be reasonably sure of good returns, whether the season be long or short, and the mixture of the two in feeding to steers or cows, is probably better than either separately.

Nothing has been said so far of the growing of corn for the grain. Until this past season Nebraska corn could be brought to Colorado about as cheaply as it could be grown. At this season's price of a cent a pound, corn growing would be profitable in most parts of Colorado, especially if care was taken to save the fodder as well as the grain. In the experiments given above, the dent corns yielded more bushels of shelled corn to the acre than the flint corns, but the latter ripened the earlier. In most parts of Colorado where corn can be raised at all, the smaller dents are probably best for ear corn. Attention should be called, however, to the Wills' 70-Day Gehu, for this grew so rapidly and ripened so quickly that it seems adapted to many parts of Colorado that are considered too cold for corn growing. It did not ripen in seventy days, as its name would indicate, and probably would not do so anywhere in this latitude, but it was ripe long before the first light frosts. It is so small that the hills can be planted near together, even thirty inches apart, and still not be crowded. This distance gives twice as many hills to the acre as the ordinary planting of forty-two inches each way. Next to the Wills' 70-Day Gehu in earliness, come the King Philip, and the Minnesota King. The latter corn shows considerable promise.

ENSILAGE AND THE SILO.

The preservation of green corn by means of the silo has attracted but little attention in Colorado, and yet there is no part of the United States better adapted naturally for its use. The expense of the silo, and labor of filling it, have been the great objections urged against it. Incidentally it has also been claimed that the large corn generally used for ensilage could not be grown in Colorado. Most writers have put the cost of building a silo at $2 for each ton capacity. This is on the supposition that it is made above ground with double walls to keep out the frost, and a roof to ward off rain and snow. The climatic conditions of Colorado enable a much simpler and cheaper silo to be made and used.

A silo was built on the College Farm the past season to ascertain how cheaply one could be made, and whether such a cheap affair would answer equally as well as the more expensive for the preservation and feeding of ensilage.

Silos in the East are not built below ground because during half the year the ground is saturated with water. No such trouble need interfere with the Colorado farmer. There are many places where a hole eight to twelve feet deep would remain dry the whole year, and such a spot on the College Farm was selected for the silo. It is on a slight slope, and a hole twenty-one feet square and eight feet deep, was dug out with the plow and scraper. The only hand work necessary was in the corners and on the sides. The dirt was dumped as near as possible to the upper end and the two sides.

Inside this hole a 2x6 sill was laid on the ground, 2x6 studding, twelve feet long, erected every two feet, and a 2x6 plate put on top. This framework was then sheathed on the inside with a single thickness of unmatched, unplaned, rough boards, such as can be bought almost anywhere in the State for $12 per thousand.

The inside was lined with a single thickness of tarred building paper, held in place by perpendicular slats. The floor was made by wetting and tramping the clay at the bottom, while the stars of heaven made an excellent and very cheap roof.

The dirt was filled in against the sides, and banked up to within two feet of the top, except on the lower side, where were doors reaching from near the top to within four feet of the bottom. Thus, our silo consists of a hole in the ground, lined with one thickness of inch boards and building paper, floored with dirt and without any roof.

The labor was done by the farm hands and teams, and could as easily be done by any farmer on his own farm.

The bill for material stands as follows:

240 feet 2x6 for sill and plate.
528 feet 2x6, twelve feet long, for studding.
960 feet rough boards for sides.

1,728 feet lumber @ $12 per M., ...	$20.74
Nails, lath, and building paper..........	7.00
	$27.74

If the silo had a partition running through the middle, dividing it into two pits, each ten by twenty feet, it would make and additional cost of about $5. Our silo has two such partitions, making four pits, each ten feet square, and the entire cost of materials was $42.

Such a silo has a capacity of about sixty-four tons of ensilage, so that the cost of materials per ton capacity, varies from 43 to 65 cents, according to the number of partitions. Had the hole been two feet deeper, and the sides two feet higher, with one partition, the two pits would then have been each, ten by twenty feet, and sixteen feet deep, with a total capacity of one-hundred tons of ensilage; while the cost of materials would have been $44. Thus, a silo can be built in Colorado for less than 50 cents for each ton capacity.

A silo twenty feet square, and sixteen feet deep, is large enough for thirty head of cows or steers, from November 15th to April 15th.

The labor of filling the silo will always remain the principal objection to its use. Corn can be put in the silo whole, but the cost of filling the silo with whole corn is no less than with cut, while the feeding out of the cut, is so much less work, and it is eaten so much more readily by the cattle, that most corn is run through a fodder cutter before it is put in the silo. We cut the corn last fall into quarter inch lengths. Most farmers could hire the use of a threshing engine for power to run the cutter, but they would have to buy the cutter. This would represent an outlay of $50 to $75, or as much as the cost of the silo.

If all the labor and teams are hired, the cost of harvesting corn, cutting it in small pieces, and packing in the silo is about 65 cents per ton.

The ensilage put in the College silo last fall is now being fed out, and proves to have kept very well. When the silo was full it was covered with a small amount of straw and then the dirt from the sides thrown onto the top to form a layer six inches thick. Both the straw and the dirt were soaked with water to make them pack tighter. When the silo was opened, from two to three inches of ensilage were found to be spoiled, under the straw and in the corners, for a little greater depth. Below this the ensilage has kept remarkably well. No eastern silo with double walls of matched lumber could produce any better. The average losses in silos are about twenty to twenty-five per cent. of the weight of the corn put in, while so far, in our feeding, the losses have been but a little more than ten per cent.

THE LOSS OF FODDER CORN IN DRYING.

It is believed by most farmers that, in the dry climate of Colorado, fodder corn, where cut and shocked in good shape, cures without loss of feeding value, and that the loss of weight that occurs is merely due to the drying out of the water. A test of this question was made in the fall of 1893, and the results obtained seemed to indicate that fully a third of the feeding value was lost in the curing. This result was so surprising, that the figures were not published, fearing that some error had crept in, though we could not see where there was the possibility of a mistake.

In the fall of 1894, the test was repeated on a larger scale. A lot of corn was carefully weighed and sampled. It was then divided into three portions; one was spread on the ground in a thin layer, the second part was set up in large shocks, containing about 500 pounds of green fodder in each, while the rest was shocked in small bundles. After remaining thus for some months, until thoroughly cured, the portions were weighed, sampled, and analyzed separately. The table gives the losses that occurred in the curing:

	Large Shocks.	Small Shocks.	On the Ground.
Total Weight.			
When Shocked..............	952	294	186
After Curing................	258	64	33
Loss in Weight..............	694	230	153
Per Cent. of Loss...........	73	78	82
DRY MATTER.			
When Shocked..............	217	77	42
After Curing................	150	44	19
Loss in Dry Matter..........	67	33	23
Per Cent. of Loss............	31	43	55

So far as could be told by the eye there had been no loss. The fodder had cured in nice shape, and the stalks on the inside of the bundles retained their green color, with no sign of moulding or heating. And yet the large shocks had lost thirty-one per cent. of their dry matter, or feeding value, the small shocks forty-three per cent., and the corn spread on the ground fifty-five per cent.

On breaking or cutting the stalks, these losses were explained. The juice was acid, and there was a very strong acid odor, showing that an active fermentation was taking place in this seemingly dry fodder. We had noticed this strong odor the fall before and all through this winter. When the fodder corn for the steers is put through the feed cutter, that same strong smell is present.

It can be said, then, that the dryness of the climate in Colorado does not prevent fodder corn from losing a large part of its feeding value through fermentation. Indeed the loss from this source, is fully as great as in the damp climate of New England.

As compared with the losses by fermentation in the silo, the cured fodder shows considerably the higher loss.

GROWTH OF FODDER CORN.

Several of the eastern experiment stations have done considerable work in testing the growth of the corn plant. They find that the corn keeps on growing until cut down by the frost, and that its growth is most rapid during the month of September. To ascertain whether the same was true for Colorado the following experiment was planned: A plat containing 600 hills of Red Cob corn was divided into halves, September 5th, by cutting alternate hills diagonally across the piece. The 300 hills cut, weighed 1,642 pounds, or thirteen tons per acre. The corn contained 22.80 per cent. of dry matter, or 2.96 tons of dry matter per acre.

On September 29th the other 300 hills were cut, and weighed 1,555 pounds. It contained 23.90 per cent. of dry matter, or 2.94 tons of dry matter per acre. Thus it had dried out a little, and the increase in per cent. of dry matter just balanced the decrease in weight.

During these three weeks, that were expected to show great growth, the plant had practically remained without gain. The days were hot but the nights so chilly that the cold seems to have checked the growth of the corn, although the slight frosts that occurred on several nights scarcely touched the ends of the leaves.

The figures seem to show that, in this part of Colorado, so near to the foothills, corn cannot be depended on to grow after the first week in September, and such varieties should be chosen as will reach the glazing stage by that time.

Notes On Tomatoes.

BY M. J. HUFFINGTON.

The work carried on with this fruit for the season of 1894, was of the nature of a variety test. Most of the new kinds offered in 1893 and 1894 were tried by the side of the leading standard sorts. Only a few of the novelties tried were equal to such standard sorts as Beauty, Perfection, Acme, or Ignotum. The two varieties, Rose Bub, and Seedling No. 2, sent us for trial by Hoover and Moore, of Antlers, Colorado, showed decided merit.

Seeds of the varieties herein described were sown in flats in the forcing house on March 5th, and on March 27th, when about three inches high were transplanted to plant boxes, six by ten inches, partitioned off so that each box held six plants. On April 21st the plants were transferred to a house where the temperature was not so high as in the forcing house, proper: here they were allowed to remain until June 1st, when they were set in the garden. After setting, a good shower fell and nearly every plant grew. On June 30th, the plants were manured with well rotted compost, two shovels full being placed around each plant and well worked into the soil. Water was applied on the following dates: June 11th, July 3d, July 15th, and July 27th. The ground was thoroughly cultivated after each irrigation, as soon as in proper condition to work. From this year's experience we believe that one or two applications of water, after the fruit begins to ripen, are necessary in order to get the best results. In 1893 water was withheld after the first fruits were picked, and the vines did not seem to suffer for lack of moisture at any time; the same course was followed this season, but not attended with the same degree of success as in 1893, as during the latter part of the summer the vines clearly showed the lack of the proper amount of moisture necessary to perfect the fruit. On September 20th, the vines were cut by frost after which they were pulled and the green fruits gathered.

The accompanying table shows the comparative earliness of the varieties:

	Date of First Ripe Fruit.			Date of First Ripe Fruit.	
Acme	August	15	Long Keeper	August	15
Aristocrat	"	15	Meteor	July	24
Atlantic Prize	"	15	Mansfield Tree	August	23
Beauty	"	23	Matchless	"	15
Bond's Early Minnesota	"	15	Maule's Earliest of All	July	21
Buckeye State	Sept.	8	Mitchell's New	August	15
Chemin Market	August	15	New Stone	"	15
Comrade	"	23	Northern Light	July	30
Crimson Cushion	Sept.	8	Perfection	August	15
Cumberland Red	August	15	Picture Rock	"	20
Dwarf Champion	July	30	Potato Leaf	"	15
Early Ruby	August	20	Ponderosa	"	23
Early Michigan	July	25	Puritan	"	20
Everett's First of All	"	30	Red Cross	July	30
Fordhook First	August	23	Rosebud	August	15
Gold Ball	July	25	Royal Red	"	23
Ignotum	August	23	Seedling No. 2	"	27
Improved Chemin or Apple	"	20	Table Queen	"	20
Logan's Giant Seedling	"	20	Trucker's Favorite	"	20
			Vaughan's Earliest of All	"	15

VARIETIES.

Acme. Seed from Vaughan. This variety is more generally cultivated for market than any other. It is productive, early, fruits large, smooth, color a dark red, solid, and a good shipper. It is largely grown at the south for the northern markets.

Aristocrat. Seed from Livingston, the originator. A dwarf variety more erect than Dwarf Champion, a strong, stocky grower, and early. It possesses the advantage of ripening its fruit rapidly, a desirable feature in a market sort. The fruits are of a medium size, smooth and solid, and of a beautiful scarlet color. Aristocrat has proven to be the best dwarf variety that we have tested.

Atlantic Prize. Seed from Vaughan. A variety which originated in New Jersey, a few years ago. The chief and only merit of the kind is its earliness, it being one of the very first to ripen; fruits of medium size, generally rough, color, a shade of scarlet; rather tender, will not sell when smooth varieties are offered in competition.

Beauty. Seed from Vaughan. This popular variety was originated and introduced a few years since by Livingston, the tomato specialist of the country. The type is well established. Its season is medium early, fruits large, roundish, smooth, and firm, color, as in Acme; productive, and regarded as one of the very best sorts for market and canning.

Bond's Early Minnesota. Seed from Iowa Seed Co. An early variety, which is only fairly productive; fruits small, roundish, smooth, medium solid, color of Acme. There are other early varieties much better than this.

Buckeye State. Seed from Livingston. This is another of Livingston's productions, though not one that can be recommended for general cultivation, as it is late and ripens very slowly. Where the season is long it would, no doubt, prove very desirable. The fruits are of the largest size, regular, roundish, very smooth, fairly solid, color of Acme.

Chemin Market. Seed from Vaughan. This is a variety of French origin, medium early in ripening, very productive, fruits of medium size, oblong roundish, very uniform, remarkably smooth, fairly solid, of a light scarlet color. This is an excellent variety for home use, but has not been sufficiently tested to be recommended as a market sort.

Comrade. Seed from Gregory & Son. A variety which originated in New England. Its season is second early, ripening with Beauty; fruits of fair size, roundish, smooth, light scarlet in color; a good variety for home use, but tender for distant shipping.

Crimson Cushion. Seed from Henderson. Originated by Peter Henderson & Co., and introduced by the same firm in 1894. The variety is of the Ponderosa class, and ripens several days later than that sort; fruits large, furrowed at stem, and also rough at blossom end; a shade of purple, solid, and a good keeper. We cannot see wherein this variety is preferable to Ponderosa.

Cumberland Red. Seed from Gregory & Son. A medium early variety, which is quite productive; fruits of fair size, smooth, color as in Ignotum. There are other sorts in the list that are more desirable.

Dwarf Champion. Seed from Vaughan. This is an early sort, which in many sections is highly prized for garden culture, being an upright grower, and thus permitting of close planting. The fruits are of medium size, smooth and solid, color as in Beauty. Altogether. for a dwarf variety, we prefer Aristocrat to Dwarf Champion.

Early Ruby. Seed from Gregory & Son. An early variety which originated in Monmouth county, New Jersey, and was introduced by Peter Henderson & Co., in 1890. The open habit of the plant is a distinctive feature of the variety, and this manner of growth accounts in part for its earliness, as the sun has a better chance to reach and ripen the fruits than with varieties of dense and more upright growth. Fruits are of medium size, generally rough, some fairly smooth, light scarlet in color, rather tender.

Early Michigan. Seed from D. M. Ferry & Co. This variety was introduced by D. M. Ferry & Co., in 1894. Its season is early, fairly productive, fruit small, smooth, the smoothest of the very early sorts, scarlet in color, not productive or large enough for a profitable market variety.

Everett's First of All. Seed from J. A. Everett & Co. A variety introduced by J. A. Everett & Co., Indianapolis, Ind. It is early, but not the earliest, medium productive, fruits of fair size, quite smooth, solid, light scarlet in color. The variety is not productive enough for a market sort.

Fordhook First. Seed from W. A. Burpee & Co. Originated and introduced by W. A. Burpee & Co., in 1894. It ripens with Acme and Beauty; fruits of good size, roundish, smooth and solid, color as in Beauty; not as early as some, but a sort that will give satisfaction.

Gold Ball. Seed from Henderson & Co. A rank growing variety, very productive for a tomato of its class; fruit small, oval, smooth, a beautiful golden yellow, firm and solid; fine for preserving or pickling, but its size, shape, and color are against it as a market variety.

Ignotum. Seed from Michigan Agricultural College, in 1888. This variety originated at the Michigan Agricultural College, in 1887, and was introduced in 1889. It possesses many points of excellence; its season is early, fruits large, regular in shape, solid, and remarkably smooth, of a bright scarlet color; a desirable variety for market and canning.

Improved Chemin or Apple. A variety sent us for trial by Hoover & Moore, of Antlers, Colorado, which seems to be identical with Chemin Market obtained from Vaughan.

Logan's Giant Seedling. Seed from J. A. Everett & Co. A medium variety in time of ripening, fruits very large and the greater part of them very rough; a few fairly smooth, solid, of a pinkish purple color, resembles Ponderosa somewhat, though not so desirable as that variety.

Long Keeper. Seed from Vaughan. A variety ripening as early as any of the desirable market sorts; fruits of medium to large size, very smooth, walls thick and solid; an excellent keeper, color as in Beauty. This is a desirable tomato both for home use and for market.

Meteor. Seed from J. M. Thorburn & Co. A dwarf variety introduced by Thorburn & Co., in 1894, which resembles Aristocrat in habit of growth. The type does not seem to be well fixed; from twelve plants three types of fruit were noted, one of a bright scarlet, another similar to Acme in color, a third, a light scarlet and very much wrinkled. Aristocrat and Dwarf Champion are both preferable to Meteor.

Matchless. Seed from W. A. Burpee & Co. This is a variety of the Ignotum type, which was originated and introduced by W. A. Burpee & Co. It is medium early in time of ripening, fairly productive, fruits of good size, very smooth, of a beautiful scarlet; a good variety, though not as productive as some.

Mansfield Tree. Seed from Vaughan. A variety of the Ponderosa class, medium to late in time of ripening, productive, fruit large, quite firm, very rough, of a purplish color; not at all a desirable kind.

Maule's Earliest of All. Seed from W. H. Maule. This variety was introduced by W. H. Maule, of Philadelphia, in 1894. It was the first to ripen. It is productive, fruits of medium size, rough, of a light scarlet, rather tender. The variety is desirable only for its earliness.

Mitchell's New. Seed from Gregory & Son. A medium early variety, very much like Ignotum, fairly productive, fruits of good size, smooth and of an attractive scarlet. This is a good variety of the scarlet class.

New Stone. Seed from Vaughan. This is another of Livingston's productions, medium in time of ripening, fairly productive, fruits of good size, roundish, smooth, and very solid, light scarlet, an excellent shipper. Altogether this is a desirable sort.

Northern Light. Seed from J. M. Thorburn & Co. A dwarf compact growing variety, introduced by Thorburn in 1894. In this as in Meteor, the type does not seem to be well established; two forms of fruit were noted, one very small, smooth, bright scarlet; the other of good size, somewhat wrinkled at the stem, a shade of scarlet.

Perfection. Seed from Vaughan. A variety originated by Livingston, medium early in season, fruits of good size, smooth and solid color as in Beauty. This is a popular sort wherever grown.

Picture Rock. Seed from Iowa Seed Co. This new tomato was introduced by the Iowa Seed Co., in 1894. Its season is early, fairly productive, fruits of medium size, very regular and smooth, color a bright scarlet. The variety is worthy of trial.

Potato Leaf. Seed from Michigan Agricultural College. This is a distinct variety originated by Livingston & Son, and introduced by them in 1887. The foliage resembles that of the potato, as the name implies. It is medium early, productive, ripens rapidly, fruits of medium size, very smooth and solid, color as in Beauty; a fine tomato for canning and market.

Ponderosa. Seed from Peter Henderson & Co., who originated the variety, and introduced it in 1892. In 1893 the variety appeared to be not well fixed, there being four distinct types of fruit, but in 1894 every plant was true to the type. Its season is medium, fruits very large, some specimens weighing over a pound; quite smooth for so large a tomato, somewhat ridged about the stem, very solid, slow in ripening, color a pinkish purple.

Puritan. Seed saved at Michigan Agricultural College, in 1888. A variety of New England origin, introduced by Rawson, of Boston. Its season is early, productive, fruit large, occasionally slightly furrowed about the stem, of a bright scarlet color, a desirable tomato of the scarlet class.

Red Cross. Seed from Gregory & Son. A variety ripening medium early, fairly productive, fruits of medium size, smooth, of a light scarlet, rather tender for much handling, though good for home use. There are other varieties in the list that are far better.

Rose Bud. Seed sent us for trial by Hoover & Moore, of Antlers, Colorado. A strong growing variety of the Potato Leaf class, productive, early, ripening as early as Vaughan's Earliest of All, Bond's Early Minnesota, and Atlantic Prize, and before Fordhook First, and Early Ruby, although only a few days; the fruits are of good size, remarkably smooth, solid, color as in Acme and Beauty. We consider this a promising variety.

Royal Red. Seed from Livingston & Son, originators. This variety is medium in time of ripening, very productive, fruits of large size, generally smooth, solid, color a beautiful red. This is a desirable tomato either for home use, market, or canning.

Seedling No. 2. Sent us for trial by Hoover & Moore, of Antlers, Colorado. The variety ripens a few days later than Beauty, fruits of medium to large size, roundish, free from ridges or furrows, very solid, of an attractive scarlet. A variety that will give satisfaction.

Table Queen. Seed from Peter Henderson & Co., introducers. A variety ripening in mid season, productive, fruits of large size, fairly smooth, some specimens much wrinkled, color as in Beauty, solid, and apparently a good shipper.

Trucker's Favorite. Seed from Burpee & Co. This is a medium variety as to season, productive, but ripens slowly, requiring a long season to realize best results; fruits large, roundish, smooth, solid, walls thick, which renders it a good shipper, color as in Beauty.

Vaghan's Earliest of All. Seed from Vaughan, the originator. This is a variety, the only merit of which is earliness; fruits small, uniformly rough, of a light scarlet color, tender.

SUMMARY.

First: The six varieties producing the largest amount of fruit by weight, from August 20th to September 1st, were Maule's Earliest of All, Vaughan's Earliest of All, Atlantic Prize, Perfection, Rose Bud, and Ignotum. Each of the first three varieties yielded very nearly the same quantity of fruit within the period designated, which was from three and a half to six times as much as that produced by the three latter sorts.

Second: While the extra early varieties are desirable, where extreme earliness is aimed at, yet when the smooth, solid kinds come into market, there is little or no demand for the former which are generally rough and tender; hence those growing tomatoes for market should plant both the extra early and the second early or main crop in order to prolong the season.

Third: For second early, or main crop varieties, we recommend the following: Acme, Beauty, Perfection, Ignotum, Puritan, and Long Keeper.

Fourth: The best varieties for canning are Beauty, Perfection, Long Keeper, Puritan, Ignotum, and Royal Red. The three former varieties are of a dark red, or purplish color, and the three latter of a bright red or scarlet.

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A PRELIMINARY LIST

OF THE

HEMIPTERA OF COLORADO

BY C. P. GILLETTE AND CARL F. BAKER

Approved by the Station Council,

ALSTON ELLIS, President.

AMERICAN STANDARD:
FORT COLLINS, COLORADO:
MAY, 1895.

THE AGRICULTURAL EXPERIMENT STATION.

FORT COLLINS, COLORADO

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INTRODUCTION.

Probably there is no state in the Union offering a richer field for the student of natural history than Colorado, whether it be in the line of mineralogy, paleontology, zoology, or botany. Its broad stretch of arid plains crossed by streams of living water, its high mountain ranges, broad plateaus, innumerable gulches and deep canons, all combine to give it a most exceptional topography with a consequent diversified fauna and flora.

The macro-lepidoptera of the state are very largely known, as a result of the extended collecting of Reakirt, Mead, Bruce, Snow and others. Lists of Coleoptera have been published from the collections of LeConte, Schwarz, Wickham, Snow and others. Lists of the Hymenoptera have been published by Cresson and Ashmead. But never before in any one publication has the attempt been made to list the Hemiptera of the state. Indeed, heretofore there have been no large collections of the Colorado species of this order to draw upon. During the past four years we have collected nearly all those previously known from the state and a very large number of additional forms. It has been our plan to make more than a simple record of the species known to occur in the state. With each species is given the bibliography of all published records of its occurence in the state so far as known to us, also the name of the collector, locality, date of collection, and, wherever we have been able to ascertain it, the food-plant. Except in the case of Uhler, the authority for the determination of our specimens is given in the same line with the name. To avoid the repetition of the titles of papers, a numbered list of the papers referred to is given, the author's name and the number of the paper only being given in the body of the list.

The determinations of specimens have been made by specialists in the different groups, the authors doing a large proportion of the systematic work on the Homoptera. It is hoped that this work will be found reasonably free from errors. In the preparation of the list we have been greatly aided by Mr. E. P. Van Duzee, who has made a large number of determinations for us, has made many helpful suggestions, and loaned us papers from his private library. We are under very special obligations to Dr. P. R. Uhler of Baltimore who has worked over our entire collection of Heteroptera and described the forty-seven new species and five new genera here published. Professor T. D. A. Cockerell of New Mexico, has determined nearly all our Coccidae and sent us many records of captures by himself, as well as valuable notes on species we had sent him for examination. The Membracidae have mostly been determined by Dr. Goding of Rutland, Illinois, and the Psyllidae by Dr. Riley. Professor Herbert Osborn of Iowa, also determined several species in the early part of the work. Mr. J. H. Cowen, a post graduate student, has done the work on the Aphididae, a large proportion of which he collected himself. Prof. W. A. Snow, of Kansas, has sent us a list of the Colorado Hemiptera in the Kansas University collection, which has added several species and many records to our list. Dr. Riley sent us a similar list from the United States National Museum.

It will be noticed that a great many species in the list, and especially of those that are new, are from mountainous localities where but little or no collecting had been previously done. All portions of the state still promise rich harvests to the collector, and especially those parts which have never yet been visited by "bug-net" and cyanide bottle. The list of new species here presented, although large, must be small compared with the forms yet unknown.

Work of a nature similar to this is being done in all orders. In view of this fact we most earnestly solicit correspondence from any quarter relative to the Colorado insect fauna. Just at this time we especially desire notice of published records not given in this list, and data on correctly determined specimens in collections which have not been accessible to us. As the authors have undertaken a special study of the North American Jassidae, they would be pleased to examine specimens in that group from any portion of the country, and will give determinations for the privilege of retaining desiderata.

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ALTITUDES OF LOCALITIES MENTIONED IN THIS PAPER.

The altitudes given represent only average heights. Timber line is at about 12,000 feet in Southern and about 10,500 feet in Northern Colorado.

Aspen	8,000
Berthoud Pass	11,300
Big Narrows of Poudre	6,000
Boulder	5,300
Cameron Pass	10,000
Canon City	5,200
Cheyenne Canon	6,200
Colorado Springs	6,000
Denver	5,200
Estes Park	8,600
Fort Collins	5,000
Four-mile Hill	7,000
Garland	7,900
Georgetown	8,700
Glenwood Springs	7,800
Golden	5,700
Gore Pass	10,000
Grand Junction	6,000
Green Mountain Falls	8,700
Horsetooth Gulch	5,600
Howe's Gulch	5,500
Idaho Springs	7,400
Lamar	4,000
La Veta	7,000
Leadville	10,200
Livermore	6,000
Manitou	6,300
Montrose	6,200
North Park	8,500
Ouray	8,000
Pueblo	4,600
Rabbit Ears Pass	10,000
Rist Canon	5,500
Rustic	7,000
Silverton	9,400
South Park	7,200
Spring Canon	5,500
Steamboat Springs	6,500
Trinidad	5,900
Veta Pass	9,500
West Cliff	7,800

A PRELIMINARY LIST OF THE HEMIPTERA OF COLORADO.

WITH DESCRIPTIONS OF NEW SPECIES, BY DR. P. R. UHLER, J. H. COWEN, AND THE AUTHORS.

Homaemus grammicus Wolff.

Colorado Springs (Tucker.)

Homaemus aeneifrons Say.

Colo. (Uhler, 1 and 6). Swept from rank weeds near water courses. West of Denver occurred in swampy spots near South Platte River, and on the high watered table lands near foot-hills. Also beaten from bushes near Beaver Brook Gulch and in Clear Creek Canon (Uhler, 5).

Estes Park, Bailey (Snow). Manitou Park (Snow and Tucker).

Homaemus bijugis Uhl.

Colo. (Uhler, 1 and 6). Foot-hills, September (Carpenter—see Uhler, 6.) Near Denver (B. H. Smith—see Uhler, 6). Not uncommon in Denver, particularly on rank growing plants in damp situations (Uhler, 5). Willow Creek, Cusack Ranch, in midalpine of Custer County, August 21st, on timothy (Cockerell, 9 and 10).

Fort Collins, September 21st to October 15th; Horsetooth Mountain,* July 4th; Steamboat Springs, July 26th; Montrose, June 24th (Gillette), Fort Collins and adjoining foothills, May 13th to October 7th, on alfalfa, wheat, and various grasses (Baker).

Phimoderma torpida Walk.

Colo. (B. H. Smith—see Uhler, 6).

Eurygaster alternatus Say.

Hills of Colo., September (Carpenter—see Uhler, 6). Common in Colorado

*A mountain about ten miles south-west of Fort Collins. Collecting was done from 5,500 to 6,000 feet.

in September in the region of the foot-hills (Uhler, 5). Custer County, midalpine, and Summit County (Cockerell, 10).

Fort Collins, July 4th; North Park, July 20th; Steamboat Springs, July 26th (Gillette). Fort Collins, July 29th, on wheat; Steamboat Springs, July 14th (Baker).

Corimelaena albipennis Say.

Of this species Dr. Uhler says: "Prof. Gillette has most kindly sent to me the only specimen of this insect of which there is any record of capture since the time of Mr. Say. It is a species of prominent interest in many respects. In the first place, it is in an undeveloped stage of coloring, showing that oxydation of the outer integuments had not been completed when the insect was captured. It is also a female of unusually large size, in this section of the genus, and it is not in the first stage of exclusion from the skin of the nymph. The body is a little more bloated and consequently more convex above than in the fully dried insect. The contour is fringed all around with slender setae, as in C. ciliata Uhler. Its size is much less than that given by Mr. Say, but it agrees with his description in nearly every respect. The hemelytra are not 'white with a small rufous spot,' but white with a spot and tinge of black near the apex, such as occurs in the drying stage of C. lateralis Fab., a few hours after it has left the skin of the nympha. The 'small rufous spot' of Mr. Say suggests a more recently excluded condition of the species, in which the color beginning as white had oxydized to rufo-piceous on its way to the final piceous or black color of the fully matured insect. C. unicolor Pal. Beauv. becomes almost uniform castaneous, or rufo-castaneous, as it changes from the milky white of exclusion to the final black."

This specimen was first determined by Osborn, who recorded it as the first specimen found since Say's description (see Osborn, 1). Fort Collins, August 11th, on Glycyrrhiza lepidota (Baker).

Corimelaena anthracina Uhl.

Steamboat Springs, July 13th (Baker). Estes Park, July 12th (Gillette).

Corimelaena atra A. & S.

Colo. (Gillette—see Osborn, 1).

Rist Canon, April 16th (Gillette). Veta Pass, June 27th (E. A. Schwarz).

Corimelaena ciliata Uhler.

Foot-hills five miles west of Fort Collins, hibernating under stones, March 22d to April 12th (Gillette and Baker).

Corimelaena coerulescens Stal.

Colo. (Ridings, see Uhler, 6).

Corimelaena extensa Uhl.

Horsetooth Gulch,* May 18th (Gillette).

Corimelaena nitiduloides Wolff.

Above timber line in mountains. (Carpenter, see Uhler, 6). A few speci-

*A gulch about nine miles south-west of Fort Collins.

mens taken concealed among roots of Yucca and other plants growing on plains near foot-hills, during August, near Colorado Springs (Uhler, 5) Custer County, midalpine (Cockerell, 10).

Corimelaena lateralis Fab.

Fort Collins, June 4th; foot-hills five miles west of Fort Collins, May 18th to June 14th; Dolores, June 18th; Montrose, June 24th (Gillette). Steamboat Springs, July 26th (Gillette and Baker).

Corimelaena renormata Uhler n. sp.

"Form of C. quadrisignata Stal. Black, polished, ciliate all around but with longer and less blunt corium and no spots on the connexivum. Upper surface obsoletely rastrate-punctate, with the punctures scarcely visible upon the disk of pronotum and scutellum. Head wide, convex near base, roughly, unevenly, rather coarsely, punctate excepting on the base, the anterior margin bluntly obliquely rounded, with the edge reflexed, and the tip notched at end of tylus, the margin inferiorly has a series of coarse setigerous punctures; rostrum rufo-piceous, reaching to middle coxae: antennae long, fulvo-testaceous. Pronotum transverse, very moderately convex, with the lateral margins little oblique and very slightly curved next the anterior angle, the surface crossed before the middle by a grooved line, which is very distinct each side and is there surrounded by an area of very coarse punctures, the ciliae are set beneath the decurved edge in very coarse sunken punctures. Scutellum bluntly rounded, feebly curved, shorter than the abdomen, with a broad oblique, punctate impression each side above the middle of the corium. The corium about three-fourths as long as the scutellum, with the apical portion of medium width, tapering, and obliquely rounded at tip, with about four lines of coarse punctures, base of both corium and clavus, nearly covered by an ivory white, remotely punctate, spot. Venter highly polished, with transverse remote series of small punctures on most of the segments, the apical segment impunctate.

Length to tip of venter nearly 4 mm. Width of pronotum 2¾ mm. Only one specimen, a female, has come to my notice. It will most likely prove to be the fully colored stage of C. albipennis Say."

Rist Canon*, April 16th (Gillette).

Homaloporus congruus Uhl.

Denver (B. H. Smith—see Uhler, 5). Near foot-hills west of Denver. August (Uhler, 5).

Fort Collins, March 24th to April 24th (Baker). Foot-hills five miles west of Fort Collins, April 21st; Trinidad, May 14th (Gillette).

Cydnus obliquus Uhl.

West of Denver (Uhler, 5).

Amnestus spinifrons Say.

Colo. (Gillette—see Osborn, 1).

Trinidad, May 14th (Gillette).

Amnestus subferrugineus West.

Foot-hills five miles west of Fort Collins, March 15th to

*A canon eight miles north-west of Fort Collins.

April 21st, under stones (Baker).

Perillus confluens H. Sch.

Custer County, midalpine (Cockerell, 10).

Perillus spendidus Uhl.

Colo. (Gillette—see Osborn, 1).

Dolores, June 18th (Gillette).

Perillus exaptus Say.

Colo. (Uhler, 1 and 6). Ula, Custer County, midalpine, November 12th (Cockerell, 10).

Fort Collins, August 4th (Baker). Foot-hills five miles west of Fort Collins, March 15th; under stones (Gillette). Garland, June 29th (E. A. Schwarz).

Perillus claudus Say.

Colo. (Uhler, 1). Colo. (Riley—see Uhler, 6). Near Denver (B. H. Smith—see Uhler, 3). Near Colorado Springs (Uhler, 3). Colo. (Gillette—see Osborn, 1).

Fort Collins, April 10th to October 6th; foot-hills five miles west of Fort Collins, April 9th to August 1st (Baker and Gillette).

Mineus bioculatus Fab.

Colo. (Snow).

Zicrona cuprea Dall.

Southern Colo., June (Carpenter—see Uhler, 7).

Podisus acutissimus Stal.

Colo. (Uhler, 6).

Podisus bracteatus Fitch. Det. Ashmead.

Colo. (Cockerell).

Podisus cynicus Say.

Colo. (Gillette—see Osborn, 1). Colo. (Snow—see Van Duzee, 5).

Spring Canon*, August 1st (Baker). Bailey (Snow).

Podisus gillettei Uhler n. sp.

"Nearly ovate, dull pale brownish made fuscous by the bronze-black close punctures on the head, fore part and sides of pronotum, base of scutellum and base and end of corium. Head finely and closely punctate with black, the tylus with a broad groove on each side, lateral lobes broad, rounded off on the outside of tip, a little longer than the tylus. Antennae a little longer than the head and pronotum united, the basal joint very short, not reaching the tip of the head, greenish yellow, a little dusky at base and tip, the second joint about three times as long as the basal, testaceous, a little dusky above, the third scarcely more than half as long as the second, blackish, paler at base, the fourth

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* A canon eight miles south-west of Fort Collins.

and fifth blackish, both longer than the third, the fifth a little longer than the fourth. Rostrum pale testaceous, piceous at tip, reaching upon the middle coxae, the third joint very thick, a little longer than the fourth which is abruptly narrow. Pronotum more remotely punctate on the disk, with the lateral margins very oblique, thick, callous, broadly pale yellow, finely punctate and a little waved; the posterior margin feebly concave, and the humeral angles tumidly rounded. Pectorial areas remotely punctate with brown. Legs minutely punctate with brown, darker above and on tips of tibiae, tarsi piceous above, the nails also piceous. Scutellum long, minutely punctate, with an obsolete pale stripe on the middle, more conspicuous at tip, and with the usual pale callosity in the basal angles. Corium and clavus with bare spots continued on the costal area. Membrane bronze brown. Venter testaceous, remotely punctate with brown. Connexivum polished, testaceous, marked with black scallops inwardly. Ventral spine very short.

Length to end of venter 13.5 mm. Width of case of pronotum 9.5 mm. This species closely resembles a pale variety of Jalla dumosi Fabr. but the head is broader, basal joint of antennae longer, and there are ten longitudinal veins to the membrane. One specimen, a female, was captured in Colorado."

Rist Canon, April 10th (Gillette).

Podisus modestus Dall.

Swept from bushes in Beaver Brook Gulch and Clear Creek Canon during early part of August (Uhler, 5).

Fort Collins, September 27th, on Clematis ligusticifolia (Gillette). May 20th to June 24th, aud September 14th on Solidago (Baker).

Podisus placidus Uhl.

Colo. (Gillette—see Osborn, 1).

Fort Collins, March 24th to May 4th (Gillette), and May 3d on box-elder (Baker).

Podisus serieventris Uhl.

Spring Canon, August 1st (Baker).

Podisus spinosus Dall.

Pueblo. Did not occur on the plains proper, but was swept from a bush in the bed of the river (Uhler, 5),

Liotropis humeralis Uhl.

From bushes near Manitou (Uhler, 5). Colo. (Gillette—see Osborn, 1),

Montrose, June 24th (Gillette),

Prionosoma podopioides Uhl.

Denver (B. H. Smith—see Uhler, 5 and 6). From bushes near Golden in August (Uhler, 5). Colo. (Gillette—see Osborn, 1). Pueblo (Uhler, 9).

Trinidad, May 14th (Gillette).

Podops dubius Pal Beauv.

Colo. (Gillette—see Osborn, 1).

Fort Collins, April 6th (Gillette).

Brochymena quadripustulata Fab.

Colo. (Uhler, 1).

Brochymena annulata Fab.

Colo. (Uhler, 6). Colo. (Gillette—see Osborn, 1).

Fort Collins, June 16th, on willow; Rist Canon, April 9th; Manitou, September 28th, on oak (Gillette). Fort Collins, September 26th, on ash (Baker).

Brochymena obscura H. Schf.

Pueblo, July (Wilkins—see Uhler, 7).

Canon City, August 31st (Gillette).

Aelia americana Dall.

Steamboat Springs, July 14th (Baker). Veta Pass, June 24th (E. A. Schwarz).

Neottiglossa undata Say.

Colo. (Uhler, 6). Clear Creek Canon, August (Uhler, 5).

Neottiglossa melanocephala.

Fort Collins, May 27th, on currant (Baker).

Cosmopepla carnifex Fab.

One specimen by sweeping weeds in region of Arkansas River, near Pueblo (Uhler, 5)

Fort Collins, July 2d, on Mentha canadensis, and September 27th; Howe's Gulch*, June 14th (Gillette). Steamboat Springs, July 15th (Baker).

Cosmopepla conspicillaris Dall.

Hills and plains of Colo. September 19th and October 4th (Carpenter--see Uhler, 6). Colo. (Gillette—see Osborn, 1).

Fort Collins, July 2d, on Mentha canadensis; Howe's Gulch, June 14th (Gillette).

Mormidea lugens Fab.

On weeds near Canon City (Uhler, 5).

Euschistus fissilis Uhl.

Colo. (Uhler, 1 and 6). Southern Colorado, June—July (Carpenter—see Uhler, 7). Colo. (Gillette—see Osborn, 1).

Fort Collins, April 23d to October 24th; Rist Canon, May 14th, and Spring Canon, June 30th to July 12th; Montrose,

*A gulch six miles west of Fort Collins

June 24th (Gillette). Fort Collins, June 10th, at light; Boulder, September 4th (Baker).

Euschistus ictericus L.

Pleasant Valley, June 12th (Gillette.)

Euschistus impictiventris Stal.

Montrose, June 24th (Gillette).

Euschistus servus Say.

Near Arkansas River, August (Uhler, 5).

Euschistus tristigmus Say.

Colo. (Gillette—see Osborn, 1).

This was probably an erroneous determination.

Euschistus variolarius Pal. Beauv.

Colo. (Uhler, 1 and 6). Denver, August 18th (Uhler, 5). West Cliff, Custer County, May 23d, on Thermopsis (Cockerell, 10). Colo. (Gillette—see Osborn, 1).

Fort Collins, September 30th (Baker). Spring Canon (Gillette).

Coenus delius Say.

Colo. (Snow—see Van Duzee, 5).

Fort Collins, March 24th, and September 2d on Solidago (Baker). Estes Park, Bailey (Snow).

Hymenarcys aequalis Say.

Near West Cliff, Custer County, July 30th (Cockerell, 10).

Liodermа ligata Stal.

Fort Collins, June 27th to August 18th; Rist Canon, May 29th to July 19th (Baker and Gillette), Golden, April 30th (Gillette). Estes Park, August (E. D. Varney). Steamboat Springs, July 15th (Baker).

Liodermа viridicata Uhl.

Roaring Fork (Rothrock—see Uhler, 6).

Pentatoma congrua Uhl.

Foot-hills of Colorado, September (Carpenter—see Uhler, 6).

Steamboat Springs, July 12th (Baker). Denver (Riley).

Pentatoma faceta Say.

Colo. (Uhler, 1).

Pentatoma juniperina L.

Estes Park, July 11th; Rist Canon, July 30th (Gillette).

Pentatoma sayi Stal.

Roaring Fork (Rothrock—see Uhler, 2). Foot-hills of Colorado, September (Carpenter—see Uhler, 6). Golden, August 6th (Uhler, 5).

Silverton (Nat. Mus. Coll).

Pentatoma uhleri Stal.

Colo. (Uhler, 6).

Carpocoris lynx Fab.

Fort Collins, June 20th to October; Estes Park, July 11th· Colorado Springs, August 1st (Gillette). Steamboat Springs, July 12th to 26th (Gillette and Baker).

Trichopepla atricornis Stal.

North-east of Denver, August 18th (Uhler, 5).

Trichopepla semivittata Say.

On weeds in vicinity of Arkansas River, August 10th (Uhler, 5).

Peribalus limbolarius Stal.

Colo. (Uhler, 1 and 5) Nymphs moderately common on several kinds of Flowering plants August 6th and 8th, in Beaver Brook Gulch and Clear Creek Canon. A few days later imagos taken near Colorado Springs and at Manitou. August 11th taken sweeping plants in mouth of Arkansas Canon (Uhler, 5). Colo. (Gillette—see Osborn, 1).

Steamboat Springs July 12th (Baker). Bailey (Snow). Veta Pass, June 24th (E. A. Schwarz).

Peribalus piceus Stal.

Rist Canon, July 30th (Gillette)

Holcostethus abbreviatus Uhl.

Colo. (Uhler, 1). Beaver Brook Gulch, August 6th (Uhler, 5).

Fort Collins, June 5th to October 7th (Gillette and Baker). Steamboat Springs, July 26th (Gillette. Rist Canon (Baker).

Thyanta custator Fab.

Colo. (Uhler, 6). Near Manitou, August 16th (Uhler, 3). Colo. (Gillette—see Osborn, 1).

Fort Collins, June 21st to October, (Baker and Gillette). Spring Canon, June 30th; Denver, July 20th; Lamar, May 7th (Gillette). Colorado Springs, Garden of the Gods (Tucker).

Thyanta perditor Fab.

Colo. (Uhler, 6). Pueblo, August 10th (Uhler, 5). Colorado, common (Uhler, 8).

Thyanta rugulosa Say.

Colo. (Uhler, 1). Colo. (B. H. Smith—see Uhler, 6). Southern Colorado, October (Uhler, 7). Moderately common in Clear Creek Canon and in Beaver Brook Gulch. Occurred on wild gooseberry, and several kinds of bushes near running streams (Uhler, 5).

Fort Collins, June 9th, in electric light globes (Gillette).

Murgantia histrionica Hahn.

Colo. (Uhler, 1 and 6). Colo. (Uhler—see Packard, 2). Near Denver, in irrigated region, and also Golden, August 6; none found south of Denver (Uhler, 5). Golden, July 3d (Packard—see Uhler, 5).

Banasa calva Say.

Larva in Clear Creek Canon, August 6th (Uhler, 5). Imagos near Blackhawk, July 2d (Packard—see Uhler, 5).

Fort Collins, September 30th; Ouray, June 22d (Gillette). Big Narrows of Poudre river, Larimer county, July 9th, on willow (Baker).

Banasa dimidiata Say.

Estes Park (Snow—see VanDuzee, 5).

Banasa sordida Uhl.

Glenwood Springs, August 24th (Gillette).

Chariesterus antennator Fab.

Colo. (Uhler, 6). Manitou, August 13th, on a small oak tree (Uhler, 5). Colo. (Gillette—see Osborn, 1).

Horsetooth Gulch, May 18th (Gillette).

Corynocoris distinctus Dall.

Colo. (Uhler, 1 and 6).

S. Colo. (Nat. Mus. Coll.).

Archimerus calcarator Fab.

Colo. (Uhler, 1). Foot-hills (Carpenter—see Uhler, 6).

Boulder, September 4th (Baker).

Leptoglossus corculus Say.

Colorado—as questionably cinctus (Gillette—see Osborn, 1).

Fort Collins, June 29th, and July 4th in flowers of Yucca; Pueblo, June 13th (Gillette). Boulder, September 4th; foothills 5 miles west of Fort Collins, August 1 (Baker).

Chelinidea vittigera Uhl.

Colo. (Uhler, 6). Beneath a mass of prickly pears on hillside near Colorado

Springs, August 10th (Uhler, 5). Colo. (VanDuzee, 5).

Foot-hills, 5 miles west of Fort Collins, March 15th to May 19th, common under stones and about plants of Opuntia; Fort Collins, April 23d to May 16th (Baker and Gillette).

Margus inconspicuus H. Schf.

Colo. (Uhler, 1 and 6). Near Manitou, August 13th (Uhler, 5). Near Denver (B. H. Smith—see Uhler, 5). Southern Colorado, June 5th (Carpenter—see Uhler, 7).

Montrose, June 24th (Gillette).

Catorhintha guttula Fab.

Fort Collins, May 7th to October 28th (Baker and Gillette). Foot-hills 5 miles west of Fort Collins, June 4th to August 3d (Gillette).

Catorhintha mendica Stal.

Colo. (Uhler, 1 and 6). Golden, July 3d (Packard—see Uhler, 5). Southern Colorado, June 5th to July 5th (Carpenter—see Uhler, 7).

Colorado Springs (Tucker).

Ficana apicalis Dall.

Manitou, July 24th, on Clematis ligusticifolia (Gillette).

Anasa tristis De G.

Colo. (Uhler, 6). Taken beneath rubbish on a farm a few miles west of Denver, August 18th. Not common (Uhler, 5). Colorado Springs, July (Yarrow—see Uhler, 7). Southern Colorado, June (Carpenter—see Uhler, 7).

Known as a common and serious pest almost everywhere squashes are cultivated. Hibernates under boards, stones, and rubbish.

Tollius curtulus Stal.

Horsetooth Mountain, July 4th (Gillette).

Alydus eurinus Say.

Foot-hills of Colo. (Carpenter—see Uhler, 6). Manitou, July 15th (Packard—see Uhler, 5). Near Denver (B. H. Smith—see Uhler, 5). Ula, Custer county July 30th; also high alpine; in Mesa county, at about 7,000 feet (Cockerell, 10)

Alydus quinquespinosus Say.

Foot-hills of Colo. (Carpenter—see Uhler, 6).

Fort Collins, September 30th; Boulder, September 4th (Baker).

Alydus pluto Uhler.

Colo. (Uhler, 1). Foot-hills (Carpenter—see Uhler, 6). Near Denver (B. H Smith—see Uhler, 6). West of Denver, August 9th (Uhler, 5). Colo. (Snow—see VanDuzee, 5).

Spring Canon, July 12th; Estes Park, July 12th (Gillette).

Alydus conspersus Mont.

Colo. (Montandon, 1). Colo. (Montandon—see Osborn, 1).

Protenor belfragei Hagl.

Colo. (Uhler, 1 and 6).

Darmistus subvittatus Stal.

Fort Collins, June 25th (Baker). Foot-hills five miles west of Fort Collins, March 12th to June 12th (Gillette).

Dasycoris nigricornis Stal.

North-east Colorado (Riley).

Dasycoris humilis Uhler.

Colo. (Uhler, 1 and 6). Near Golden, August 6th (Uhler, 5). Colorado Springs, July (Yarrow—see Uhler 7).

Fort Collins, April 26th; foot-hills 5 miles west of Fort Collins, April 16th to June 13th (Gillette).

Scolopocerus secundarius Uhler.

Colo. (B. H. Smith—see Uhler, 6). Colo. (Gillette—see Osborn 1).

Foot-hills five miles west of Fort Collins, March 15th (Gillette). Fort Collins, May 20th (Baker).

Neides muticus Say.

Colo. (Uhler, 1 and 6). Clear Creek Canon, entrance to Beaver Brook Gulch, August 7th, flying in bright sunlight (Uhler, 5).

Manitou, June 25th; Montrose, June 24th (Gillette). Foot-hills five miles west of Fort Collins, May 19th and 21st; Steamboat Springs, July 15th to 26th (Gillette and Baker). Fort Collins, March 18th (Baker).

Jalysus spinosus Say.

Pueblo (Yarrow—see Uhler, 7). Not uncommon in the valley of the Arkansas east of Canon City, August 11th. Occurred in places slightly wooded, where wild grape vines abounded (Uhler, 5).

Colorado Springs (Tucker).

Harmostes propinquus Dist.

Fort Collins, August 18th and 26th (Baker). Foot-hills five miles west of Fort Collins, July 12th and 30th (Gillette).

Harmostes serratus Fab.

Manitou, July 15th (Packard—see Uhler, 5).

Harmostes reflexulus Stal.

Colo. (Uhler, 1). Foot-hills, July to September (Carpenter—see Uhler, 6). Sweeping weeds on hills west of Denver August 5th. Beyond Canon City, August 11th. Colorado Springs, August 16th (Uhler, 5). Near West Cliff, Custer County, end of July (Cockerell, 10).

Fort Collins, September 30th (Baker). Steamboat Springs, July 14th and 26th (Baker and Gillette). The Rustic, Larimer County, August 11th; Dolores, June 18th; Montrose, June 24th; Glenwood Springs, August 24th (Gillette). Aspen (W. W. Willard). Colorado Springs (Tucker).

Harmostes reflexulus Stal. var. ***virescens*** Dall.

Howe's Gulch, June 14th; Dolores, June 17th (Gillette). All variations between this and the typical form occur commonly.

Auteius impressicollis Stal.

Swept from bushes in the suburbs west of Denver, August 18th. Not common (Uhler, 5).

Corizus hyalinus Fab.

Colo. (Uhler, 1). Foot-hills (Carpenter—see Uhler, 6). Pueblo, July (Yarrow—see Uhler, 7). Golden, July 3d, and on Arapahoe Peak, 11,000 to 12,000 feet, July 1st (Packard—see Uhler, 5). Widely distributed in Eastern Colorado. Lodges in flowers of various plants, and seems to be common on plains, foot-hills, and parks in the mountains. Less abundant in Clear Creek Canon, but found everywhere west of Denver, around Colorado Springs, and near Manitou. Lived singly in crowns of small flowers in Manitou Park. Common on weeds in Arkansas Valley, and near mouth of Canon of Arkansas, August 4th to 19th (Uhler, 5). Ula, Custer County, July 30th; also high alpine (Cockerell, 10).

Howe's Gulch, June 14th; Steamboat Springs, July 26th; Glenwood Springs, August 24th (Gillette). Fort Collins, May 18th to July 14th, on alfalfa, barley, Sisymbrium canescens, and Oenothera biennis (Baker). Colorado Springs, August (Tucker).

Corizus lateralis Say,

Colo. (Uhler, 1 and 6). Swept from weeds on low hills near Colorado

Springs, August 18th (Uhler, 5).

Fort Collins, March 20th to August 25th, and September 27th on Bigelovia (Baker and Gillette). Foot-hills five miles west of Fort Collins, June 5th and 14th; Steamboat Springs, July 26th (Gillette).

Corizus nigristernum Sign.

Golden, July 3d (Packard—see Uhler, 5).

Rist Canon, June 13th (Gillette).

Corizus punctiventris Dall.

Colo. (Uhler, 1 and 6).

Fort Collins, September 30th (Baker). Steamboat Springs, July 14th and 26th (Baker and Gillette). The Rustic, Larimer County, August 11th; Estes Park, July 12th; North Park, July 20; Montrose, June 24th (Gillette).

Corizus validus Uhl.

Steamboat Springs, July 14th (Baker).

Leptocoris trivittatus Say.

Colorado, common (Uhler, 1). Colo. (Uhler, 6). Southern Colorado, July (Carpenter—see Uhler, 7). Canon City, August 11th, at roots of cacti and yuccas (Uhler, 5). Colo. (VanDuzee, 5).

Canon City, August 31st (Gillette). Very common in Fort Collins and vicinity. Hibernates in large numbers about buildings. Commonly called "brick-bugs" or "box-elder bugs," although not found commonly on box-elder.

Jadera haematoloma H. Schf.

Colo. (Uhler, 6).

Nysius angustatus Uhl.

Colo. (Uhler, 1). Above timber line in mountains of Colorado in June (Carpenter—see Uhler, 6). Pueblo, July (Yarrow and Wilkin—see Uhler, 7). Fort Garland, July (Hunt—see Uhler, 7). Golden, July 3d (Packard—see Uhler, 5). Very abundant on tall weeds in cultivated grounds, near Denver, at Golden, in Manitou Park, and near Canon City, August 6th to 18th (Uhler, 5). Colo. (Gillette—see Osborn, 1).

Estes Park, July 12th; Leadville, August 23d (Gillette). Fort Collins, July 29th; Steamboat Springs, July 15th, on Solidago (Baker). Colorado Springs, Bear Creek Canon (Tucker).

Nysius californicus Stal.

Colo. (Uhler, 1 and 6). Found sparingly on weeds in moist places, as well on the plains as in canons and parks. Swept from flowers west of Denver, in Clear Creek Canon, near Manitou and Colorado Springs, and more abundantly near Canon City. On a low composite with pale whitish flower, Manitou Park, August 14th (Uhler, 5). Golden, July 3d (Packard—see Uhler, 5).

Nysius minutus Uhler n. sp.

"Grayish fulvo-testaceous, pubescent, punctate with black, narrow, with the outer margin of the hemelytra nearly straight. Head of medium length, comparatively acute, pale dull fulvous, closely punctate, except on the immediate base, the punctures of the sides especially black, a grooved line midway between the eye and tylus; throat black, covered with small punctures, sericeous pubescent, with a white line next the eyes; antennae fulvo-testaceous, the basal joint mostly black, reaching a little beyond the tip of tylus, second joint about one-third longer than the third and both piceous at tip, the fourth long blackish; rostum reaching behind the middle coxae, blackish piceous, sometimes paler at base. Pronotum subquadrate, a little wider than long, coarsely punctate with black, especially on the sides of disk, the fulvous color of the middle of the head carried back as a line between the callosities, the callosities and adjoining sutures and a line each side of the convex posterior lobe black, the humeral callosities and a short line on the middle of the posterior border whitish, humeri nearly surrounded by black. Pectoral areas black, minutely sericeous pubescent, coarsely punctate anteriorly, with a series of large white spots, including the coxae, extending from behind the throat to the metapleura, the outer angle and posterior margin of the metapleura and collar next the throat whitish or white, legs dull fulvo-testaceous, the formora mostly black beneath. Scutellum fulvo-testaceous, coarsely punctate and with a black mark on each basal angle, the middle line black, including the blunt base of the middle carina, which becomes very slender on the depressed apex of the scutellum. Hemelytra whitish, minutely pubescent. obsoletely and minutely punctate, with the veins and inner and posterior margin interruptedly streaked with brown, the apex of the clavus with a brown dot; membrane long, whitish hyaline, with a few brown flecks near the middle and from thence outwards. Abdomen piceous or blackish, narrow, polished, closely covered with fine white pubescence. Length to tip of abdomen, male 3-3.5 mm. Width of pronotum, .75 mm.

This is a common species in many parts of the western states, from Dakota to Colorado, California and Texas. On the eastern side of the continent it inhabits Canada, New England, New York, New Jersey, Maryland, Virginia, and North Carolina."

Fort Collins, June 4th to October 15th, and September 27th on Bigelovia; Pleasant Valley, June 12th; The Rustic, Larimer County, August 11th; Estes Park, July 12th; Grand Junction, August 26th, on sugar beets; Colorado Springs, August 3d; Montrose, June 24th (Gillette). Steamboat Springs, July 14th; Fort Collins, July 29th, on sugar beets, and July 26th, very injuriously abundant on mustard (Baker).

Nysius thymi Wolff.

Estes Park, July 12th (Gillette).

Orsillus scolopax Say.

Fort Collins, August 11th, on Glycyrrhiza lepidota (Baker).

Ischnorhynchus didymus Zett.

Southern Colorado (Yarrow—see Uhler, 7). Denver and Canon City (Uhler, 5). Colo. (Gillette—see Osborn, 1).

Rist Canon, May 29th; Estes Park, July 12th; Montrose, June 24th: Manitou, June 25th to September 29th (Gillette). Fort Collins (Baker). Manitou Park, Cheyenne Canon (Tucker).

Cymus luridus Stal.

Swept from weeds near Arkansas river, east of Canon City, August 11th (Uhler, 5). Near West Cliff, Custer county, end of July (Cockerell, 10).

Cymodema tabida Spin.

Fort Collins, March 28th to April 26th under boards (Baker). Garland, June 18th (E. A. Schwarz).

Blissus leucopterus Say.

Pleasant Valley*, June 12th, a single specimen (Gillette). Dixon's Canon, February 28th, one specimen under a stone (Baker).

Ninyas pallens Stal.

Colo. (Riley).

Geocoris borealis Dall.

Fort Collins, March 24th, under board; Glenwood Springs, August 24th (Gillette).

Geocoris bullatus Say.

Pueblo (Yarrow—see Uhler, 7). Foot-hills, July (Carpenter—see Uhler, 6). Collected around the roots of weeds on foot-hills and plains west of Denver, August 18th. Very pale varieties of this species occur on light colored sand; those from canons and mountain altitudes are darker (Uhler, 5).

Geocoris decoratus Uhler.

Clear Creek Canon, August 3d, in warm, sunny spots on dark sand (Uhler, 5). Ula, Custer County, November 12th (Cockerell, 10).

Geocoris fuliginosus Say.

Denver, August 5th (Uhler, 5).

Geocoris griseus Dall.

Estes Park, July 10th (Gillette).

Geocoris limbatus Stal.

Steamboat Springs, July 26th (Gillette.)

Geocoris pallens Stal.

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*Six miles north-west of Fort Collins.

Colorado Springs, August 3d; Lamar, May 7th; Glenwood Springs, August 24th; Dolores, June 18th (Gillette). Fort Collins, June 29th on sugar beet, and August 18th; foot-hills five miles west of Fort Collins, August 1st (Baker).

Geocoris piceus Stal.

Colo. (Uhler, 1 and 6).

Geocoris punctipes Say.

Colo. (Uhler, 6).

Oedancala dorsalis Say.

Valley of Arkansas near Canon City (Uhler, 5).

Crophius bohemani Stal. Det. through Riley

Montrose, June 24th (Gillette.)

Crophius disconotus Say.

Foot-hills five miles west of Fort Collins, March 15th to August 1st, and May 12th abundant on Pinus ponderosa var. scopulorum (Gillette and Baker). Golden, April 30th (Gillette). Fort Collins, May 16th on alfalfa, May 31st on apple, and April 11th very abundant along a fence row, flying in the sunshine (Baker).

Ligyrocoris constrictus Say.

Southern Colorado June and July (Carpenter—see Uhler, 7).

Livermore, Larimer county, August 11th (Gillette).

Ligyrocoris sylvestris Linn.

Foot-hills (Carpenter—see Uhler 6). Near Manitou, August 15th (Uhler, 5.) Colo. (Gillette—see Osborn, 1).

Fort Collins, August 18th (Baker). Steamboat Springs, July 15th and 26th (Baker and Gillette).

Myodocha serripes Oliv.

Valley of Arkansas river, east of Canon City, August 11 (Uhler, 5).

Heraeus insignis Uhler.

Colo. (Uhler, 1 and 6). Near Golden, at mouth of Clear Creek Canon, August 7 (Uhler, 5).

Pamera una Say.

Ouray, July 17th; Fort Collins, September 27th (Gillette),

Ptochiomera clavigera Uhler n.sp.

"Similar in form to P. nodosa, Say, but shorter and thicker, with a dull dark surface and thicker clavate antennae. Color dark brown, closely and coarsely punctate with fuscous, pubescent. The head thick, abruptly contracted at tip, clothed with bronze pubescence, closely punctate; the rostrum thick, brown, reaching between the anterior coxae; antennae piceous, pale pubescent, blackish on the two long and very thick clavate apical joints, the basal joint thick, scarcely longer than the tylus, the second much shorter, more slender, growing thicker towards the tip; the ocelli very large and prominent, coarsely and densely granulated. Pronotum thick, a little longer than wide, almost flat above; the anterior lobe nearly twice as long as the posterior one, the two separated each side by a deeply incised line; the lateral edge moderately oblique, reflexed, a very little curved; collum distinct. but rather turned up than ridged; the middle of posterior margin indented, the anterior margin as wide as the head to the middle of the eyes; the humeral angles callous, long triangular. Pleural pieces reddish brown, somewhat coarsely punctate. Coxae dull yellow; femora obscure yellow, pale fuscous on the middle; the tibia tinged with brown; tarsi more or less piceous. Scutellum reddish brown, punctate, the apex with a long thick carina. Hemelytra thick, opaque, coarsely punctate in somewhat longitudinal lines, bare parts of the surface dull fulvous, the costal border testaceous, interrupted by about four black spots; the broad apex almost truncated, sometimes marked with two or three yellow dots; the membrane brown, very small or absent. Abdomen dark dull or brown, closely punctate, spread with minute bronze pubescence; the connexivum wide, sharp edged, with a yellow dot on the apex, and sometimes with testaceous specks at the outer end of the sutures; anal segment of the male large and prominently convex, very dark brown.

Length to end of abdomen 2.5 mm. Width of pronotum .75 mm. Three or four specimens are in the Colorado Agricultural College collection. In my own cabinet may be seen specimens from New York, Texas, and the vicinity of Denver and Manitou. Colorado"

Fort Collins, April 6th (Baker). Poudre Canon*, March 16th to April 22nd (Gillette). The specimens taken were found under boards and stones. This is the species recorded from Colorado as P. diffusus Uhler (see Uhler, 1).

Ptochiomera puberula Stal.

Denver, August 8th (Uhler, 5).

Cnemodus mavortius Say.

Colorado, August (Riley).

Trapezonatus nebulosus Fall.

Colo. (Uhler, 1 and 6). Southern Colorado, June, July (Carpenter—see Uhler, 7). Moderately common at Denver, also few from plants in Beaver Brook Gulch, August 6th (Uhler, 5). Custer county, mid-alpine (Cockerell, 10).

Fort Collins, February 19th to September 2d (Baker and Gillette). The Rustic, Larimer county, August 11th; Foothills seven miles north-west of Fort Collins, March 16th; Manitou, June 25th; Montrose, June 24th; Dolores, June 18th (Gillette). Steamboat Springs, July 14th (Baker). Colorado Springs, Manitou Park (Tucker).

Emblethis arenarius Linn.

Colo., seems to be quite common (Uhler, 6). Quite common in eastern

*The canon of the Poudre river, 10 miles north-west of Fort Collins.

Colorado as well on plains and foot-hills as in mountains. Near Denver and also in Clear Creek Canon, August 6th (Uhler, 5). Summit of Arapahoe Peak, 13,000 feet, July 14th (Packard--see Uhler, 5). Custer county, midalpine (Cockerell, 10). Colo. (Gillette—see Osborn, 1).

Fort Collins, February 19th to April 16th; Spring Canon, March 12th (Gillette).

Peritrechus fraternus Uhl.

Ula, Custer county, November 12th (Cockerell, 10).

Rhyparochromus floralis Uhler n. sp.

"Long-elliptical, rusty fulvous, opaque, minutely sericeous pubescent. Head piceous paler or rufo-fulvous at tip, subconic, nodding, smooth, shorter than the pronotum, minutely scabrous, strongly convex above, with the throat pale rufo-fulvous; antennae stout, about as long as the pronotum and corium united, dull fulvous, pale pubescent, with the fourth joint and apex of the third blackish piceous, the basal joint extending a little beyond the tip of the head, second much longer, the third about one-half longer but a little shorter than the second, the fourth about equal to the second; rostrum reaching upon the middle coxae, slender, pale fulvous, with the apical joint black. Pronotum subquadrangular, a very little wider at base than at tip, fulvous or rufo-fulvous, dull testaceous and punctate with black on the basal one-third, the lateral margins a little reflexed, black, slightly convexed next the apical angle, the submargin ivory white, expanding posteriorly where it abuts against a tumid black humeral spot, the inner boundary of this stripe and the anterior submargin finely punctate with black, disk not distinctly punctate, behind this is a feebly raised whitish line. Scutellum very long and acute fulvous, transversely indented on the middle, finely punctate before the middle and corsely punctate with black towards the tip, the middle line more or less black. Corium whitish testaceous, with about nine slender black oblique lines (including the clavus) which are mostly composed of impressed punctures, the costal border and a transverse spot upon a wide black area, which also covers the cuneus, dull white, exterior reflexed edge of costal border dark brown; membrane smoke brown, with a short white spot next the tip of cuneus, and a double fainter one at tip. Legs pale fulvous, pale on middle of tibiae and base of tarsi, apices of tibiae and tarsi piceous. Pectus dark rust brown, paler anteriorly, the segments on the posterior border and a spot above each of the coxae pale yellow. Venter dull black, bordered above with testaceous or fulvous.

Length to tip of venter, 6-6.5 mm. Width of pronotum, 1.75-2 mm. This seems to be a common species in Colorado, Montana, California, etc."

Abundant at Fort Collins, throughout the season, under stones, etc., usually in company with Formica neoclara Em. (Baker).

Rhyparochromus (*Dorachosa*) *illuminatus* Dist.

Dixon's Canon, February 28th, under a stone (Baker).

Eremocoris ferus Say.

Custer county, midalpine (Cockerell, 10). Colo. (Gillette—see Osborn, 1).

Dolores, June 16th (Gillette).

Eremocoris tropicus Dist.

Fort Collins, March 26th; foot-hills five miles west of Fort Collins, March 15th and 16th (Gillette).

Peliopelta abbreviata Uhl.

Clear Creek Canon, August 6th (Uhler, 5).

Melanocoryphus admirablis Uhl.

Colo. (Uhler, 6). Ula., Custer Co., Nov. 12 (Cockerell, 10).

Rist Canon, May 29th; Montrose, June 24 (Gillette).

Melanocoryphus bicrucis Say.

Colo. (Gillette—see Osborn, 1).

Horsetooth Gulch, May 18th; Dolores, June 16th; Montrose, June 24th (Gillette).

Melanocoryphus facetus Say.

Foot-hills, July (Carpenter—see Uhler, 6). Swept from yuccas near Denver; most common near Colorado Springs, August 13th to 17th, and were generally in shelter beneath dried dung, chips, stones or about the roots of yuccas (Uhler, 5). In a meadow at Nathrop, Chaffee County, August 14th (Cockerell, 10) Colorado (Gillette—see Osborne, 1).

Fort Collins, June 9th, on alfalfa and in electric light globes; foot-hills five miles west of Fort Collins, February 28th to August 1st (Gillette and Baker). Trinidad, May 14th; Grand Junction, August 28th; Leadville, August 23d (Gillette). Denver, at light (R. C. Stephenson).

Lygaeus admirabilis Uhl.

Colorado (Uhler, 1).

Pleasant Valley, June 12th; Fort Collins, June 10th (Gillette).

Lygaeus circumcinctus Stal

Colorado (Carpenter, 1).

Lygaeus kalmii Stal.

Custer County, midalpine (Cockerell, 10)

Lygaeus melanopleurus Uhl.

Foot-hills five miles west of Fort Collins, June 14th to September, 1st; North Park, July 20th (Gillette). Steamboat Springs, July 16th and 26th (Baker and Gillette).

Lygaeus reclivatus Say.

Found at 14,000 feet in abundance on surface of snow. Found above timber belt from May to October, throughout an area of 20,000 square miles (Carpenter, 1). Colorado (Uhler, 6). Pueblo, July (Yarrow and Wilkin—see Uhler, 7). Boulder, June27th; Arapahoe Peak, 10,000 to 12,000 feet, July 1st;

Manitou, July 15th; summit of Pike's Peak, 13,000 feet, July 14th; Garden of the Gods, July 13th; Gray's Peak, about 14,000 feet, July 7th (Packard—see Uhler, 5). Everywhere, Denver to Canon City, August 6th to 18th. Among roots of yuccas, near Colorado Springs and Manitou. Swept from weeds near bunches of Asclepias in mouth of Arkansas Valley. Dwells on Asclepias (Uhler, 5). Ula, Custer County, November 12th (Cockerell, 10). Fort Collins (Riley and Blount, see Cockerell 10). Colorado (VanDuzee, 5)

Montrose, June 24th (Gillette). Fort Collins, March 20th to April 20th (Gillette and Baker). Manitou Park (Snow). Colorado Springs (Tucker).

Lygaeus turcicus Fab.

Lower end of Wet Mountain Valley, just in Fremont County (Cockerell, 10).

Largus cinctus H. Sch.

Colorado—as succinctus (Gillette—see Osborn, 1).

Lamar, May 7th (Gillette). Cheyenne Canon (Tucker).

Largus succintus Linn.

Colorado (Uhler, 1). Southern Colorado (Uhler, 6)

Brachytropis calcarata Fall.

Near water, in weedy places on outskirts of Denver, August 4th (Uhler, 5).

Steamboat Springs, July 12th on Carex (Baker).

Megaloceroea debilis Uhl.

Berthoud Pass and other parts of Colorado (Uhler, 1). Colorado (Uhler, 5).

Fort Collins, June 4th to July 24th; Steamboat Springs, July 26th, and July 12th on Carex (Gillette and Baker).

Megaloceroea rubicunda Uhl.

Colorado (Uhler, 1 and 6).

Trigonotylus pulcher Reut.

Fort Collins, October 15th; Pleasant Valley, June 12th; Estes Park, July 12th; Lamar, May 7th; Trinidad, May 14th; (Gillette). Fort Collins, June 13th, on cottonwood sprouts, and July 29th (Baker).

Trigonotylus ruficornis Fall.

Colorado (Uhler 1 and 6). On weeds and grass in damp situations near Denver, and also on hills near water a few miles west of Denver (Uhler, 5). Colorado (Gillette—see Osborn, 1).

The last record perhaps refers to pulcher.

Miris affinis Reut.

Roaring Fork (Rothrock—see Uhler, 2). Hills, July (Carpenter—see Uhler, 6). Southern Colorado, July (Carpenter—see Uhler, 7). Yellow varietes on weeds near water, in suburbs of Denver. Green variety, marked with fuscous, from rank growing plants in Beaver Brook Gulch, August 6th (Uhler, 5). Ula, Custer County, July 30th (Cockerell, 10). Estes Park (Snow—see VanDuzee, 5).

Fort Collins, May 8th to October 7th and June 9th, on alfalfa and barley (Baker). Foot-hills five miles west of Fort Collins, May 11th to 19th; Manitou, June 25th (Gillette). Veta Pass, June 21st (E. A. Schwarz).

Teratocoris discolor Uhl.

Garland, June 18th (E. A. Schwarz—see Uhler, 3).

Teratocoris longicornis Uhler n. sp.

"Elongated, bright green, resembling a Miris. Head very slightly nodding, green, broad, the front tabulated above and bounded by deep sutures, black anteriorly along the depressed middle line and also each side, the vertex produced in an arch posteriorly, and with a black arc at base; tylus black, rostum reaching midway between the middle and posterior coxae; mostly greenish-testaceous, piceous at tip; antennae long, the basal joint green, the other joints dull reddish, the basal one as long as the vertex and pronotum united, the second as long as the pronotum and clavus united, the third and fourth broken from the specimen. Pronotum trapezoidal, a little longer than wide, flat anteriorly, the sides gradually oblique, with the edge reflexed, a little constricted behind the line of the callosities and crossed there by a black band, the middle line unevenly impressed, black, connected behind with a broad black band across the base, which is obsoletely punctate and wrinkled, the submargin before the humeri tabulated and with the edge not reflexed, posterior margin very slightly sinuated. Sternum whitish along the middle. Legs green, the tibiae and the tarsi more or less yellow, with the nails and apex blackish. Scutellum black, with a large yellow spot near each basal angle. Hemelytra green, long elliptical, minutely rugulose and punctate, the costal border prominently reflexed; membrane long, dull whitish, faintly dusky at base, including the base of vein. Mesosternum, posterior coxae and middle and apex of venter, pale yellowish, the abdomen minutely pubescent.

Length to tip of abdomen 4.5 mm. To tip of membrane 5.5 mm. Width of pronotum 1.25 mm. This is a well marked species of which only a single male was sent to me from Colorado. The genital hook is placed on the left side, and is long, stout and moderately curved. In this specimen the base of the scutellum is broadly exposed. A series of both sexes is greatly desired for comparative study."

Steamboat Springs, July 12th on Carex (Baker).

Leptoterna amoena Uhl.

Steamboat Springs, July 14th and 26th (Baker and Gillette). Estes Park, July 10th; North Park, July 20th; Colorado Springs, August 3d (Gillette).

Resthenia atripennis Reut.

Foot-hills twelve miles west of Fort Collins, June 30th (Gillette).

Resthenia bivittis Stal.

Steamboat Springs, July 26th; North Park, July 20th (Gillette).

Resthenia contraterna Uhl.

Colorado (Uhler, 1 and 6). Beaver Brook, August 6th (Uhler, 5). Idaho Springs, July 6th (Packard—see Uhler, 5). Colorado (Gillette—see Osborn, 1).

Resthenia insignis Say.

Colorado (Uhler, 1 and 6). Colorado, as insignis and as rubrivittata (Gillette—see Osborn, 1).

North Park, July 20th (Gillette). Steamboat Springs, July 15th; Rabbit Ears Pass, July 20th (Baker).

Resthenia insitiva Say.

Colorado (Gillette—see Osborn, 1).

Resthenia maculicollis Reut.

Foot-hills twelve miles west of Fort Collins, June 30th (Gillette).

Oncerometopus nigriclavus Reut.

Colorado (Gillette—see Osborn, 1).

Dolores, June 18th; Estes Park, July 12th (Gillette). Steamboat Springs, July 13th (Baker). Colorado Springs (Tucker).

Oncerometopus ruber Reut.

Foot-hills five miles west of Fort Collins, September 1st (Gillette).

Lopidea confluens Say.

Estes Park (Snow). North-east Colorado (Riley).

Lopidea marginata Uhl.

Colorado (Uhler, 8).

Lopidea media Say.

Foot-hills and plains, September 19th and October 4th (Carpenter—see Uhler, 6). Plentiful at Denver, Golden, Colorado Springs, and in the valley of the Arkansas near Canon City, August 5th to 18th. Occured most frequently upon the wild rose bushes (Uhler, 5). August 12th at Cottonwood Creek, Pleasant Valley, Fremont County (Cockerell, 3). West Cliff, Custer County, July 31st on Glycyrrhiza lepidota (Cockerell, 10). Colorado (Gillette—see Osborn, 1).

Lopidea nigridia Uhler n. sp.

"Thicker and more compact than L. media Say, mostly dull black, pubescent, narrowly margined with rufo-fulvous or rufous on the outer border of the corium, including most of the cuneus. Head a little thicker than typical, dull black, pubescent, with a yellow spot on each side of the vertex next the eye, continued slenderly downward, a red spot on each side of the tylus, and the cheeks and sides below also red, with black sutures, the gula black and the tylus shining black, antennae black, moderately stout, the basal joint much longer than the head, the second joint as long as from base of pronotum to front of eye, the third gradually decreasing in thickness, about two-thirds the length of the second, the fourth more slender, acutely tapering, about one-third as long as the third joint; rostrum all black or black at base, rufo-piceous posteriorly, reaching to posterior coxae. Pronotum wide, moderately short, the anterior lobe almost flat, with the front border reflexed, thick, whitish, and sinuated in the middle, callosities large, diagonal, prominent, black, with the deep space between also black, the posterior lobe convexley elevated transversly, faintly rufous on a smoky ground color, wrinkled, the posterior margin a little sinuated, with the edge depressed and thin and the middle of the submargin distinctly indented; the lateral margin reflexed throughout, including the border of the humeri; pleura rufous, a little fuscous anteriorly and on the sternum. Middle and posterior pectus black. Legs shining black. Scutellum dull black, tumid, indented at base. Hemelytra brownish black, irregularly granulated, and hairy, especially upon the clavus, outer border of the corium red, the color becoming wider posteriorly and covering nearly the whole cuneus. Abdomen black, shining, minutely pubescent.

Length to end of abdomen 5 mm. Width of pronotum 1,75 mm. Numerous specimens of this insect are present in the collection of the Colorado Agricultural College. It inhabits also New Mexico and Arizona."

Estes Park, July 12th (Gillette). Steamboat Springs, July 16th on willow and Delphinium occidentale (Baker).

Lopidea obscura Uhl.

Steamboat Springs, July 26th; North Park, July 20th (Gillette). Steamboat Springs, July 12th to 16th, on willow Delphinium occidentale, and Artemisia tridentata (Baker).

Lomatopleura caesar Ruet.

Colorado (Gillette—see Osborn, 1).

Fort Collins, July 24th to August 11th on Glycyrrhiza lepidota, and September 27th on Rhus trilobata (Baker and Gillette). Foot-hills five miles west of Fort Collins, June 5th to 14th; Colorado Springs, August 3d (Gillette).

Hadronema militaris Uhl.

Colorado (Uhler, 1). Roaring Fork (Rothrock—see Uhler, 2). Hills, July to September (Carpenter—see Uhler, 6.) Clear Creek Canon, well up on the mountain side, August 6th (Uhler, 5). Blackhawk, July 2d (Packard—see (Uhler, 5). Smith's Park, Custer County, August 6th; also high alpine (Cockerell, 10). Colorado (Gillette—see Osborn, 1). Colorado (VanDuzee, 5).

Fort Collins, June 4th; Rist Canon, June 12th to July 30th; Estes Park, July 9th; North Park, July 20th; Steamboat Springs, July 26th; Georgetown, July 19th; Colorado Springs, August 3d; Montrose, June 24th (Gillette). Estes Park (Snow). Colorado Springs (Tucker).

Hadronema picta Uhler n. sp.

"Form nearly the same as in H. militaris. Having the antennae a little shorter, witl the second and third joints nearly of equal length. Head dull black, hairy, short, and transverse above, the vertex transversely impressed, prominently elevated behind; face tumidly convex, marked with a yellow stipe on the middle and a line of the same color on the groove next the inner margin of the eyes; cheeks, throat and bucculae pale greenish yellow; rostrum stout, greenish, black on the two apical joints, reaching upon middle coxae; antennae short, thick, the second not quite as long as the width of the base of pronotum, the third a very little shorter and not much thinner. Pronotum transverse, red or orange, set with erect black hairs, the collum white, and the band including the callosities black; lateral margins sharp, but not very prominent, pleural and sternal areas pale greenish, with the sutures and the areas between the coxae black. Legs pale fulvous at base, the apex of femora, and the tibiae and tarsi black. Scutellum pale rufous or yellow with the base blackish. Corium pale yellowish, with a large long black spot running back to tip, clavus nearly or all black, cuneus pale yellowish, bordered inwardly with black, membrane blackish. Abdomen pale greenish, with the ovipositor, genitalia and some short slender lines on the sutures of the segments black.

Length to tip of abdomen 3.5—3.75 mm. Width of pronotum 1.12—1.25 mm. Specimens of both sexes were kindly sent to me by Prof. Snow and Prof. Gillette. The first were collected at Colorado Springs, in July, by Mr. E. S. Tucker. Damaged specimens, from alcohol, were obtained for me in Dakota, and I captured a weather-worn specimen west of Denver in the month of August."

Hadronema princeps Uhl.

Fort Collins, June 4th; Rist Canon, June 13th to July 30th; Gore Pass, July 29th; North Park, July 20th (Gillette). Steamboat Springs, July 12th to 16th, on Delphinium occidentale and other low plants (Baker).

Hadronema pulverulenta Uhl.

Colorado (Gillette—see Osborn, 1).

Fort Collins, May 6th, about roots of a rose bush (R. C. Stephenson). Soldier Canon, May 19th; Golden, April 30th (Gillette). Fort Collins, September 26th, on elm (Baker).

Hadronema robusta Uhl.

Colorado (Cockerell—see Ashmead in litt.).

Pachytropis nubilus Uhl.

Steamboat Springs, July 26th (Gillette).

Phytocoris colon Say.

Colorado (Gillette—see Osborn, 1).

Phytocoris interspersus Uhler n. sp.

"In form similar to P. eximus Reut., but larger, and almost flat on the hemelytra. Pale delicate green, mottled with very pale brown all over the hemelytra, which are almost hirsute and the hairs interspersed with dark bristles. Head of medium size, convex, smooth, pubescent in front and on the sides; the eyes brown, prominent, reniform, placed almost vertical; front feebly grooved to near the back line of the eyes; rostrum thick at base, reaching well behind the posterior legs, dusky at tip; the antennae longer than the body, whitish, set with long bristles, the second joint longer than from the front to the posterior coxae, less hairy than the basal joint, the third a little more slender, about two-thirds the length of the second, the fourth much shorter and equally slender, the basal joint of medium thickness, about as long as the fore femur. Pronotum smooth, much wider than long, obsoletely veined with fulvous, contracted before the middle, a little bristly on the sides and anteriorly, the region of the callosities transversely sunken, lateral margins deflexed, thick, fringed with dark bristles, collum narrow, whitish. Legs long, pale yellowish green, the posterior femora mottled with pale brown, tibial spines long, blackish. Scutellum convexly prominent, bald, polished, with the tip bent down, two black dots just back of it, and the lateral edge a little reflexed. Clavus and corium indented, rugose, set with silvery and dark hairs, the lateral margins gently curved, the costal submargin interrupted with pale brown lines; the membrane very large, faintly smoky, minutely flecked with brown. Venter whitish green, pubescent, polished.

Length to end of abdomen 4 mm. To tip of membrane 6 mm. Width of pronotum 2 mm. Only one specimen of this neat insect is known to me. It is a female taken in Cheyenne Canon, Colorado Springs, July (Tucker); it is somewhat above the average size of the species in this genus, and it bears a general resemblance to some of the green types of the genus Oncotylus, which might cause it to be confused with some of them."

Phytocoris pallidicornis Reut

Colorado (Riley).

Neurocolpus nubilus Say

Near Denver, August 4th (Uhler, 5). Colorado (Snow—see VanDuzee, 5). Colorado (Gillette—see Osborn, 1).

Colorado Springs, Garden of the Gods (Tucker).

Neurocolpus inops Say.

On small plants in Beaver Brook Gulch, next to Clear Creek Canon, August 6th (Uhler, 5).

Compsocerocoris annulicornis Reut

Colorado (Snow—see VanDuzee, 5).

Callodemas Uhler n. gen.

"Having the features of a greatly elongated Calocoris. Head vertical, wider than the collum, having a short neck, the vertex transverse, front broad tumido-conical, with the eyes reniform, prominent, and placed below the level of the vertex, line between the front and tylus deeply cut, the tylus long, thick, subcylindric, prominently curved at base; superior cheeks quadrangular, wide, almost flat, placed a little obliquely, the base of antennae very thick, deep seated directly above the quadrangular cheeks, against the inferior third of the eyes, lower cheeks rhomboidal, placed nearly horizontal beneath the eye; bucculae narrow, short, not extending beyond the inner line of the eye; rostrum quite thick at base, the basal joint reaching upon the anterior coxae. Anterior border of prosternum with a narrow, double, curved fold, mesosternum tumidly elevated. Pronotum transverse, abruptly sloping in front, the front border very narrow, carrying a prominent collum which is but little wider than the base of the head. Scutellum widely exposed at base, deeply incised across the disk, the posterior division triangular and almost equilateral. Hemelytra long and narrow, the costal border almost straight, veins distinct, regular, membrane long and wide, the looped vein fusiform in contour, round at the outer end, slenderly acute at the inner end, the adjoining areole but little shorter. Abdomen almost flat above, widely curving behind the base, with the connexivum broadly reflexed."

Callodemas laevis Uhler n.sp.

"Long-suboval, yellow tinged with green, bald, polished. Head highly polished, eyes dark brown, pale behind; rostrum pale testaceous, piceous on the apical joint, reaching to behind the posterior coxae: antennae filiform, very long, set with black stiff hairs, the basal joint thick, as long as from the front of the eye to the apex of the middle coxae, the second not quite as stout, longer than the corium, the other joints destroyed. Pronotum rapidly narrowing obliquely towards the front, the lateral margins sinuated, with the humeri rounded, lobate, the posterior margin a little sinuated on the middle, and deeply excavated inwardly from the humeri. middle sometimes with two black dots. Scutellum long triangular, acute at tip, obsoletely punctate in parts near base, each side next the pronotum sometimes with a black spot. Clavus a little dusky, corium with a dusky large spot behind the middle which is triangularly forked on the posterior end, the surface remotely spread with minute silky pubescence; membrane dusky at base and apex, omitting the centre of the areoles, the veins pale yellow. Legs yellow, with the femoral and tibial spines darker; tip of tarsi and the nails piceous. Tergum black, excepting the sides and end which are greenish yellow. Venter light clear yellow.

Length to end of abdomen 8 mm. To tip of membrane 9 mm. Width of pronotum 2 mm. One specimen, a female, is in the collection from Colorado, and another from New Mexico."

Glenwood Springs, August 24th (Gillette).

Calocoris palmeri Uhl.

Southern Colorado (Uhler, 6).

Calocoris rapidus Say.

Colorado (Uhler, 1 and 6). Pueblo, August 10th (Uhler, 5). Pueblo, June (Yarrow--see Uhler, 7). Custer County, midalpine (Cockerell, 10).

Fort Collins, July 14th to August 11th; July 14th on alfalfa and Oenothera biennis; Steamboat Springs, July 14th, on Solidago and other low herbs (Baker). Rist Canon, July 14th; North Park, July 20th; Estes Park, July 12th; Steamboat Springs, July 26th (Gillette).

Calocoris superbus Uhl.

West Cliff, Custer County, July 27th (Cockerell, 10). Colorado (Gillette—see Osborn, 1).

Fort Collins, June 23th to August 25th, and September 27th on Senecio douglassi (Baker and Gillette).

Calocoris tinctus Uhler n. sp.

"Oblong-oval, olive brownish, moderately pubescent, mostly bald above. Head long nutant, contracted obliquely on the front, the vertex a little sunken, longitudinally incised, bounded behind by a prominent ivory white carina, the front most compressed next the line of the tylus, tylus smooth, dark brown; rostrum reaching behind the posterior coxae, pale rufo-piceous; antennae long and slender, as long as pronotum and corium united, pale dull fulvous, a little darker on the last two joints and tip of second joint, the second joint a little thicker than the following ones, as long as the head and pronotum united, the third and fourth filiform, together a little shorter than the second. Pronotum wider than long, trapezoidal, moderately convex, almost regularly punctate, with the collum, lateral and posterior margins almost straight, white, the submargin and callosities black, anterior angles a little rounded; pleural flaps deep, black, polished, coarsely remotely punctate and wrinkled, sternum blackish brown, the borders of pleural areas white. Legs brown, paler at base and on the trochanters, nails black. Scutellum moderately convex, brown, pale at tip, minutely wrinkled and obsoletely punctate. Clavus and corium covered with close shallow punctures, subcostal area with a broad and long pale almost hyaline stripe; membrane dusky, with a large whitish spot near the base, the veins dark; wings dusky. Venter purplish black, opaque, pale on the middle, fulvous on the last segment, all the incisures margined with white, and with a series of pale dots on the lateral submargin, pubescence hardly distict.

Length to end of abdomen 6 mm. To tip of membrane 7 mm. Width of pronotum 2 mm.

Only one specimen, a female, was taken in Colorado. It is peculiar from the conical and compressed form of the clypeus, and the genital slit for the ovipositor extends back in a pale line to next base of venter. The male is a great desideratum."

Estes Park, July 15th, on Pinus (Gillette).

Megacoelum fasciatum Uhl.

Near Manitou, August 13th (Uhler, 5). Manitou, July 16th (Packard—see Uhler, 5).

Lygus annexus Uhl.

Colorado (Uhler, 1). Foot-hills (Carpenter—see Uhler, 6). Pueblo, July (Wilkin—see Uhler, 7). Several var. in Beaver Brook Gulch. Pale varieties common near Denver on Euphorbia marginata (Uhler, 5). Denver, July 28th; Idaho Springs, July 6th (Packard—see Uhler, 5). Custer County, midalpine (Cockerell, 10).

Gore Pass, July 29th; Montrose. June 24th (Gillette). La Veta, July 4th (E. A. Schwarz).

Lygus diffusus Uhl.

Custer County, high alpine (Cockerell, 10)

Lygus guttatipes Uhler n. sp.

"Form of L. prasinus Reut., but having a narrower head, the femora on the sides and the tibial spines at base marked with black dots. Ovate, convex. dull pale green. in some specimens obsoletely tinged with brownish around the base of membrane, obsoletely scabrous and effaced punctate, set with silky stiff pubescence which is mixed with dark bristles on the sides of the pronotum. Head polished, strongly convex; eyes large, brown; antennae green, stout, the basal joint thick, a little brownish, somewhat longer than from the eye to tip of tylus, second joint growing gradually thicker towards the tip, much shorter than the base of pronotum; rostrum greenish, broadly black at tip, reaching upon the middle coxae. Pronotum transverse, convex, remotely pubescent, unevenly and finely punctate, lateral margins acute, slightly curved, the pleural piece beneath them short, sunken, having a few punctures on the middle. Legs green, the femora stout, marked with round, black spots; tibial spines black, and with a black dot at the base of each, apex of tibiae and of tarsi also black. Scutellum moderately convex, a little wrinkled. Corium and clavus obsoletely rugose-puntate; cuneus with remote dusky pubescence, the tip sometimes minutely fuscous; membrane moderately long, pale greenish, with paler veins. Abdomen brighter green, minutely pubescent, the genital pieces blackish,

Length to end of abdomen, male 3.25, female 3.5 mm; to tip of membrane 4 mm. Width of pronotum 1.5 mm. Four specimens have been sent to me by Prof. Snow for examination. They were collected at Manitou, in August, by Mr. E. S. Tucker."

Lygus invitus Say.

Steamboat Springs, July 16th (Baker).

Lygus plagiatus Uhler n. sp.

"Robust, dull fulvo-griseus, or griseo-testaceous with fuscous obscure spots, opaque, pubescent. Head olivaceo-testaceous, polished, vertex incised on the middle, indented next the occipital carina, eyes brown, placed perpendicular, front convex, a little obsolete punctate, indistinctly marked with about four brown uneven stripes, cheeks and tylus brown below; rostrum flavo-testaceous, piceous at tip, reaching to the middle coxae, antennae short and moderately stout, the basal joint dark brown, the second joint a little longer than the pronotum, darker and a little thicker towards the tip, the third and fourth dusky, more slender than the second and together about equal to it in length. Pronotum broad, very moderately convex, bald, with coarse uneven punctures separated by wrinkled spaces in somewhat transverse lines, color dull, sometimes marked with a pair of black spots on the middle, a larger black spot in each humeral angle, and some faint, short stripes of brown on the disk, the lateral margins reflexed, whitish, a little curved, anterior angles well rounded and converging towards the elevated, ivory white collum, posterior margin pale, a little sinuated; pleural flap coarsely punctate, blackish on the middle; sternum and coxae pale greenish-testaceous. Legs testaceous, anterior coxae and sternum black, the usual two brown bands near tip of femora, the tibiae dark at tip and with black spines, tip of tarsi and nails black. Scutellum with an oblong pale spot each side near base, and the apex also pale. Corium finely pubescent, flecked with pale dots, more finely and closely punctate than the pronotum, costa dull testaceous, piceous at tip, inner angle with a pale spot on each wing-cover, tip of the broad cuneus with a dark brown spot; membrane brown at the outer end of the areole. Venter pubescent, greenish testaceous, with a dark stripe each side, and some pale dots on the connexivum.

Length to end of venter 4.5-5 mm. To tip of membrane 5.5-6 mm. Width of pronotum 2-2.5 mm. One specimen, a male, is in the collection from Colorado, others were sent to me from Indiana, Nebraska, Washington, Mackenzie River region, province of Quebec, and Maine. It is allied to L. pratensis Linn., but it differs in form, length of antennae, and markings."

Manitou, April 17th (Gillette).

Lygus pratensis Linn.

Colorado (Uhler, 1). Above timber line (Carpenter—see Uhler, 6, and Packard, 2). Common in cultivated districts (Uhler—see Packard, 2). Colorado, common (Packard, 2). During August, around Denver, near Golden, near Colorado Springs, and near Cannon City (Uhler, 5). Golden, July 3d; Blackhawk, July 2d (Packard—see Uhler, 5). West Cliff, Custer County, July 27th; also high-alpine (Cockerell, 10).

Fort Collins and adjoining foot-hills April 6th to September 30th, very common on alfalfa, sugar beets, and many wild and cultivated plants (Baker and Gillette). Steamboat Springs, July 26th; Trinidad, May 14th; Georgetown, July 19th; Manitou, September 29th (Gillette). Aspen (W. W. Willard). Manitou Park and Colorado Springs (Tucker). La Veta, July 4th (E. A. Schwarz).

Lygus sallei Sign.

Steamboat Springs, July 15th (Baker). Manitou, July (Snow).

Neoborops Uhler n. gen.

"Aspect of Neoborus, but with the eyes vertical, more prominent, the vertex and base of front narrower, the lateral margins of pronotum not decurved, and the anterior border of prosternum collum-like, with the inner borders of the pleural flaps carried far inward and leaving only a narrow space for the posternum."

Neoborops vigilax Uhler n. sp.

"Bright fulvous or fulvo-testaceous, oblong-oval, scabrous and obsoletely, minutely punctate on most of the upper surface. Head nearly vertical, narrow between the very prominent brown eyes, with a broad yellow line on the middle which is bounded each side by a slightly punctate, impressedline; the front a little convex, widening beneath; tylus long, of nearly uniform width throughout, curving a little at tip; rostrum reaching to behind middle coxae, wax yellow; antennae of medium length, pale wax yellow, the basal joint moderately thick, longer than the head, the second joint black at tip, tapering slender towards the base, about as long as the clavus, the third joint abruptly more slender, about half the length of the second, also black at tip, the fourth about equally slender, very short, black from beyond the base to the tip. Pronotum transverse, bluntly subtriangular, moderately convex, but steeply sloping anteriorly, punctate, polished, more or less distinctly marked with about four red stripes composed of spots; the humeri lobately rounded, marked with a black dot, the lateral margins callous, not reflexed, the posterior margin pale and slenderly reflexed; the collum prominent, deeply cut, abruptly narrower than the front of the prothorax; pleural flaps deep, subtriangular, spotted with red, white below, slightly wrinkled, and with a few punctures. Legs long, yellowish-testaceous, shaded with red, and with a broad brown band on the knee of middle and posterior femora and tibiae in common, tips of tarsi piceous. Scutellum yellow, marked with brown or rufous, or with a round spot on middle and a triangular one at base. Hemelytra testaceous, translucent, obsoletely punctate and wrinkled, marked with irregular, remote spots of brown or red, at base and apex of corium and with vestiges between these points, veins and sutures whitish, cuneus and membrane also with clouded brownish spots. Abdomen minutely pubescent, sprinkled with red, somewhat in stripes, leaving a linear space of yellow between, the outer submargin sometimes marked with brown spots in the suture, apical border of the last ventral ring yellow, the genital segment also yellow.

Length to end of abdomen 4 mm. To tip of membrane 5.5 mm. Width of pronotum 2 mm. I have examined two specimens from Colorado, and six of both sexes from Arizona. It seems to be common in Arizona and most of the specimens thus far seen have not been maturely colored."

Steamboat Springs, July 16th on willow (Baker).

Neoborus rubeculus Uhler n. sp.

"Oblong-oval, minutely pubescent, mostly yellowish or greenish-testaceous, marked with chestnut brown. Head normal, bald, polished grooved, between the eyes, the face nearly vertical, testaceous yellow, with a broad, curved, brown line on either side; tylus long, narrow, with a brown line on the middle; the cheeks yellow, smooth, the suture and a mark next the antennae rufous; rostrum rufo-testaceous, slender, reaching behind the middle coxae, piceous at base and tip; antennae stout, the basal joint much longer than the head, dark brown, the second joint about as long as the pronotum and scutellum united, a little thickening towards the tip, fulvous, dark at base and tip, the third and fourth much more slender, filiform, dark brown, conspicuously hairy, the third about one-half as long as the second, the fourth still shorter. Pronotum longer than normal, a little convex, strongly sinuated on the sides, the anterior width reaching to the middle of the eyes, with a sharply elevated ivory-white collum which corresponds to the space between the eyes; the surface transversely wrinkled, coarsely so and a little punctate on the posterior lobe, the region of the callosities dark, tumidly prominent, with the exterior submargin widely flattened, yellow, and the outer border strongly reflexed, punctate, the middle line yellow, each side, posteriorly, brown on a rufous ground, the posterior edge yellow; pleural flaps deep, triangular, brown and punctate above, yellow below; the sternum and pleural pieces clear yellow. The coxae and legs yellowish or greenish white, a little reddish on the posterior femora, the tarsi black at tip. Scutellum brown, feebly convex, pubescent, wrinkled, with a few remote punctures, the middle line and base yellow. Clavus coarsely wrinkled, dusky, paler exteriorly, pubescent, corium, closely wrinkled and punctate, testaceous for two-thirds of its length, red at the costal tip and angularly dark brown on the apical third, the inner border with a yellow line next base of cuneus, the cuneus yellow, margined exteriorly with red; the membrane dusky, paler at base exteriorly, the veins yellow, with the areole smoke brown. Exterior margin of venter with a line of brown spots which continue along the pleura to the stripe on the pleural flap; middle of venter yellowish-testaceous, the genital segment more or less marked with red and brown.

Length to end of abdomen 4.5 mm. To tip of membrane 6 mm. Width of pronotum 2 mm. This insect is quite variable in colors. The red is sometimes replaced by olive-green or fuscous, and there is sometimes a broad black stripe along the whole submargin beneath. It inhabits Colorado, and is common in Northern Illinois, in June; it is also found in Michigan."

Steamboat Springs, July 16th on willow (Baker).

Poeciloscytus basalis Reut.

Sweeping weeds at Colorado Springs, near Fountain Creek, August 16th (Uhler, 5). Colorado (Uhler, 8).

Manitou Park (Snow). Colorado Springs (Tucker.)

Poeciloscytus diffusus Uhl.

North Park, July 20th; Estes Park, July 10th (Gillette). Steamboat Springs, July 12th to 26th, on Solidago and other low herbs (Baker and Gillette).

Poeciloscytus intermedius Uhl.

Steamboat Springs, July 13th to 26th (Baker and Gillette). Estes Park, July 12th (Gillette).

Poeciloscytus unifasciatus Fabr.

Smith's Park, Custer County, midalpine, August 6th (Cockerell, 10).

Steamboat Springs, July 12th (Baker) Veta Pass, July 1st (E. A. Schwarz).

Poecilocapsus goniphorus Say.

Fort Collins, June 23d to August 25th (Gillette).

Systratiotus americanus Reut.

Colorado (Gillette—see Osborn, 1).

Steamboat Springs. July 15th to 26th (Baker and Gillette).

Systratiotus venaticus Uhl.

Colorado (Uhler, 1 and 6).

Garland, June 19th (E. A. Schwarz).

Camptobrochis grandis Uhl.

Colorado (Snow—see VanDuzee, 5)

Camptobrochis nebulosus Uhl.

Colorado (Uhler, 6). Colorado (Gillette—see Osborn, 1).

Fort Collins, June 9th on alfalfa, May 3d and September 26th on box-elder; Big Narrows of Poudre River, Larimer County, July 9th on Bigelovia (Baker). Foot-hills five miles west of Fort Collins, April 10th to August 1st (Baker and Gillette). Manitou, September 29th on Salix; Glenwood Springs, August 24th (Gillette)..

Camptobrochis robustus Uhler n. sp.

"Short and thick, dusky testaceous, strongly marked with fuscous and black, coarsely, and in part densely punctate. Head almost vertical, vertex short, transversely grooved. bordered with a broken fulvous line in front, the occipital carina high, fitting into the collum, ivory yellow; front bordered with pale dull yellow, polished, remotely minutely obsolete-punctate and wrinkled, closely freckled with black, the inner border of the eyes also pale dull yellow, the lower part of tylus and the bucculae yellow; rostrum pale at base, piceous at tip, reaching to the middle coxae; antennae long and slender, as long as the corium and cuneus united, mostly pale fuscous, the basal joint dull pale fulvous, obscured with fuscous, the second very long, a little stouter than the third and fourth, slightly thicker towards the tip, the third and fourth together a little onger than the second, the fourth much the shortest. Pronotum convex, coarsely, deeply, irregularly punctate in somewhat transverse wavy lines, with about four obscure stripes which widen posteriorly, the lateral margins a little curved, the humeral angles broadly rounded, the posterior margin feebly curved and sinuated, and the anterior margin contracted and bordered with a somewhat pale collum. the callosities tumid, black, polished. Scutellum dark brown, closely and roughly wrinkled and unevenly punctate, convex, olive-fulvous at tip. Legs pale olive-brownish, the femora piceous, rough at a few points, having one or more yellowish dots near the tip, the tibiae spotted with dark brown, closely pale pubescent, with the spines, tip of tarsi and nails dark piceous. Clavus coarsely punctate and wrinkled. dark olivaceo-fuscous. corium a little paler, smoother, more finely punctate, almost bald, with the surface near the costa translucent, punctate with brown, the costal border dark brown, ending in a darker spot before the cuneus, the embolium broad and piceous black, the cuneus dark brown, bordered all around with pale testaceous; the membrane whitish, a little stained with brown at base and tip, and the veins mostly brown. Abdomen olivaceo-testaceous, finely pubescent, dusky at tip, with a line of black marks on the outer submargin, and a series of yellow dots on the connexivum.

Length to end of abdomen 5 mm. To tip of membrane 6 mm. Width of pronotum 2.5 mm. Three or four specimens have been brought to my notice. One specimen from Colorado is chiefly dark fulvous, others were mostly chestnut brown or nearly black. The pale stripe with black arrest at the end of costal area will go far towards quickly distinguishing this species."

North Park, July 20th (Gillette), and July 10th on Artemisia tridentata (Baker). Leadville, August 23d (Gillette). Cameron Pass, at 12,000 feet. on Salix (Baker).

Orthops scutellatus Uhler.

From bushes in Clear Creek Canon, August 7th. Not rare (Uhler, 5). Colorado (Uhler, 8).

Steamboat Springs, July 15th to 26th (Baker and Gillette). North Park, July 20th; Dolores, June 18th (Gillette).

Thyrillus brachycerus Uhl.

Colorado (Uhler, 6). Near West Cliff, Custer County, end of July (Cockerell, 10).

Estes Park, July 10th (Gillette).

Thyrillus pacificus Uhl.

Weld County (Uhler, 1).

Pamerocoris anthocoroides Uhl.

Near Denver (B. H. Smith—see Uhler, 5).

Monalocoris filicis L.

Swept from a small fern which grows in damp places among the rocks high up in the mountains near Beaver Brook, adjoining Clear Creek Canon, August 6th (Uhler, 5).

Eccritotarsus scabrosus Uhler n. sp.

"Compact, thick and short, somewhat resembling E. vestitus Dist., a little pubescent, the general color piceous-brown, with red head and legs, and nearly all of the upper surface roughly, and coarsely punctate. Head tumidly convex, with a callous ridge against the inner border of the eyes, and this continued along the border of the occiput; surface somewhat coarsely punctate, the front indented in the middle and grooved each side, a little obscured with brown; tylus a little more prominent than the front, placed almost vertical; the rostrum rufous, a little tinged with piceous; antennae blackish, short, stout, the basal joint shorter than the head, contracted at base, the second longest, growing thicker towards the tip, shorter than the pronotum, the third much more slender, about one-half as long as the second, the fourth much shorter. Pronotum strongly convex, a little longer than wide, steeply sloping towards the head; the anterior lobe abruptly contracted, separated by a transverse and curved series of indented points; surface tinged with rufous, coarsely, roughly punctate; lateral margins sinuated and steeply curved down; the posterior margin a little curved, feebly sinuated, bent down; pleural flaps very coarsely punctate. Legs stout, rufous, covered with pale pubescence. Scutellum small, tumid at tip, punctate basally. Hemelytra broad, thick, coarsely and roughly punctate, the cuneus long, depressed, curved on both sides, the membrane fuliginous, with a pale arc on the middle, the areoles rough and of thick texture. Sternum and venter somewhat rufous, the latter obsoletely punctate, highly polished, minutely pubescent.

Length to end of abdomen 2.5 mm. Width of pronotum 1.25 mm. Described from one specimen, a male, from Colorado"

Estes Park, July 10th (Gillette).

Pycnoderes insignis Reut.

Steamboat Springs, July 26th (Gillette).

Ilnacora chloris Uhl.

On the flowers of a slender pale composite, growing in Manitou Park, August 14th. Also near Colorado Springs, in the low grounds near Fountain Creek (Uhler, 5). West Cliff, Custer County, sweeping herbage, July 25th (Cockerell, 10).

Estes Park, July 10th; Dolores, June 18th; Steamboat Springs, July 26th (Gillette).

Ilnacora divisa Reut.

Steamboat Springs, July 14th and 26th (Gillette and Baker).

Ilnacora stallii Reut.

Steamboat Springs, July 16th (Baker).

Ilnacora viridis Uhler n. sp.

"Bright grass green, narrow, not highly polished. Head flat as usual, set with black stiff pubescence, with the vertex more or less broadly impressed before the sharp occipital carina; front prominently convex, wider than long, grooved each side near the eyes; tylus short, inferior, placed much below the lower end of the eyes; rostrum dull green, broad and compressed at base with the basal joint protracted upon the anterior coxae, the tip black, reaching to the middle coxae; antennae dusky greenish, long, growing slender towards the tip, the basal joint thick, black at base and apex, much longer than the head, the second joint very long, black at base and tip, about equal to the corium in length, the third darker, more slender, less than half as long as the second, the fourth about equally slender, also dark, much shorter than the third. Pronotum trapeziform, almost flat, very gently sloping, set with erect blackish pubescence anteriorly and on the sides; the anterior margin reaching to about the middle of the eyes, with the collum raised in the middle; the callosities large, transverse, separated by a deep excavation, the anterior angles broadly rounded; the lateral margins oblique, reflexed and sinuated posteriorly; the humeral angles a little protracted, forming lobes a little recurved with the tip cut obliquely, surface wrinkled, hardly punctate. Scutellum feebly convex, acute at tip, sometimes a little whitish at base. Legs long, the femora green, somewhat spotted with white; the tibiae dull yellowish, armed with black spines; tip of tarsi piceous. Hemelytra long and ample with the costal border very slightly curved; surface of clavus and corium flat, obsoletely scabrous; membrane smoke brown. Coxae and base of venter whitish.

Length to end of abdomen 4.5 mm. To tip of membrane 5.5 mm. Width of pronotum 1.33 mm. I have examined four specimens of both sexes, from Colorado. They approach I. (Sthenarops) malina Uhler, but differ in the absence of the indented black dots on the pronotum, and of the black markings of face, in less convex front, and in the color of the antennae and scutellum. The form is somewhat variable, as is also the length of the hemelytra."

Steamboat Springs, July 14th (Baker).

Sthenarus rubidus Uhler n. sp.

"Ovate, thick set, dark piceous, polished, covered above with silky yellow, caducous scales and fine pubescence. Head broad, feebly convex, a little fulvo-piceous around the borders and at base and tip, vertex with a feebly impressed line on the middle, occipital posterior ridge distinct; face polished, covered with yellowish prostrate scales; cheeks and inner underside of eyes pale yellowish; rostrum piceous, paler rufous at base, reaching to the posterior coxae; antennae, basal joint piceous, thick, scarcely as long as the width of the eye, second joint fulvous or piceous, thick, about as long as the pronotum, the third and fourth abruptly more slender, pale piceous, together scarcely longer than the second. Pronotum convex on the middle and strongly curving down anteriorly, dark piceous, or black, polished, covered with yellow scales and fine pubescence, nearly twice as wide as long, with the callous humeri subacute, the posterior margin sinuated, with the lateral margins curving down; the surface minutely wrinkled, and the pleural flaps triangular, sunken, densely covered with scales and the margins raised in relief. Anterior coxae and a spot at tip of mesopleural segment whitish; femora pale rufous, piceous on the middle, tibiae paler, the spines black and placed on black dots, tip of the tibiae and of the tarsi black. Scutellum unevenly wrinkled, piceous, rufous towards the tip, invested with the yellow scales. Hemelytra dark brown, fulvous at base, on the suture of clavus and on the embolium, apex of the costal border and the cuneus red; surface roughly, shallow punctate, covered with yellow scales and finely pubescent; membrane fuliginous, white along the border and around the looped vein. Venter fulvous brown, minutely pubescent and spread with bronze-yellow scales.

Length to tip of abdomen 2.75-3 mm. To tip of membrane 3-3.25 mm. Width of pronotum 1.25 mm. One specimen from Colorado Springs, taken in August by Mr. E. S. Tucker, is darker and less rufous than the others that I have examined; it has also more white at the base of membrane. Other specimens have been collected in Illinois by Mr. Bolter and Mr. Stromberg; at Lancaster, N. Y. in August by Mr. VanDuzee; in Cuba by Dr. Gundlach, in San Domingo by myself, as also in Texas and Florida. A form appearing to be a variety of this species is also found in Mexico."

Tinicephalus simplex Uhl.

Colorado (Uhler 1). Foot-hills, July (Carpenter—see Uhler. 6). Mountains west of Denver, July and August (Uhler, 5).

Garland, June 30th (E. A. Schwarz).

Pilophorus gracilis Uhler n. sp.

"Narrower than usual, dark piceous, or nearly black, the pronotum longer than wide, and the corium distended and almost hyaline at the tip. Head depressed subconical, the vertex transversely depressed, with a central carina running back to the thick carina bounding the occiput behind: face convex, piceous, polished, becoming fulvous below; tylus narrow, pale rufo-fulvous like the cheeks; rostrum dark honey-yellow, darker at tip, reaching upon the middle coxae: antennae moderately long and slender, the basal joint short, dull fulvous, the second a little longer than the pronotum, of the same color, but darker on the gradually thickening tip, the apical joints more slender, but not abruptly decreasing, the two united scarcely longer than the second. Pronotum highly polished, semi-cylindric, with the sides a little sinuated, almost of equal width throughout, dark piceous, minutely wrinkled on the disk and behind, with the humeral angles acute and the anterior ones rounded off. Scutellum depressed behind the middle, black, and minutely scabrous. Hemelytra long, dark brown, sometimes almost black, minutely pubescent, velvety, not banded, distinctly sinuated on the sides, the membrane a little dusky, with a dark brown spot near the base, the inner border of apex of corium with a curved callous line. Legs pale dull piceous, paler on the tibiae. Abdomen black, highly polished.

Length to end of abdomen 3.5 mm. Width of pronotum 1.25 mm. One specimen, a female, lacking the tarsal joints and two apical joints of the antennae, was sent to me from Colorado. It lives on Pinus inops in summer, June to September, in Maryland, Virginia, New Jersey; and is also found in Massachusetts. Maturely colored specimens do not have the reddish clypeus and cheeks observed in the specimens from Colorado."

Colorado Springs, August 3d (Gillette).

Globiceps angustata Uhler n. sp.

"Black, highly polished, delicate, slender. Head transverse above, convex, having a few remote punctures, the eyes large and prominent, much elevated above the line of the head, the face nearly vertical, with the front a little convexly prominent, the tylus moderately narrow; rostrum very stout at base, with the basal joint long, stout and blackish-piceous, the middle testaceous and the tip piceous; antennae long, slender, dull black, the basal joint longer than the head, testaceous at base, the second barely thicker at tip, nearly as long as the costa and cuneus united, the third a little more slender, about half as long as the second, the fourth broken off. Pronotum sub-campanulate, highly polished, about twice as long as the eye; the collum contracted, narrow: the callositites very large, tumid, with a groove between, which is partly occupied by a blunt carina that runs back to posterior lobe; posterior lobe wide, convex, transversely wrinkled, with the anterior slope high, the sides steep, oblique, and gently sinuated, the humeri a little turned up and acute. Scutellum high, almost flat above, with steeply sloping sides, acute at tip. Legs pale fulvous, whitish at base, the ends of tarsi piceous. Clavus dusky, corium whitish-yellow at base, dusky on the remaining two-thirds; the cuneus pale yellowish, dusky at tip; membrane long and wide, pale fuliginous, white at the extreme base, with the looped vein dark brown. Abdomen black, highly polished.

Length to end of abdomen 2.75 mm. To tip of membrane 4 mm. Width of pronotum .87 mm. Described from a single male specimen from Colorado. It is closely related to, if not the same species as one which I found in the Province of Qubec. The female is earnestly desired for study, to complete the description of this species. This insect might readily be mistaken for one of the small Chalcididae which have black bodies and yellow legs."

Steamboat Springs, July 12th (Baker).

Cyrtorrhinus marginatus Uhler n sp.

"Long and narrow, black, moderately flat above, pale pubescent, bordered with green on the abdomen and corium. Head black, highly polished, much wider than the front of pronotum, indented and grooved in front of the carina of vertex, the carina sharp and high; face almost vertical, the tylus prominent; eyes large, brown, prominent, placed a little obliquely, the border of their inner side pale yellowish; tylus, bucculae, and rostrum greenish-testaceous, the latter reaching upon the middle coxae, blackish at tip; antennae moderately stout, as long as the head, pronotum and corium united, the basal joint much longer than the head and stouter than the second, the second joint as long as the clavus, the third more slender and about half as long as the second, the fourth still more slender and much shorter. Pronotum shining black, sometimes with a yellow line, the sides gradually contracting, rather strongly sinuated, the callosities large and prominent, the surface transversely wrinkled, convex posteriorly, longitudinally impressed near the humeri, the margin sometimes broadly yellow. Legs pale greenish, the tibiae dark at tip, the anterior pair with stout spines, tarsi piceous at tip. Scutellum black, moderately convex, transversely wrinkled, acute and pale at tip. Clavus dull black minutely pubescent, corium dull black as far as next to the cuneus, also pubescent, broadly margined with greenish yellow, the cuneus mostly yellowish, the surface of the hemelytra granulate throughout; membrane long, smoke brown, with the veins pale yellow at tip. Middle line of the sternum and disk of venter pale greenish-yellow, finely pubescent.

Length to tip of abdomen 4 mm Width of pronotum 1.25 mm. Only males of this insect have been brought to my notice. Should the female prove to be of the inflated type, with the spherical head, this insect will have to be transferred to the genus Globiceps Fiebr. This species is common in the province of Quebec, and it occurs as far north as Great Slave Lake, in British America."

Steamboat Springs, July 16th, on willow (Baker).

Diaphnidia Uhler n. gen.

"Near Actorhinus Fab., elongate subelliptical, tender, opaque. Head gently sloping and curved anteriorly, the face almost vertical, a little longer than the width between the eyes; tylus projecting beyond the line of the face, curving beneath, the upper bounding line placed nearly on the level of the lower end of eyes; eyes prominent, sub-reniform, nearly vertical, with somewhat swollen neck behind their line; occiput with a carina sometimes arched in the middle, and with the surface flattened in front of it, cheeks diagonal, acutely narrowed at tip; gula almost horizontal, swollen at base; bucculae narrow and short, followed behind by a waved surface, basal joint of rostrum much shorter than the under side of head; antennae longer than the head, pronotum and corium united. Legs long. Pronotum trapeziform, with the lateral margins moderately oblique, the anterior margin forming a narrow, flat, sinuated collum; the transverse impressed line behind the callosities shallow. Hemelytra long and wide, contractingly curving towards the base, semi-diaphanous, with a sharply reflexed costal margin; cuneus large and long, with the outer border reflexed. Abdomen very narrow."

Diaphnidia debilis Uhler n sp.

"Delicate green, or greenish-white, indistinctly and very minutely pubescent around the sides of head, pronotum and beneath. Head a little grooved on the middle line, and a little callous each side between the eyes; antennae yellowish, the basal joint much longer than the head, thicker than the second joint and contracted at base, the second of uniform thickness throughout, as long as the outer margin of the corium; rostrum yellowish, black at tip, reaching between the anterior coxae. Pronotum wider than long, almost flat on the disk, gently sloping, with the surface a little wrinkled, the lateral margins a little sinuated in front of the prominent humeri; the anterior submargin occupied by the transverse ridge of the almost contiguous callosities. Legs pale green, more yellow upon the tibiae, upon which the spines are dark, and the base and apex of the tarsi piceous. Clavus, corium and cuneus minutely, remotely and obsoletely scabrous. Abdomen silvery greenish.

Length to end of abdomen 3 33 mm. To tip of membrane 5.5 mm. Width of pronotum 1.5 mm. Two males from Colorado are the only specimens I have seen."

Steamboat Springs, July 14th (Baker). Later we also received specimens (which were afterwards determined by Uhler) from Snow, taken by Tucker at Colorado Springs in July.

Diaphnidia pellucida Uhler n. sp.

"Elongate, very pale green, delicate, with minute whitish pubescence on the pronotum and hemelytra. Head short and small, with the eyes nearly globose, very prominent, very pale brownish; middle of vertex incised, the incision running back to an impressed line which extends across to the base of the eyes; base of head thick, curvedly contracting to base of occiput, surface next to inner line of eyes incised; front vertical, forming a rounded lobe as far as to below the middle of the eyes; tylus short, tapering and curving beneath, a very little more prominent than the front; rostrum pale green, slender, reaching behind the posterior coxae. Antennae long and slender, pale green or yellowish, the basal joint longer than the head, sometimes a little dusky at tip, the second joint cylindrical throughout, a little longer than the pronotum and scutellum united, third joint a little more slender and about two-thirds the length of the second, the fourth still more slender, very short, sometimes a little dusky. Pronotum nearly trapeziform, a little wider than long, gently sloping anteriorly; the lateral margins sinuated directly before the prominent humeri; surface a little uneven, the callosities distinct and with an indented space between them, the impressed line behind them deep and clearly defined, arrested by the thick carinate lateral edge which stops against the end of the callosities; the anterior angles rounded off, the anterior edge a little sinuated, callous, extending to about the middle of the eyes; posterior margin a little yellowish, hardly sinuated. Clavus and corium minutely scabrous, almost transparent, very ample as compared with the abdomen; cuneus long, bordered exteriorly with a thick green line; membrane very thin, whitish green, the vein deeper green. Legs greenish, the tibiae sometimes yellowish, dusky at tip; apex of the tarsi and the nails piceous.

"Length to end of abdomen 2.25-2.5 mm. To tip of membrane 3.5 mm. Width of pronotum 1-1.25 mm. Numerous specimens have been brought to my notice. The first of these I found near Montmorency, in the province of Quebec, others were obtained near Washington, D. C., by my friend Otto Heidemann, and a male specimen has been sent from Colorado. The specimen from Colorado has the callosities near together on their inner ends."

Fort Collins, September 26th on box-elder (Gillette).

Dacota hesperia Uhl.

Colorado (Uhler 1 and 6).

Diommatus angulatus Unler n. sp.

"Long, almost parallel-sided, nearly flat above, black or dark smoke-brown, minutely pubescent, rather broader than D. congrex Uhl., with stouter and longer antennae. Head moderately convex, highly polished between and before the eyes, piceous anteriorly and upon the tylus, the latter becoming paler below; the occipital carina pale piceous, bounded in front by an arcuated, punctate impression; eyes large, prominent, dark brown; rostrum wax-yellow, piceous at tip, reaching to behind the middle coxae; antennae long and stout, longer and thicker in the male, black or dark brown, the basal joint a little longer than the head in the female, much longer in the male, the second joint a little thinner than the first, about as long as the corium, the third still more slender, about two-thirds the length of the second, the fourth thinner and much shorter. Pronotum a little wider than long, very slightly convex, with the lateral margin oblique; the surface finely pubescent, very gently sloping, the anterior lobe distinctly defined, with the callosities large, prominent, black; the collum indistinct; posterior lobe large, obsoletely wrinkled and with a few faint punctures, the posterior margin feebly sinuated, with the humeral angles a little prominent and broadly rounded; the pleural flaps moderately short, grooved vertically. Scutellum small, black, convex, acute. Coxae and legs yellowish, a little dusky towards the knees, the tarsi more or less piceous. The clavus pale yellow; corium with a large, triangular, black spot on each wing-cover which covers most of the snrface to next the base of cuneus, the cuneus yellowish, but dusky at tip. Abdomen black, polished, the base, disk, and a part of the apex of venter yellowish.

Length to end of abdomen 3-3.25 mm. To tip of wing-covers 4.5 mm. Width of pronotum 1.25 mm."

Fort Collins, June 24th; Montrose, June 24th (Gillette).

Diommatus congrex Uhl.

Steamboat Springs, July 16th, on willow (Baker).

Tuponia subnitida Uhler n. sp.

"Whitish-green, long oval, minutely pubescent, with the costal margin of the hemelytra very feebly curved. Head broad and very convex, pressed back upon the thorax, smooth, not punctate; front nearly vertical, highly polished; the tylus short, compressed, but little prominent, curved beneath; the rostrum pale fulvous, reaching over the middle coxae, with the tip piceous; antennae long and slender, the basal joint short, blackish, second joint green, dark at base and tip, not much thicker than the following joint, about as long as from the front of the eye to the base of pronotum, the third a little shorter and slightly more slender, the fourth scarcely more than one-third the length of the third, equally slender. Pronotum transverse, uneven, steep, very slightly convex, smooth, impunctate; with the callosities forming an arc, preceded by a semicircular area touching the front margin; the lateral margins very oblique, sharp-edged and deflexed; the posterior margin sinuated at the base of the scutellum; the the humeral angles broad and rounded. Scutellum very moderately convex, the base uncovered, the disk a little wrinkled and the tip acute. Legs greenish-white, the knees, tibial spines, dots at intervals, and the tips of tarsi black. Corium and clavus greenish-white, very minutely, scabrous, and remotely effaced-punctate; membrane a little dusky behind the middle to the tip. Abdomen pale green, minutely white pubescent.

Length to end of abdomen 2.5 mm. To tip of membrane 3 mm. Width of pronotum 1.12 mm. Described from two specimens from Colorado."

Steamboat Springs, July 12th (Baker).

Stiphrosoma atrata Uhl.

Fort Collins, July 14th on alfalfa; Steamboat Springs, July 12th on Carex and Artemisia tridentata (Baker).

Stiphrosoma croceipes Uhl.

Big Narrows of Poudre river, Larimer County, July 9th on Bigelovia (Baker).

Stiphrosoma robusta Uhler n. sp.

"Black, polished, shorter, thicker, and more compact than S. stygica Say, with a more convex front. Head thick, convex from the vertex to end of upper cheek, the vertex with a low carina behind against the pronotum, and marked with a shallow impression each side, front highly polished impunctate, tylus narrowing a little towards the tip, deep seated in the cheeks; rostrum stout, a little piceous, reaching to the middle coxae; antennae slender, black, about as long as the head, pronotum and scutellum united, the second joint nearly the same length as the clavus, a little thicker towards the tip, the third more slender, nearly two-thirds the length of the second, the fourth about one-half the length of the second. Pronotum pubescent on the sides. with the lateral margins oblique and more bent down than in S. stygica, the surface scabrous, obsoletely punctate and transversely wrinkled, the callosities large, convex placed diagonally, and separated by a wide depression, the disk convex posteriorly, with the humeri acutely prominent. Pleura a little wrinkled and with a few punctures. Scutellum short, scabrous, a little punctate. Legs with stiff spines on both femora and tibiae. Clavus coarsely, closely scabrous, and obsoletely punctate, the corium a little less coarsely scabrous, and punctate, but with these features almost obliterated behind the middle, the sides and margins pubescent; membrane moderately short, brown. Abdomen broad ovate, highly polished, scarcely punctate.

Length to end of abdomen 4 mm. Width of pronotum 1.75 mm. Described from two specimens. both females, sent to me from Colorado. It inhabits also Texas and New Mexico."

Steamboat Springs, July 26th (Gillette).

Stiphrosoma stygica Say.

West Cliff, Custer County, July 27th; Ula, July 30th (Cockerell, 10).

Steamboat Springs, July 26th (Gillette). Garland, June 30th (E. A. Schwarz).

Halticus bractatus Say.

Manitou, July 24th; Colorado Springs, August 3d (Gillette).

Labopidea chloriza Uhl.

Howe's Gulch, June 14th; North Park, July 20th (Gillette). Steamboat Springs, July 13th and 26th (Baker and Gillette). Aspen (W. W. Willard).

Labops hesperius Uhl.

Colorado (Uhler, 1). Foot-hills and mountains, July and September (Carpenter—see Uhler, 6). From bushes growing among rocks on mountainside near Gray's Peak, August 6th (Uhler, 5).

Estes Park, July 12th (Gillette). Colorado, June, on pine (Riley). Veta Pass, July 1st (E. A. Schwarz).

Dicyphus californicus Stal.

North Park, July 20th; Montrose, June 24th; Colorado Springs, August 3d; Manitou, September 29th on oak and Salix (Gillette). Steamboat Springs, July 16th and 26th (Baker and Gillette). Fort Collins. May 20th (Baker).

Dicyphus californicus Stal. var. ***agilis*** Uhl

Beaver Brook Gulch, August 7th (Uhler, 5).

Steamboat Springs, July 16th (Baker).

Dicyphus vestitus Uhler n. sp.

"Resembling D. famelicus Uhler, but much less elongated, smaller, having nearly linear blackish antennae, with the apex of the second joint not thickened, and the colors darker, with a black head and mostly black scutellum. Head subglobose, a little fringed with pubescence, black, polished, with a pale spot on the vertex; rostrum dull testaceous, darker at tip, reaching to the middle coxae; antennae moderately stout, blackish, with the first joint pale towards the base, the second joint about as long as the pronotum, the third a little shorter, and not much thinner than the second, the fourth short, acutely tapering. Pronotum a little longer than wide, subcylindric anteriorly, with the sides sinuated and reflexed; the collum narrow and white; the surface highly polished, dark brown, with the middle broadly orange, which is replaced by dull white on the posterior segment; the humeri are sometimes also pale orange; callosities distinct, prominent, followed exteriorly by a swelling of the sides; posterior lobe wide, broadly sinuated behind. Base of scutellum wide, uncovered, black, the scutellum proper black with a yellow spot on each side at base. Coxae white, legs dull yellowish, with the tip of tarsi piceous. Clavus pale, with the suture dusky, corium long and narrow, obscure whitish, translucent, with a small brownish spot near the base, a dusky streak on the middle, a line of same color on the suture, and a double lobed spot of brown on the tip; cuneus white, bordered more or less with brown at tip; membrane pale dusky, usually white in the areole and next the tip of the cuneus, also a little whitish next the posterior border. Posterior part of propleura, and upper part of mesopleura whitish. Abdomen fulvo-piceous, testaceous at tip.

Length to end of abomen 3-3.25 mm. To tip of membrane 3.75-4 mm. Width of base of pronotum .75-1 mm. Described from two speciemens. including both sexes, sent to me from Colorado. Mr. Coquillet also sent specimens from Los Angeles, and I have examined other specimens from Dakota and northern New York. It is variable as to the amount of yellow on the antennae, head and pronotum, and as to the brown clouding of the hemelytra."

Fort Collins, May 20th to June 4th (Baker and Gillette). Montrose, June 24th (Gillette).

Orectoderus amoenus Uhl.

Near Denver (B. H. Smith—see Uhler, 5). Colo. (Gillette—see Osborn, 1).

Orectoderus longicollis Uhler n. sp.

"Piceous, opaque, elongate subfusiform, with the head broad subconical, as seen from above, the base abruptly contracted into a short neck, the prothorax campanulate, and the wing-covers widening behind the middle. Head very moderately convex above, much longer than wide, polished, piceous, rather minutely scabrous than punctate, the vertex moderately arched and obsoletely carinate in front, the neck shorter than the corresponding contraction of the pronotum, front broadly depressed each side near the middle of the eyes, upper cheeks placed superiorly; tylus narrow, moderately short, not separated above by a distinct suture, tip tapering; rostrum set much below the depressed gula, blackish-piceous, thick at the very base, slender from thence to tip, reaching behind the anterior coxae; eyes low, close-set against the side of the head; antennae of medium length, the basal joint rufo-piceous, shorter than the head, the second rufo-piceous, with the apical third moderately clavate, and dull blackish, as long as the middle line of the corium, third abruptly more slender, almost setaceous, testaceous, scarcely more than one-half the length of the second, the fourth much shorter, dusky, equally slender. Pronotum dull black, minutely granulated and wrinkled, the two lobes of nearly equal length, the callosities large, tumid, separated by a very shallow line, but connected with the swelling of the sides, the line separating the lobes is placed behind this swelling; posterior lobe wide at base, having sinuated sides, and with prominently tubercular humeri; side flaps steep, rounded, coarsely wrinkled. Legs dull fulvo-piceous, with the spines, tip of tibiae and apical portion of tarsi black. Scutellum smooth, dull black, with sinuated sides, and a little tumid at apex. Clavus ivory white, coarsely scabrous, with a piceous band at base which also runs diagonally upon the base of corium; corium also ivory white, less coarsely scabrous, crossed behind the middle with an obliquely bounded piceous spot which covers the entire end; cuneus piceous, with an ivory yellow acute diagonal spot on the basal portion; membrane dark brown at base, gradually paler to almost white posteriorly. Abdomen black, highly polished.

Length to end of abdomen 5 mm. Width of base of pronotum 1.5 mm. Only a single specimen, a male, has thus far been brought to my notice. The female is a desideratum requiring the attention of collectors."

Steamboat Springs, July 14th (Baker).

Orectoderus obliquus Uhl.

Hills, June to September (Carpenter—see Uhler, 6). Estes Park (Snow—see VanDuzee, 5).

North Park, July 20th; Steamboat Springs, July 26th; Montrose, June 24th (Gillette). In mountains south-west of North Park, July 10th, on Artemisia tridentata (Baker).

Coquillettia insignis Uhl.

Steamboat Springs, July 13th and 26th (Baker and Gillette). Fort Collins, August 11th (Baker). North Park, July 20th; Dolores, June 16th; Howe's Gulch, June 14th (Gillette).

Orthotylus viridicatus Uhler n. sp.

"Oblong-ovate, grass green, opaque, minutely pubescent, pale green beneath. Head slightly convex, impunctate, broad between the eyes, the vertex transversely sulcate before the carina; the eyes brownish, moderately prominent, well rounded, placed nearly vertical; front convex, contracting below, the tylus narrow, prominent, separated above by a deep groove; rostrum stout, reaching to the middle coxae, pale green at base, black on apical third; antennae stout, the basal joint pale green, the second dusky, about equal to the clavus in length, the third and fourth joints dusky, more slender than the second, filiform, and together not as long as that joint. Pronotum wider than long, almost flat, with the lateral margins oblique, and the anterior angles a very little rounded, the callosities large and tumid, separated by a deep depression, the collum narrow, and confined to a narrow space of the anterior margin, the transverse impressed line behind the callosities slender, but distinct on the outer margin, behind it the margin of the posterior lobe is distinctly reflexed, the margin before this callous; posterior margin nearly straight, with the humeral angles oblique and a little curved; the pleural flap is deep and nearly triangular. Scutellum little longer than wide, feebly convex, faintly carinate at tip. Clavus faintly scabrous, with a few obsolete punctures next the coarse vein, corium minutely and obsoletely scabrous, the cuneus pale yellowish, smooth; membrane black, with the veins pale yellowish. Abdomen short, minutely pubescent.

Length to end of abdomen 3 mm. To tip of membrane 4 mm. Width of pronotum 1.25 mm. A few specimens of both sexes have been sent to me for examination. They have been mostly shriveled from immaturity at time of collecting. Three specimens are in the collection from Colorado. Others were obtained in the vicinity of Denver, and in New Mexico. The pale color of head, thorax, sides of corium and cuneus, is owing to fading of color after death of the insect."

North Park, July 20th; Dolores, June 18th; Trinidad, May 14th; Estes Park, July 10th (Gillette). Steamboat Springs, July 16th and 26th (Baker and Gillette).

Oncotylus guttulatus Uhl.

Colorado Springs, August 3d (Gillette).

Oncotylus longipennis Uhler n. sp.

"Elongated, sub-elliptical, pale greenish testaceous, with a long cuneate, dusky stripe on the middle of corium, polished, minutely pubescent. Head moderately convex, bald, highly polished, subconical, sometimes with a semicircle of blackish spots between the eyes; front yellowish, the tylus narrow, black; the vertex with a high carina in the male and a transverse groove before it; eyes brown, large, prominent, placed a little obliquely; bucculae pale; rostrum slender, obscure testaceous, piceous at tip, reaching to the middle coxae; antennae long, moderately slender, black, the basal joint longer than the head, the second as long as the clavus, the third a little more slender, about two-thirds the length of the second, the fourth of the same thickness, much less than half the length of the third. Pronotum subtrapezoidal, polished, obsoletely wrinkled behind, feebly convex, the sides rapidly narrowing towards the front, and a little sinuated, causing the humeral angles to appear prominent, callosities distinct, directly transverse, approximate, lateral edge decurved, the pleural flaps deep, subtriangular, black on the middle. Legs greenish-testaceous, the femora with a black band near tip, and the knees, spines, tip of tibiae, and tarsi blackish. Prosternum each side, and pleura also, with a black stripe which continues back to the posterior segment; the venter each side with a series of diagonal black streaks. Scutellum feebly convex obsoletely wrinkled, usually black at tip and in each basal angle. Clavus dusky, with the outer vein pale, corium a little granulated translucent, with a dusky tapering spot on the middle, the veins pale, cuneus a little dusky on the inner border; membrane very long, dusky, with the veins pale yellow.

Length to end of abdomen 4 mm. To tip of membrane 6 mm. Width of pronotum 1.33 mm. Described from three specimens from Colorado. It is notable for the extreme length of the wing-covers."

Gore Pass, July 29th; Steamboat Springs, July 26th (Gillette). Rabbit Ears Pass, Routt County, July 20th; Steamboat Springs, July 14th (Baker).

Oncotylus repertus Uhler n. sp.

"Blunter than O. sericatus Uhler, clear bluish green, distinctly pubescent, moderately flat, with the costal margin more broadly curved than in the species cited, with the head, base of scutellum and outer border of corium almost white, yellowish when less fresh. Head broad, subconical, polished, closely white pubescent, vertex feebly convex, the carina low, a little curved back of the line of the eyes; grooved in front of the carina; eyes brown, of medium size, moderately prominent, placed nearly vertical; the front transverse, wrinkled, moderately convex, becoming a little narrower below, separated from the tylus by a deep incision, which crosses the entire face; tylus subconical, wide at base, curving beneath; rostrum greenish-white, piceous and acute at tip; the inferior cheeks very long and wide, incised, a little swollen, bucculae minute; antennae having the basal joint thick, shorter than the head, the second joint very long, much more slender, almost as long as the clavus the last two joints lost. Pronotum transverse, pubescent, the anterior border almost straight, a little callous and abruptly separated from the head, the surface very uneven, with the anterior angles rounded off, the callosities are oval, flat and far apart, the transverse impressed line sinuous, placed about one-third the way back; the sides diagonal, callous, and the pleural flaps subtriangular, narrow at tip, granular on the middle, a little hirsute; humeral angles with a small knob; posterior margin feebly sinuated in the middle, obliquely curved each side. Scutellum triangular, nearly equilateral, with the base exposed. Legs pale green, the tarsi yellow, piceous at tip, spines dark. Corium, clavus, and cuneus a little hairy, minutely and remotely granulated, the exterior margin strongly reflexed and bristly; cuneus a little longer than wide, pale exteriorly; membrane moderately short, smoke-blackish, whitish on the base and on the margins basally, the veins green. Venter with longer bristles posteriorly.

Length to end of abdomen 4 mm. To tip of membrane 5.25 mm. Width of pronotum scant 2 mm. Described from two specimens, both females, sent to me from Colorado. A variety of this species with hyaline membrane occurs near Los Angeles, California."

Steamboat Springs, July 12th on Artemisia tridentata (Baker). Foot-hills six miles west of Fort Collins, June 14th (Gillette).

Oncotylus sericatus Uhler n. sp.

"Similar to Macrotylus vestitus Uhler, but larger and with a less acute and wider head, the second joint of antennae much shorter and a little thicker; the color grass-green above, closely covered with stiff white pubescence, greenish-white beneath. Head closely pubescent, depressed across the vertex in front of the carinate line; the front a little covex; the tylus wide and almost vertical, distinctly pubescent, rostrum slender, reaching midway between the middle and anterior coxae, pale at base, piceous at tip; antennae moderately stout, prominently pubescent, the basal joint clear green, longer than the head, the second dull yellowish, but little longer than the distance from the tip of scutellum to apex of clavus, the third and fourth joints a little dusky, becoming gradually more slender, the fourth quite short. Pronotum very moderately convex, wider than long, finely wrinkled, in front almost as wide as the distance across the eyes, the humeral angles subacutely prominent, a very little rounded, with the outer border callous, white, and sinuated, the transverse impressed line placed just behind the callosities and not reaching the sides; the pleural flaps long triangular, with the apex a little curved forwards. Scutellum small, moderately convex. Hemelytra very long, the costal margin gently curved, so as to be widest back of the middle, the surface of clavus, corium and cuneus, minutely and remotely granulated, with the exterior margin a little paler than the general surface; the membrane long, very faintly obscured, translucent, with the veins green. Legs pale green, with the nails, spines, and tip of tarsi piceous. Abdomen closely set with white pubescence.

Length to end of abdome, 4 mm. To tip of membrane 6.5-7 mm. Width of pronotum 2 mm. Several specimens have been sent to me from Colorado, where the species appears to be rather common."

Steamboat Springs, July 12th on Artemisia tridentata (Baker). We have also received specimens (determined by Mr. Uhler) taken at Colorado Springs in July by E. S. Tucker.

Macrocoleus coagulatus Uhler.

From wild gooseberry and other bushes in Clear Creek Canon. August 7th (Uhler 5). Colo. (Gillette—see Osborn, 1).

Manitou, September 29th, Lamar, May 7th; Foot-hills five miles west of Fort Collins, June 12th (Gillette). Fort Collins, July 4th to October 7th; mountains south-west of North Park, July 10th on Artemisia tridentata (Baker).

Macrotylus affiguratus Uhler n. sp.

"Robust, grayish testaceous, finely pubescent, obscure fuliginous on most of the hemelytra. Head conico-triangular, pale fulvous in front, greenish on the vertex, with a diagonal black line each side converging anteriorly, from this a divaricating black line runs downward each side upon the cheeks below to the eye, cheeks and tylus black, polished; rostrum slender, piceous-black, reaching to the middle coxae; antennae stout, black, moderately short, tapering continuously to the tip, the second joint a little longer than the pronotum, the third a little shorter, the fourth very short, acute at tip. Pronotum broad, well rounded off towards the sides on the posterior lobe, the lateral margins oblique, gently curved, broadly pale, the surface greenish, uneven and wrinkled posteriorly, set with short black bristles at remote intervals, the anterior submargin flat, pale with the margin recurved, a little sinuated in the middle, the callosities prominent, surrounded with black and set in a blackish depression, behind the middle is an obscure arc of broken spots, humeri oblique, a little rounded at tip, the posterior margin very gently curving toward the humeri; the pleural flaps deep, sunken, black, excepting the margins, the flap of prosternum also black bordered with pale yellow; sternum and a long stripe on the outer border of pleura also black. Legs obscure yellowish, with flecks, the spines, knees, tip of tibiae and tarsi black. Scutellum greenish, widely exposed at base, with a few scattered points, a faint middle line and the sparse bristles black. Clavus dull pale greenish, minutely sparsely granulate and punctate, with but few indications of hairs, the corium more obscure, similarly granulate and bristly, with the costal margin and veins pale; the cuneus, its callous inner angle, and thickened short inner margin of the corium and the basal margin of the membrane pale yellowish; membrane short a little dusky, with the veins pale. Venter pale greenish, with the sutures, and border of the ovipositor black.

Length to end of abdomen 4.5 mm. Width of pronotum 1.75 mm. Decribed from one specimen, a female, sent to me from Colorado."

North Park, July 20th (Gillette). Steamboat Springs, July 12th, on Delphinium occidentale and other low herbs (Baker).

Macrotylus moerens Uhl.

Steamboat Springs, July 16th and 26th (Baker and Gillette). Spring Canon, June 30th; Estes Park, July 10th; North Park, July 20th; Manitou, June 25th (Gillette).

Macrotylus verticalis Uhl.

Montrose, June 24th (Gillette).

Bolteria picta Uhl.

North Park, July 20th; Leadville, August 23d (Gillette). On Grizzly Creek, in mountains south-west of North Park, July 10th, on Artemisia tridentata; Steamboat Springs, July 12th (Baker).

Episcopus ornatus Reut.

Colorado Springs, August 3d (Gillette).

Plagiognathus annulatus Uhler n. sp.

"Closely related to P. arbustorum F., but narrower and smaller, brownish-black, long-oval, polished, with pale yellow legs, having the femora streaked and the tibiae annulated or spotted with black. Head longer than wide, acute in front, convex, highly polished, faintly tinged with brown; vertex concurrently convex with the front; the occiput arched and with the edge obscure fulvous; tylus scarcely more prominent than the front, curved, highly polished; rostrum reaching to the middle coxae, yellow, with the basal joint black and the apex piceous; antennae of medium length, the basal joint black, scarcely longer than the head, the second yellow in the middle, or nearly all yellow but the base, a little longer than from the front of the eye to the base of pronotum, third and fourth more slender, yellow. Pronotum deep black, highly polished, growing much narrower anteriorly, minutely, irregularly and obsoletely rugose, more convex posteriorly; the callosities large, very slightly prominent, with an indented space between, and a wavy impressed line forming the boundary between them; the lateral margins oblique, barely sinuated with the edge a little keeled, deflexed; anterior angles a little rounded, callous; posterior margin gently arcuated; the humeri prominent, almost acute, with an impression bounding them inwardly. Scutellum feebly convex, a little unevenly rugulose, the tip acute and set off by a transverse series of punctures placed a little way back. Corium deep black, long, highly polished, obsoletely and irregularly rugose over most of the surface, with some punctures on the depressed borders; the clavus obsoletely and coarsely rugose, with series of shallow punctures on the sutures; base of cuneus marked by an obscurely pale sutural line; the outer angle of base of membrane marked by a triangular white spot, remainder of membrane fuliginous black. Legs pale yellow, the base of anterior coxae, the knees, rings and spines of tibiae and the tarsi black.

Length to end of abdomen 3.5 mm. To tip of membrane 4 mm. Width of pronotum 1 full mm. Described from one female specimen sent to me from Colorado. It inhabits also northern Illinois, Canada west, and New England."

Steamboat Springs, July 16th (Baker).

Plagiognathus fraternus Uhler n. sp.

"Larger and more flat above than P. obscurus Uhler, color black, minutely sericeous pubescent. Head triangular, a little longer than wide. acute at tip, with the sides a little sinuated; occipital carina indistinct, pale yellow, front convex, a little roughened on the middle; the tylus prominent, highly polished, comparatively narrow, a little curved; rostrum reaching upon the middle coxae, basal joint stout, a little longer than the throat, blackish-piceous, the middle joints fulvo-piceous, the apical joint blackish; antennae black, dull testaceous beyond the base of the third joint, the basal joint shorter than the head, the second rod-shaped, scarcely as thick as the basal one, about as long as the face and pronotum united, the third much more slender, about two-thirds as long as the second, the fourth about equally slender, a little shorter. Pronotum wider than long, with the lateral margins oblique; the front margin with a pale collum, reaching to the middle of the eyes; middle surface behind the collum uneven and depressed between the large oblique callosities; lateral margins reflexed, slender, pale; the humeral angles subacute and pale; disk a little wrinkled, not distinctly punctate; pleural flaps polished, black, with the segment next behind marked with a large greenish spot. Coxae mostly greenish-white, femora flattened, testaceous, more or less piceous towards the tip, but always omitting the apex of the posterior pair; tibiae testaceous with black knees, spines and their bases; tip of tarsi piceous. Scutellum obsoletely scabrous, acute at tip. Clavus black, roughly wrinkled and a little punctate; corium pale testaceous, or ivory white, marked with a large, somewhat ovate, ragged spot from before the middle to next the tip; cuneus pale with a small black spot at tip; membrane dark fuliginous with a large, clear spot on the middle, veins testaceous. Abdomen black, polished, the base more or less greenish, and the incisures of the connexivum slenderly bordered with greenish.

Length to end of abdomen 4.5 mm. To tip of membrane 5 mm. Width of pronotum 1.5-1.75 mm. Described from three specimens, including both sexes, sent to me from Colorado. This species is more robust and less tender than P. obscurus. It also lacks the yellow marking of the scutel, and has the callosities oblique, widely separated, and the collum yellow or greenish."

Steamboat Springs, July 12th, on Solidago, Delphinium occidentale, and other low herbs (Baker).

Plagiognathus obscurus Uhl.

Colorado (Uhler, 1 and 6). West Cliff, Custer County, July 27th (Cockerell, 10).

Fort Collins, September 27th, on Bigelovia (Gillette).

Plagiognathus politus Uhler n. sp.

"Black, narrow, oval, highly polished, the sides of hemelytra but little wider behind than anteriorly. Head short, acute at tip, including the eyes, but little wider than the front of pronotum, base with a pale yellow carina; front moderately convex: tylus wide, prominent; rostrum flavo-piceous, reaching upon the middle coxae; antennae long and slender, black, the basal joint thickest, the second as long as from the front of the eye to the base of the pronotum, the third more slender, about two-thirds the length of the second, pale piceous or yellowish, the fourth equally slender, of the same color as the third, and about one-half the length of the second. Pronotum a little wider than long, faintly wrinkled, with the transverse impression interrupted and faint on the middle continued to a sinus inward from the lateral margin; the lateral margins oblique, turned down, sharply defined, with the interior angles rounded; posterior margin gently curved; the humeral angles subacute. Scutellum convex, a little longer than wide, acute at tip. Femora piceous black, the anterior ones pale at tip, coxae, in part and tibiae testaceous, the spines and their bases black, tip of tarsi piceous. Clavus highly polished, remotely and coarsely punctate and wrinkled; corium more minutely scabrous and obsoletely punctate, very highly polished, the callous linear apex of the inner border testaceous; the membrane dusky brown with the vein pale yellowish. Abdomen black, highly polished, obsoletely scabrous.

Length to end of abdomen 3 mm. Width of pronotum 1.25 mm. Only one specimen, a female, was sent to me from Colorado. A variety with yellow face and a pale lunule at base of the cuneus was collected near Buffalo, N. Y., by Mr. VanDuzee. The type from Colorado has also a faint, very narrow, curved band at base of cuneus."

Fort Collins, July 24th (Baker).

Atomoscelis seriatus Reut.

Fort Collins, September 27th, on Bigelovia (Gillette).

Maurodactylus angulatus Uhler n. sp.

"Mostly pale obscure testaceous above and black beneath, long oval, minutely sericeous pubescent. Head nearly triangular, wider than long, dull black, irregularly testaceous at base, face almost vertical, minutely, sparsely pubescent, feebly convex, not apparently punctate, the occipital edge sharp, nearly straight, not carinate; the tylus narrow, almost acute at tip; rostrum yellow from base to middle, black from thence to tip, reaching to behind the middle coxae, the basal joint reaching to the end of the arched mucro, swollen at tip; the bucculae slender and pale yellow; antennae blackish, moderately stont, reaching as far as to the middle of the venter, the basal joint projecting little beyond the tip of the head, the second joint stout, of uniform thickness throughout, a little longer than the vertex and pronotum, the following joints shorter and more slender. Pronotum short, trapezoidal, transverse, a little polished, impunctate, minutely and remotely pubescent, pale greenish testaceous, almost flat, with an abbreviated black line crossing the line of the callosities, the anterior and posterior margins almost straight, the lateral margins a very little sinuated, the pleural flaps deep, obscure black, bordered with testaceous; pleural and sternal areas black, also partly margined with whitish. Legs including the coxae, greenish yellow, the middle of femora, the spines, and apex of tarsi black. Scutellum dull black, uncovered at base, and with a pale fulvous spot in each basal angle. Hemelytra obscure testaceous, minutely pubescent, placed almost flat, with the costal border a very little curved; clavus dusky towards the tip, corium with a double, long, dusky, widening spot running back to tip, cuneus with a dusky spot near tip; membrane long, pale dusky, darker in the basal cell. Venter polished, black, narrow, with the edges of the segments obscure whitish.

Legth to end of venter 3 mm. To tip of membrane 3.5 mm. Width of pronotum 1 mm. Only one specimen has thus far been brought to my notice. It is a male, and bears some resemblance to Maurodactylus alutaceus Fieber., of Europe."

Steamboat Springs, July 12th (Baker).

Maurodactylus consors Uhler n. sp.

"Form narrow, almost parallel sided on the hemelytra, very slightly pubescent above, black, polished. Head triangular, wider than long, acute at tip; the occipital edge sharp, a little raised at the middle; the face moderately convex, not apparently punctate; eyes prominent, large, placed nearly vertical, set close to the pronotum, dark brown; the tylus prominent, curving beneath; rostrum fulvo-piceous, darker at base and tip, reaching upon the middle coxae; the bucculae pale, narrow; antennae black, long, with the two basal joints stout, the second as long as from the scutellum to inner angle of the corium, the third a little more slender, about three-fourths as long as the second, the fourth scarcely more slender than the third, hardly one-half the length of the third. Pronotum small, moderately convex, a little wider than long, minutely scabrous and a little wrinkled; the anterior lobe short, tumidly elevated, with the impressed line feebly defined; the lateral margins oblique, hardly sinuated; the anterior margin but very little wider than the space between the eyes, with the collum obsolete, and a slight indentation behind its middle; the forward slope of surface moderately steep; humeral angles wrinkled, a little callous and acute. Scutellum widely exposed at base, longer than wide, obsoletely and remotely scabrous, acute at tip. Femora broad, black, yellow at tip, the anterior and middle parts. tibia and the tarsi pale piceous, with the spines black. Clavus obsoletely scabrous; the corium a little more finely so; cuneus separated from the corium by a slender angular pale line; membrane dusky, iridescent, with the base next the cuneus and the looped vein pale. Venter black, short, polished.

Length to end of abdomen 3 mm. To tip of hemelytra 4.5 mm. Width of pronotum 1.25 mm. Only one specimen, a male with long, curved, acute genital hooks, has been sent to me from Colorado"

Leadville, August 23d (Gillette).

Agalliastes apiatus Uhler n. sp.

"Long-oval, polished, dark brown or black, minutely pubescent. Head short, moderately wide, highly polished, with an indented line on the middle, the vertex prominent, and a little triangular at base; front moderately convex, nearly vertical; tylus short, narrow, prominent, black; rostrum slender, testaceous, piceous at tip, reaching to the posterior coxae; antennae dull black, of medium length, the second joint nearly as long as the line from the tip of scutellum to the apex of clavus, the third joint a little shorter and slightly more slender, tapering, the fourth scarcely more than one-third the length of the third, still more slender. Pronotum transverse, polished, minutely pubescent, with a few sparse punctures on a line in front of the low callosities, lateral margins short, oblique, with the edge a little turned down, the collum confined to the middle of the margin, and fading into the raised surface before reaching the line of the eyes; humeral angles prominent, almost acutely callous; the posterior margin almost straight. Scutellum short, almost flat, clothed with pale pubescence, the base usually exposed, sometimes disclosing the yellowish spot at each basal angle. Legs dull yellow, the posterior pair having the femora black, all the tibiae with black spines and dots at base of spines; tarsi piceous at tip. Hemelytra covered with short yellowish pubesence, the clavus wide smoky fuscous; corium with a large fuscous, wedge-shaped spot, closed on the middle, the outer and inner borders and base and tip dull testaceous; the cuneus dusky, bordered all around with dull testaceous; membrane dusky, with the veins, base and sometimes the outer border pale. Abdomen black, polished, with a large greenish spot near the base, and some greenish spots on the pleura.

Length to end of abdomen 2.25-2.5 mm. Width of pronotum 1-1.25 mm. This species inhabits both Colorado and Kansas. It is no doubt quite common, but hitherto only a few less mature specimens have been sent to me for examination. It closely resembles A. apicalis Uhler, of the Atlantic States, but is a more robust and clumsy style of insect."

Fort Collins. June 4th; Manitou, June 25th (Gillette). Steamboat Springs, July 12th and 26th (Baker and Gillette).

Agalliastes associatus Uhl.

Colorado (Uhler, 6). Pueblo (Yarrow—see Uhler, 7). Various parts of Colorado (Uhler, 9).

Fort Collins, July 24th to August 18th; Steamboat Springs, July 12th (Baker). Horsetooth Gulch, May 18th; North Park, July 20th; Trinidad, May 14th; Montrose, June 24th; Glenwood Springs, August 24th (Gillette). Colorado Springs, July (Tucker).

Agalliastes decolor Uhl.

On Redstone Creek, twelve miles south-west of Fort Collins, August 1st (Baker).

Agalliastes fumidus Uhler n. sp.

"Oblong-oval, pale fusco-olivaceous, clouded with smoke brown. Head narrow, polished, almost vertical, black upon the clypeus and tylus, pale greenish above, vertex strongly convex; rostrum pale towards the base, slender, reaching to the middle coxae; antennae dusky testaceous, almost piceous at base, slender, about three-fourths the length of the body, the basal joint short, piceous black, the second fuscous, nearly as long as the head and pronotum united, pubescent, the third and fourth more slender, pale, much shorter than the second, eyes prominent, dark brown, placed diagonally. Pronotum trapezoidal, transverse, bald, polished, moderately convex, pale olivaceo-testaceous, not distinctly punctate, tinged with fuliginous each side anteriorly, the collum lower than the base of the head, a little curved, with a black callous curved transverse line behind its middle; lateral margins a little sinuated, slightly notched at the outer end of the transverse impressed line, the lateral margin acute and reflexed throughout, the humeral angles moderately prominent, pale; posterior margin a little curved. Exposed base of scutellum black in the middle, yellow on either side, the scutellum proper tumid in the middle, sunken and dark at base, pale on the acute apex. Legs smoky testaceous, dark near the tip of upper side of femora, tibiae testaceous with black dots and spines, tarsi blackish; the coxae pale testaceous, the anterior pair with a black dot at base. Hemelytra pale dull testaceous, the clavus entirely and the corium with a large long diagonal spot reaching to the inner angle, two or three faint traces near the outer border, and the middle of the cuneus, smoke brown; membrane smoke brown, the tip, inner border and veins pale testaceous; a geminate pale short line occupies the point next the tip of the cuneus. Abdomen smooth, piceous black, pale pubescent, the venter with a pale greenish spot on the middle and another next the tip.

Length to end of abdomen 3.5 mm. To tip of membrane 4 mm. Width of pronotum 1.25 mm. A single specimen of the male was sent to me from Colorado."

Steamboat Springs, July 15th (Baker).

Agalliastes signatus Uhler n. sp.

"Form closely resembling A. associatus Uhler, black, dull, minutely pubescent. Head short, acute, moderately convex, carinate on the occipital margin; the vertex with a yellow band between the eyes; summit of front indented; tylus prominent, bounded by deep incisions; bucculae and rostrum fulvo-testaceous, the latter reaching to the middle coxae, a little piceous at tip; antennae dull black, stout, tapering, the second joint shorter than the head and pronotum united, the third and fourth together shorter than the second, more slender and pale piceous. Pronotum transverse, feebly convex, pale pubescent, rough in the depressed space between the callosities and behind the anterior margin; middle of the anterior margin carinate; lateral margins oblique and curved down; posterior margin hardly sinuated, a little hollowed each side near the humeri. Scutellum short, subequilateral, apparently impunctate (damaged). Coxae and femora of the anterior and middle legs fulvo-testaceous, with the tibiae paler, and together with the posterior pair having black spines placed on black dots; posterior femora blackish; tips of tarsi piceous. Posterior margin of propleura pale, remainder dull black Clavus dull fuscous, pale pubescent, scabrous: corium obsoletely scabrous, pale pubescent, brown, pale at base and along the costal border, with the inner suture a little paler than the adjoining surface; cuneus fuscous, with a pale band at base, and a small spot at tip; membrane dusky, with the veins pale testaceous. Abdomen black, polished, minutely pubescent.

Length to end of abdomen 2 mm. Width of pronotum .87 mm. The description is derived from a single male specimen sent to me from Colorado. The characters given will no doubt require modification when both sexes are sufficiently studied."

Manitou, June 25th (Gillette).

Agalliastes simplex Uhl.

Steamboat Springs, July 14th (Baker).

Lyctocoris campestris Fab.

Fort Collins, March 2d, under a board (Baker).

Triphleps insidiosus Say.

Suburbs of Denver, August 5th. Doubtless introduced into the west with raspberries, blackberries, and other small fruit (Uhler, 5).

Fort Collins, May 27th to August 22d, and May 18th to June 12th on alfalfa (Gillette and Baker).

Anthocoris antevolens B. White.

Leadville, August 23d; Montrose, June 24th (Gillette).

Anthocoris musculus Say.

Above timber line (Carpenter—see Uhler, 6). On wing and on plants on steep side of mountain in pine woods, Beaver Brook Gulch; also on Clematis, August 6th (Uhler, 5).

Fort Collins, March 24th to April 26th; foot-hills five miles west of Fort Collins, April 20th to August 1st; Cameron Pass at 12,000 feet, July 5th on Salix (Baker). Estes Park, July 12th; Manitou, September 29th, on willow; Dolores, June 1st; Montrose June 24th; Leadville, August 23d (Gillette).

Acanthia hirundinis L.

Dolores, June 18th, common in swallow's nests (Gillette).

Acanthia lectularia L.

West Cliff, Custer County, too frequent (Cockerell, 10).

Fort Collins and Denver (Gillette). Colorado Springs (Tucker).

Piesma cinerea Say.

West Cliff, Custer County, July 27th (Cockerell, 10). Colorado (Gillette—see Osborn, 1).

Fort Collins, March 23d to October 15th, May 7th to June 9th on alfalfa, and August 18th on black walnut (Baker). Manitou, June 25th; Montrose, June 24th; Dolores, June 18th (Gillette). Colorado Springs (Tucker).

Agrammodes Uhler n. gen.

"Form conico-ovoid, similar to a bro d Agramma, but widely different in venation, and having the head formed nearly as in Piesma. Head much narrower than the pronotum and curving down in continuity therewith, the base wide, with the clypeus abruptly narrower, protracted forwards in two slender tapering lobes in advance of the stouter tylus; eyes large, round, seated close against the pronotum. Antennae short, clavate at tip, the basal joint stout, contracted at tip the second very short, moniliform, the third longest and most slender, the fourth shorter, contracted on the basal portion. Rostrum tapering, reaching behind the anterior coxae. Pronotum gently curved, somewhat flattened near the anterior angles and depressed behind them, the anterior submargin inflated into a crescentiform low hood which does not extend to the lateral angles; lateral margin sharp cut, a little diagonal; surface coarsely granulated. Scutellum minute, tumid. Legs short and thick. Hemelytra broad suboval, granulated, coriaceous throughout, with the veins very coarse and prominent; clavus formed of one short triangular areole, bounded exteriorly by a long and moderately narrow areole which is oblique at tip, and from this the inner vein runs back to near the tip and forms an arrest for the two discoidal veins which bound wide triangular areas, and curve inward as they approach this inner vein; the costal area wide, depressed, continued to end of wing-cover, crossed by a few irregular veins, the inner veins are continued across the area which forms a substitute for the membrane."

Agrammodes costatus Uhler n. sp.

"Dull pale greyish-brown, with the pronotal submargin and a large spot on the base of each wing-cover white. Head blackish-brown, unevenly scabrous and granulated, the clypeus prolonged, acute and cleft; antennae honey-yellow, the apical joint piceous black; rostrum and throat rust-brown. Pronotum fuscous, coarsely granulated, narrower than the base of the wing-covers, and somewhat quadrangular in outline, the lateral margins a little reflexed, the posterior margin distinctly curved, anterior angles a little rounded, the anterior margin wider than the breadth across the eyes. Wing-covers pale greyish-yellow, with irregular patches of dark brown granules aggregated more particularly near the base and along the disk; the large pale spots at base angular and tinged with greenish; veins mostly dark brown, very prominent, the area on the apical border pale, crossed by the divaricating inner vein and the one next outside from it, the areoles are continued to near the apex, and the discoidal one is crossed by four oblique veins. Underside rust-brown, obscured by some darker patches, and set with a few small granules, the orifices of the stigmata placed in knobs.

Length to end of hemelytra 2 mm. Width of base of pronotum .75 mm, Only one specimen has been brought to my notice. It is a male sent to me from Colorado. This is the most remarkable form of the family Tingidae which has yet been placed within my reach for study. It is a synthetic type which unites in itself a structure of wing-covers closely related to Oxycarenus, of the family Lygaeidae, and on the other hand, the characteristic head of Piesma and the granular surface of Agramma. Taken in all its features it is the most peculiar form of Tingid which has yet been discovered in North America. The other sex is unknown to me and it might add further characteristics to the genus if once brought to notice."

Estes Park, July 12th (Gillette).

Corythuca arcuata Say.

Colo. (Gillette—see Osborn, 1).

Fort Collins, July 29th (Baker). Foot-hills five miles west of Fort Collins, April 25th to August 1st (Gillette and Baker). Steamboat Springs, July 26th (Gillette).

Corythuca ciliata Say.

Custer County, midalpine (Cockerell, 10).

Fort Collins, May 31st on alfalfa (Baker). Steamboat Springs, July 16th and 26th (Baker and Gillette). Montrose, June 24th (Gillettee).

Corythuca fuscigera Stal.

Fort Colllns, July 2d in all stages on Cnicus; Steamboat Springs, July 15th (Baker). Colorado Springs, August 3d (Gillette).

Gargaphia tiliae Walsh.

Rist Canon, May 29th (Gillette).

Aradus acutus Say.

Colo. (Uhler, 6). Roaring Fork (Rothrock—see Uhler, 2).

Fort Collins, March 31st (Gillette).

Aradus affinis Kirb.

Dolores, June 18th; Estes Park, July 9th (Gillette).

Aradus americanus Fab.

Colo. (Carpenter, 1).

Rist Canon, May 29th (Gillette).

Aradus debilis Uhl.

Colo. (Gillette—see Osborn, 1).

Aradus obliquus Uhl.

Rist Canon, April 9th (Baker).

Aradus rectus Say.

Colo. (Uhler, 1 and 6). From mountains near Beaver Brook Gulch, August 6th (Uhler, 5). Colo. (Gillette—see Osborn 1).

Fort Collins. August 19th; Steamboat Springs, July 26th; Montrose, June 24th; Dolores, June 18th (Gillette).

Aradus tuberculifer Kirb.

Colo. (Uhler, 6). Far up Beaver Brook Gulch, August 6th (Uhler, 5). Near Idaho Springs, July 6th (Packard—see Uhler, 5).

Phymata fasciata Gray

Colo. (Uhler, 1). Widely distributed over the west. Common around foot-hills and on plains wherever land is cultivated. Generally found on stems of Euphorbias and sun-flowers (Uhler, 5). Colo. (Uhler, 8).

Rist Canon, August 10th (C. E. Pennock). Foot-hills five miles west of Fort Collins, September 1st (Gillette). Boulder, September 4th (Baker). Colorado Springs (Tucker).

Coriscus ferus Linn.

Colo. (Uhler, 6). Colorado Springs, June (Yarrow—see Uhler, 7). Southern Colorado June to July (Carpenter—see Uhler, 7). Widely distributed on plains and in mountains and foot-hills, especially in settled portions. In damp situations in Beaver Brook Gulch, Clear Creek Canon, in Denver and around it at the lower levels, in the region of Colorado Springs and Manitou, near Canon City, and in the valley of the Arkansas, it is quite common in August (Uhler, 5). Denver, June 27th (Packard—see Uhler, 5). Ula, Custer County, November 12th; West Cliff (Cockerell, 10). Colo. (Gillette—see Osborn, 1).

Fort Collins, September 27th, on Bigelovia and Rhus trilobata, and October 7th (Baker and Gillette). Colorado Springs, Green Mountain Falls (Tucker).

Coriscus inscriptus Kirb.

Colo. (Uhler, 1). August 14th, Nathrop, Chaffee County (Cockerell, 3). West Cliff, Custer County, July 27th; also subalpine; also in Chaffee, Gunnison, and Pueblo Counties (Cockerell, 10).

Coriscus kalmii Reut.

Fort Collins, April 7th to May 13th, September 14th on Solidago, and September 27th on Solidago and Carex (Baker and Gillette).

Coriscus punctipes Reut.

Mesa County (Cockerell).

Coriscus rufusculus Reut.

Fort Collins, May 27th to August 18th, June 9th on alfalfa, September 2d on Solidago, October 7th on grass; Steamboat Springs, July 12th on Carex (Baker). Colorado Springs, August 3d; Montrose, June 24th; Dolores, June 18th (Gillette).

Coriscus sericans Reut.

Steamboat Springs, July 25th; Rabbit Ears Pass, Routt County, July 20th (Baker).

Coriscus subcoleoptratus Kirb.

Colo. (Uhler, 1 and 6).

Sinea diadema Fab.

Colo. (Uhler, 6). From weeds in suburbs of Denver, August 8th (Uhler, 5).

Foot-hills five miles west of Fort Collins, March 15th to August 11th (Gillette).

Acholla multispinosa DeG.

Colo. (Uhler, 1).

Boulder, September 4th (Baker).

Fitchia nigrovittata Stal.

Colo. (Uhler, 6). Colo. (Gillette—see Osborn, 1).

Common near Fort Collins, and in the adjoining foot-hills, during winter, under stones and boards (Baker and Gillette).

Fitchia spinosula Stal.

Colo. (Uhler, 6).

Repipta taurus Fab.

Southern Colorado (Riley).

Milyas cinctus Fab.

Foot-hills, five miles west of Fort Collins, September 1st

(Gillette).

Diplodus luridus Stal.

Colo. (Uhler, 1 and 6). Colorado Springs, August 10th (Uhler, 5). Manitou and Garden of the Gods, July 13th to 16th (Packard—see Uhler, 5).

Fort Collins, July 4th; foot-hills five miles west of Fort Collins, June 30th (Gillette).

Diplodus socius Uhl.

Estes Park, July 16th (Gillette).

Apiomerus flaviventris H. Schf.

Larva from a bush in Clear Creek Canon, near mouth of Beaver Brook Gulch, August 7th (Uhler, 5). Brown variety on foot-hills at mouth of Clear Creek Canon, July 3d, in Garden of the Gods, and at Manitou, July 13th to 15th (Packard—see Uhler, 5).

Apiomerus pictipes H. Schf.

Foot-hills eight miles south-west of Fort Collins, June 30th to July 12th; Silverton, June 20th (Gillette).

Apiomerus spissipes Say.

Colo. (Uhler, 1 and 6). Valley of Arkansas, near Canon City, August 11th (Uhler, 5). Colo. (Snow—see VanDuzee, 5).

Apiomerus ventralis Say.

Colo. (Gillette—see Osborn, 1). Estes Park (Snow—see VanDuzee, 5).

Fort Collins, May 14th on alfalfa (Baker). Foot-hills five miles west of Fort Collins, March 12th to June 12th; Graymont, July 15th (Gillette).

Pygolampis pectoralis Say.

Fort Collins, April 6th under a board in edge of field (Baker).

Spilalonius geniculatus Stal.

Pueblo (John Lansing).

Hygrotrechus remigis Say.

Colo. (Uhler, 1). Mountains in July (Carpenter—see Uhler, 6). From water on plains of Southern Colorado, June to July (Carpenter—see Uhler, 7). On still water along margin of Sloan's Lake; very abundant on surface of irrigating canal proceeding from Canon of Arkansas, in August (Uhler, 5). Denver, July 10th; Boulder, June 20th; Manitou, July 15th (Packard—see Uhler, 5).

Near Fort Collins and in the adjoining foot-hills, common throughout the summer, especially on water in ditches; during winter hibernates under stones, rubbish, etc. (Baker). Dolores, June 16th (Gillette).

Limnotrechus marginatus Say.

On surface of puddles in western suburbs of Denver in August (Uhler, 5). Near Manitou, July 15th (Packard—see Uhler, 5). Common on Grape Creek, West Cliff, Custer County, May 25th (Cockerell, 10).

Limnotrechus productus Uhler n. sp.

"Larger and somewhat more robust than L. marginatus Say. with long, somewhat flattened, anal processes of a yellow color forming the prolonged ends of the flat, broad connexivum, and is of the same color as the last three segments. Color of the upper surface dark brown with a tinge of fuscous on the pronotum. Head of medium length, fuscous, covered with silvery, scaly pubescence on the lower sides and beneath. The antennae short and stout, rusty brown, the second and third joints a little thicker and darker at tip, the second shorter than the apical, but longer than the third, the basal one a little longer than the superior line of head, the fourth a little shorter, dark in color and tapering towards the tip. Rostrum swollen at base, reaching a little behind the anterior coxae, with the tip black. Pronotum with the anterior lobe quadrangular and flat, a very little shorter than wide, the anterior border a little thickened and raised, the middle line behind this depressed and marked with a short, yellow stripe, the posterior lobe evenly rounded off, a little flattened, destitute of a carinate line, lateral margins narrowly yellow; underside all silvery white. Legs of medium length, pale rusty beneath, the posterior femora as long as from the base of posterior coxae to the end of venter. Veins of corium prominent, two of the oval medio-apical areoles pale. Sutures of connexivum pale, outer half of the connexivum of the last three ventral segments including most of the segments themselves and the cerci, yellow, the middle line of venter with four indented spots.

Length to end of anal segment 10 mm. Width of pronotum 2 mm. A single female was sent to me from Colorado."

Fort Collins, April 13th (Gillette).

Limnoporus rufoscutellatus Latr.

From stagnant water above the Rio Grande (Rothrock—see Uhler, 2). Mountains, July (Carpenter—see Uhler, 6). Seems to be common in Colorado, where it attains to full proportions, and puts on its clearest russet-brown coat (Uhler, 6). On surface of small ponds and puddles in depressions of plains west of Denver, August 8th and later (Uhler, 5). Denver, July 28th (Packard —see Uhler, 5).

Hebrus concinnus Uhl.

Fort Collins, April 7th to October 15th (Baker).

Hebrus sobrinus Uhl.

On margins of ponds west of Denver (Uhler, 5).

Microvelia americana Uhler n. sp.

"Dark brown, velvety above, more or less powdered with plumbeous, body a little tapering behind the curved base of sides. Head short, triangular before the eyes, margined with silvery, prostrate pubescence from behind the eyes and along their inner border forward to the cheeks; the throat testaceous; middle line of head obsoletely callous-carinate; rostrum testaceous, piceous at base and tip, reaching to the posterior line of the anterior coxae; antennae slender, obscure testaceous, darker on the tip of the first and second joints, the second joint shortest, the third and fourth much more slender, the fourth a little longer than the third. Pronotum triangular both before and behind the humeral angles, the anterior division very slightly sinuated on the sides, feebly notched at the end of the scutellum behind the anterior lobe; collum distinct, with an orange band on the middle; the surface rugulose and punctate behind this; the lateral and posterior margin orange, the tip a little rounded; the humeral angles moderately subacute, with the edge a little callous Pleural pieces bordered with rufo-testaceous; the coxae, trochanters, border of sternum, and legs yellowish-testaceous, with the femora, tibiae and tarsi dusky or piceous above. Scutellum fuscous, almost completely concealed beneath the projecting pronotum. Hemelytra pale smoke-brown, narrower than the abdomen, with the veins darker, and a short streak at base of corium pale yellowish. Tergum rufous along the middle, blackish exterior to this; the connexivum both above and below, orange interrupted with black. The underside dull black with a tinge of plumbeous, a little sericeous, the posterior segments rufous on the middle, and the genital segment yellow.

Length to tip of venter 3 mm. Width of pronotum 1.25 mm. This is a common species in Maryland, and is also found in North Carolina. It has also been collected in Colorado, and in the vicinity of San Diego, California. In Maryland it occurs on the borders of small streams during summer, and is occasionly found full-winged in the month of June. The male is narrower and more wedge-shaped posteriorly than the female."

Foot-hills five miles west of Fort Collins, March 12th to April 21st (Gillette).

Macrovelia hornii Uhl.

Fort Collins, April 14th; Rist Canon, April 9th (Baker).

Salda coriacea Uhl.

Denver (B. H. Smith—see Uhler, 5).

Salda dispersa Uhl.

Comparatively abundant in various places west of Denver (Uhler, 9).

Salda humilis Say.

West Cliff, Custer County, July 31st (Cockerell, 10).

Salda interstitialis Say.

Roaring Fork (Rothrock—see Uhler, 2). Colorado (Uhler, 6). Ula, Custer County, November 12th (Cockerell, 10).

Fort Collins, August 27th; foot-hills five miles west of Fort Collins, March 12th to April 9th; Estes Park, July 12th (Gillette).

Salda pallipes Fab.

In western suburbs of Denver may be found in untold numbers on dark, damp, sandy and muddy soil, during August. Also near stream in Beaver Brook Gulch, and in Clear Creek Canon (Uhler, 5). Georgetown, July 8th, 9,500 feet (Packard—see Uhler, 5).

Colorado Springs, July (Tucker).

Galgulus oculatus Fab.

Colorado (Gillette—see Osborn, 1).

Boulder, September 4th; Fort Collins (Baker).

Ambrysus signoretii Stal.

Fort Collins, August 11th (Baker).

Zaitha micrantula Stal.

Fort Collins, August 27th (Gillette).

Belostoma americanum Leidy.

Occasional about electric lights at Fort Collins (Baker).

Belostoma annulipes H. Schf.

Pagosa, September 5th (Yarrow—see Uhler, 7).

Ranatra quadridentata Stal.

Fort Collins, August 27th (Gillette).

Notonecta insulata Kirb.

Mountains, July (Carpenter—see Uhler, 6). Quite common in several pools of water standing in hollows near bed of creek on outskirts of Denver, August 4th and 5th (Uhler, 5).

Fort Collins, August 27th (Gillete).

Notonecta mexicana A. and S. Det. by Osborn.

Fort Collins (Gillette).

Notonecta undulata ***Say.***

In several pools of water standing in hollows near bed of creek on outskirts of Denver, August 4th and 5th. Not so common as N. insulata (Uhler, 5). Larva, nymph and imago from Sloan's Lake, west of Denver, July 10th (Packard—see Uhler, 5).

Fort Collins, August 27th; foot-hills five miles west of Fort Collins, April 20th (Gillette).

Corisa calva Say.

Fort Collins, August 27th (Gillette).

Corisa expleta Uhler n. sp.

"Olivaceo-fuscous above, form of C. alternata Say. Head strongly and bluntly carinate above, the carina produced posteriorly on the base of the vertex; face moderately convex, a little peaked above in front of the blunt carina, marked with a line of punctures each side, a little hollowed beneath the eyes, and with a few shallow punctures there as well as towards the front; clypeus depressed, covered with long coarse, white bristles. Pronotum subcordate, wider than long, convex, obsoletely and minutely rastrated, with the transverse bands bounded in part by scratched lines, the black bands slender, bent anteriorly, about thirteen in number, the lateral margin and anterior angles broadly yellow, the middle behind the produced occiput marked with a short carina, the apex of posterior margin obliquely curved. Palae of female moderately slender, long, cultrate, strongly curved, subacute, with long bristles, the trochanter stout and moderately long, the coxae long, stout, compressed inwardly and growing wider towards the base. Clavus finely rastrate, crossed by slender yellow lines, those of the base nearly straight, of the middle broken and irregular, of the posterior third waved; yellow lines of the corium very short, wavy or irregularly sigmoid, beginning at base in two widely separated series and continued towards tip in about five, partly broken series; marks of the membrane short, uneven, sigmoid or irregularly waved; the embolium (sic Fieber) is broad, whitish, marked at base with a streak, with an oblique stripe on the cross vein, a spot some distance before the tip and another at the tip, black. Beneath whitish yellow; tergum black, excepting the lateral border and tip, which are yellowish.

Length to end of abdomen 7-8 mm. Width of pronotum 2.25-2.75 mm. Two specimens, females, were sent to me from Colorado. A closely related species occurs in Texas and California, but my series of them is too imperfect to afford accurate deductions. The male is a desideratum."

Fort Collins, June 25th at light (Baker). Spring Canon, April 21st (Gillette).

Corisa inscripta Uhl.

Southern Colorado (Uhler, 8).

Corisa interrupta Say.

Sloan's Lake, west of Denver, August (Uhler, 5); same place in July (Packard—see Uhler, 5).

Corisa striata L.

Fort Collins, June 13th (Baker).

Corisa sutilis Uhl.

Mountains, July to September (Carpenter—see Uhler, 6), Sloan's Lake, west of Denver, August 5th (Uhler, 5). Common in the mountains of Colorado (Uhler, 9).

Corisa tumida Uhl.

Sloan's Lake west of Denver, July 10th (Packard—see Uhler, 5). Sloan's Lake, in August, and also in several pools of water on the low grounds of suburbs of Denver, August 5th and 8th (Uhler, 5).

Colorado Springs, August (Tucker).

Cicada dorsata Say.

Colorado (Thomas—see (Uhler, 6).

Cidada marginata Say. Det. Baker.

Canon City, August 31st (Gillette).

Cicada tibicen L.

Mountains of Colorado (Uhler, 6).

Proarna valvata Uhl.

Canon City, July 3d (Riley).

Tibicen synodica Say.

Common in eastern Colorado (Thomas and B. H. Smith—see Uhler, 6). Near Canon City, August 11th (Uhler, 5). Southern Colorado, June to July

(Carpenter--see Uhler, 7). Denver and Boulder (Putnam, 4).

Fort Collins, June 21st (Baker), and July 5th (Gillette). Manitou Park (Snow).

Tibicen rimosa Say.

Southern Colorado, June to July (Carpenter—see Uhler, 7). Near Denver (Thomas—see Uhler, 6). On Clear Creek at Floyd's Hill (Putnam, 4).

Spring Canon, July 4th (Gillette).

Tibicen cruentifera Uhl.

Colorado (Riley).

Platypedia putnami Uhl.

Clear Creek Canon (Uhler, 4). Near Clear Creek (Putnam—see Uhler, 5). On Clear Creek, near Floyd's Hill (Putnam, 4).

Horsetooth Gulch, May 18th; Rist Canon, May 29th; Howe's Gulch, June 14th (Gillette).

Melampsalta parvula Say.

Colorado (Snow).

Publilia modesta Uhl.

(*Publilia bicinctura* Godg. Ent. News, III, p. 200.

Colo. (Thomas—see Uhler, 6). Clear Creek Canon, August 6th; Colorado Springs and Manitou, August 17th, west of Denver, August 18th; Pueblo, August 10th (Uhler, 5). Cusack Ranch, Custer County, on Gymnolomia multiflora (Cockerell, 10). Fort Collins, June and August, on Glycyrrhiza lepidota (Gillette—see Goding, 2).

Foot-hills five miles west of Fort Collins, May 18th to September 1st (Gillette). Fort Collins, May 29th to October 7th on Solidago, Glycyrrhiza lepidota, alfalfa. Helianthus, Iva xanthiifolia, and Artemisia; Steamboat Springs, July 15th (Baker). Colorado Springs, August (Tucker).

Goding's bicinctura must be referred to this species. We have every gradation between the two, and also forms varying to a uniform deep chocolate. Furthermore, we have reared them in abundance together on the same food-plants from nymphs which were indistinguishable. Dr. Uhler, to whom we sent a complete series, corroborates the reference and states that he was previously acquainted with all the forms.

Ceresa bubalus Fab. Det. Goding.

Near Pueblo (Yarrow—see Uhler, 7). Met with at every place affording sufficient moisture for growth of willows. In Denver found on many weeds in low places as well as willows. Also found at Canon City and in Clear Creek Canon (Uhler, 5). Near Eagle River in August, and in other parts of Colorado, June to September (Carpenter—see Uhler, 6). Colorado (Riley—see Goding, 3).

Colorado Springs (Tucker). Glenwood Springs, August 24th; Canon City, August 31st; Fort Collins, September 27th on Solidago spectabilis and Aster canescens, September 31st female depositing eggs in apple twigs (Gillette). Fort Collins, July 24th on Apocynum androsaemifolium, August 4th on alfalfa, August 11th very abundant on Glycrrhiza lepidota (Baker). Specimens of apple twigs with egg punctures have been received from several parts of the state, including Rocky Ford, Arvada and Windsor, From the last lot, which were placed in a breeding cage, there emerged on May 19th, numerous specimens of Cosmocoma howardii Ash. (determined by Ashmead). We have often found the imago infested with a minute red mite, Eupalpus echinatus Bks. (determined by Banks). Soft maple twigs in the vicinity of Fort Collins are also considerably infested with the eggs of this insect.

Ceresa turbida Godg. Det. Goding.

Colorado (Gillette—see Goding, 3).

Steamboat Springs, July 26th; The Rustic, Larimer County, August 11th (Gillette).

Ceresa diceros Say.

Colorado Springs (Tucker).

Stictocephala festina Say.

Colorado (Riley—see Goding, 3).

Stictocephala franciscana Stal.

Steamboat Springs (Gillette—see Goding, 3).

Steamboat Springs, July 26th; Rist Canon, July 30th (Gillette).

Stictocephala gillettei Godg. Det. Goding.

Colorado (Gillette—see Goding, 1 and 3). Trinidad, May 14th (Gillette—see Goding, 2).

Fort Collins, July 29th, on Psoralea tenuiflora; Four-mile

Hill eight miles south of Steamboat Springs, July 15th (Baker).

Stictocephala inermis Fab. Det. Goding.

Steamboat Springs, July 26th (Gillette).

Stictocephala viridis Godg. Det. Goding.

Rist Canon, May 29th (Gillette)

Thelia univittata Harr. Det. Goding.

Routt Co. (Gillette—see Goding, 3).

Steamboat Springs, July 26th (Gillette).

Telamona monticola Fabr.

Colorado (Goding, 3).

Telamona pyramidata Uhl. Det. Goding.

Southern Colorado, June to July (Carpenter—see Uhler, 7). Southern Colorado (Uhler—see Goding, 3). Colorado (Snow—see VanDuzee, 5).

Fort Collins, July 20th on cottonwood, and August 14th on Virginia Creeper (Baker). Colorado Springs, July 27th on cottonwood (Gillette).

Telamona querci Fitch.

Colorado (Carpenter—see Uhler, 6).

Telamona reclivata Fitch. Det. Goding.

Colorado (Baker—see Goding, 3).

Fort Collins (Baker).

Heliria scalaris Fm. Det. Goding.

Fort Collins, July 4th (Gillette—see Goding, 2). Colorado (Baker—see Goding, 3).

Fort Collins, July 5th (Baker). La Veta, July 4th (E. A. Schwarz).

Acutalis calva Say.

Colorado (Riley—see Goding, 3).

Cyrtolobus fenestratus Fitch.

Colorado (Thomas—see Uhler, 6). Manitou, on small oak trees, August 16th (Uhler, 5). Colorado (Uhler—see Goding, 3).

Cyrtolobus vau Say. Det. Goding.

Colorado (Gillette—see Goding, 3).

Manitou, June 25th; Montrose, June 24th (Gillette).

Steamboat Springs, July 12th (Baker). Garden of the Gods; Green Mountain Falls (Tucker).

Vanduzea arquata Say. Det. VanDuzee.

Colorado (Gillette—see Goding, 3).

Dixon's Canon, five miles west of Fort Collins, September 1st (Gillette).

Vanduzea vestita Godg.

Colorado (Goding, 3).

Campylenchia curvata Fab. Det. Goding.

Eagle River, August 29th (Carpenter—see Uhler, 6). Near Boulder, June 29th (Packard—see Uhler, 5). Denver, near Golden, near Colorado Springs, on small plants in low ground, and also in the valley of the Arkansas near Canon City in August (Uhler, 5). Colorado (Riley—see Goding, 3).

Steamboat Springs, July 26th; Rist Canon, August 8th; Dixon's Canon, September 1st; Estes Park, July 12th (Gillette). Fort Collins, August 11th on Glycyrrhiza lepidota, July 24th on Psoralea tenuiflora and Apocynum androsaemifolium; Steamboat Springs, July 15th (Baker). Colorado Springs (Tucker).

Scolops angustatus Uhl. Det. Osborn.

The Rustic, Larimer County, August 11th (Gillette).

Scolops grossus Uhl. Det. VanDuzee.

Fort Collins, July 24th to August 18th (Baker).

Scolops hesperius Uhl.

Southern Colorado (Thomas—see Uhler, 6). Denver (Smith—see Uhler, 6).

Scolops sulcipes Say Det. Osborn.

On low ground, in suburbs of Denver, August 18th (Uhler, 5). Colorado (Uhler, 6).

Denver, July 21st (Gillette). Fort Collins, July 24th to August 18th (Baker). Colorado Springs (Tucker).

Cixius stigmatus Say. Det. VanDuzee.

Colorado (Uhler, 6).

Lamar, May 7th (Gillette). Big Narrows of Poudre River, Larimer County, July 9th on Bigelovia; Steamboat Springs, July 14th (Baker). Colorado Springs (Tucker).

Cixius vicarius Walk.

Swept from weeds in west Denver, August 5th (Uhler, 5).

Oliarus franciscanus Stal. Det. VanDuzee.

Montrose, June 24th (Gillette).

Helicoptera floridae Walk. Det. VanDuzee.

Dolores, June 16th (Gillette).

Pissonotus pallipes VanD. Det. VanDuzee.

Fort Collins, August 25th (Gillette).

Stenocranus dorsalis Fitch. Det. Osborn.

Foot-hills five miles west of Fort Collins, April 25th; Fort Collins, September 27th on Carex; Dolores, June 18th (Gillette). Fort Collins, May 18th on alfalfa; Steamboat Springs, July 12th on Carex (Baker).

Conomelus tricarinatus Say. Det. VanDuzee.

Manitou, June 25th; Montrose, June 24th; Glenwood Springs, August 24th (Gillette). Steamboat Springs, July 14th (Baker).

Myndus impunctatus Fitch. Det. VanDuzee.

Montrose, June 24th (Gillette).

Myndus n. sp. Det. VanDuzee.

Manitou, July (Tucker). Mr. VanDuzee says, "Differs from all the species I know by the lunate pale area on the front."

Delphacinus obesus VanD, Det. VanDuzee

Fort Collins, May 8th (Gillette).

Delphacinus zonatus VanD. Det. VanDuzee.

Manitou, June 25th; Montrose, June 24th (Gillette).

Delphacinus vittatus VanD. Det. VanDuzee.

Dolores, June 18th (Gillette).

Liburnia consimilis VanD. Det. VanDuzee.

Lamar, May 7th; Dolores, June 18th (Gillette).

Liburnia gillettei Van D. Det. VanDuzee.

Lamar, May 7th; Dolores, June 18th; Estes Park, July 12th (Gillette).

Lamenia californica VanD. Det. VanDuzee.

Montrose, June 24th (Gillette).

Tylana ustulata Uhl.

Colorado (Uhler, 6).

Bruchomorpha oculata Newm. Det. VanDuzee.

Colorado (Uhler. 6).

Steamboat Springs, July 26th (Gillette).

Bruchomorpha pallidipes Stal.

Swept from plants on plains near Colorado Springs, August 13th (Uhler, 5).

Colorado Springs, August (Tucker).

Stiroma inconspicua Uhl.

Moderately abundant on small bushes in Clear Creek Canon, August 6th (Uhler, 5).

Philaenus abjectus Uhl.

Colorado (Thomas—see Uhler, 6).

Philaenus lineatus L. Det. VanDuzee.

In foot-hills near Golden, August 5th. Doubtless widely distributed through the mountain region of Colorado (Uhler, 5). Hills and high mountains (Carpenter—see Uhler, 6). Colorado (Thomas—see Uhler, 6).

North Park, July 20th; Gore Pass, July 29th; Steamboat Springs, July 26th; Estes Park, July 16th (Gillette). La Veta, July 4th (E. A. Schwarz).

Clastoptera binotata Uhl. VanDuzee.

Steamboat Springs, July 26th; Leadville, August 23d (Gillette). Steamboat Springs, July 12th on Artemisia tridentata (Baker).

Clastoptera delicata Uhl. Det. VanDuzee.

Near Colorado Springs, sweeping rank growths of plants in damp ground, August 16th (Uhler, 5). Colo. (Thomas and Smith—see Uhler, 6).

Steamboat Springs, July 26th (Gillette).

Clastoptera obtusa Say. Det. Osborn.

Beaver Creek, Larimer County, August (Gillette). Fort Collins, July 19th (R. C. Stephenson).

Clastoptera osborni n. sp.*

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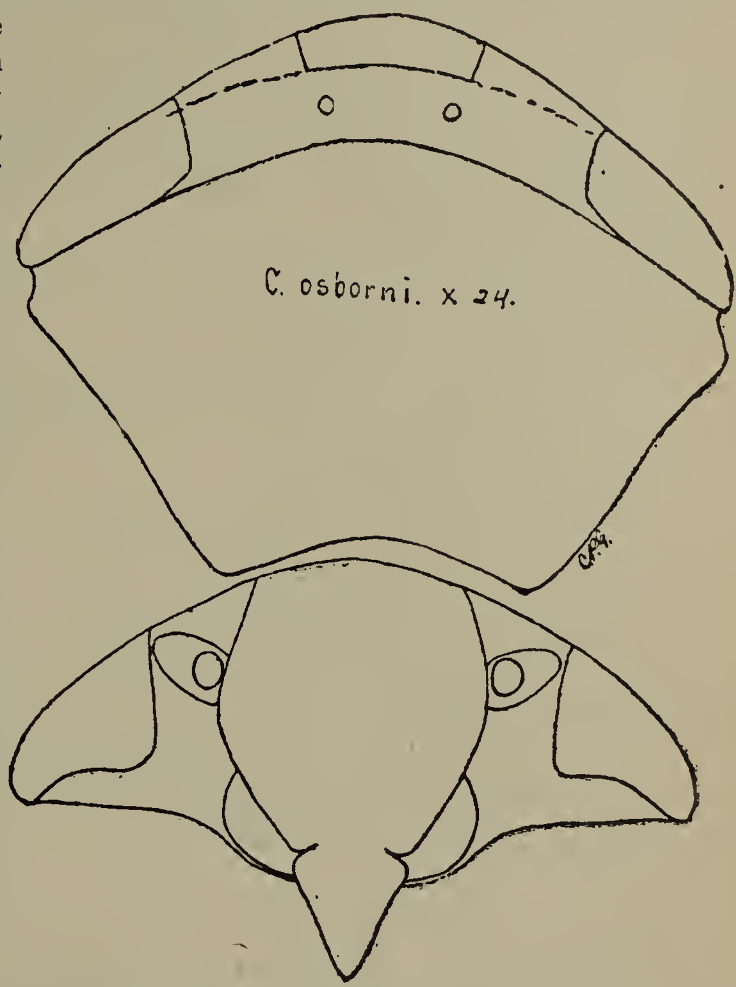
*All the illustrations are magnified 22 diameters unless otherwise marked.

Female: Face two-thirds wider than long, minutely, indistinctly sculptured; clypeus broad at base, gradually tapering to the pointed apex, one-fifth longer than broad, basal suture obsolete: lorae long, nearly as long and half as broad as clypeus; genae narrow, outer margin concave beneath eyes, convex below the lorae where they are very narrow, touching the clypeus at the broadest part; front but little longer than broad, superiorly very broadly and evenly rounded. Vertex very slightly transversely depressed, anterior margin carinately elevated, not longer at middle than at eyes. Pronotum transversely wrinkled, minutely scabrous, two distinct pits behind anterior margin near the median line, thee-fourths wider than long, anterior curvature three-eights of length. Scutellum finely and transversely wrinkled and minutely scabrous, longer than head and pronotum, twice longer than wide. Elytra with a fine, thickly set, golden pubescence, entirely finely, densely punctured. Color pale rufous throughout, tinged with olive green on pronotum and clavus, beneath more yellowish.



Length 5.5 mm. Described from two females. Large, but somewhat narrower across the hemelytra than is u ual in this genus.

Manitou, July 24th on oak (Gillette). Cheyenne Canon, Colorado Springs, July (Tucker).

Lepyronia angulifera Uhl. Det. VanDuzee.

Howe's Gulch, June 14th and September 1st (Gillette).

Lepyronia quadrangularis Say. Det. VanDuzee.

Canon City, and the irrigated region west of Denver, August 6th to 17th (Uhler, 5). Colorado (VanDuzee, 6).

Fort Collins, September 27th on Solidago, Clematis ligusticifolia, and Carex (Gillette). Fort Collins, August 26th to September 14th, on Solidago (Baker).

Aphrophora permutata Uhl.

Colorado (Uhler, 6). Colorado (Snow—see VanDuzee, 5).

Manitou Park (Snow).

Pachyopsis laetus Uhl.

At Manitou and near Canon City, upon small bushes near water August 11th to 16th (Uhler, 5). Custer County, midalpine (Cockerell, 10). Colorado (Snow—see VanDuzee, 5). Colorado (VanDuzee, 4).

Pachyopsis robustus Uhl. Det. VanDuzee.

Colorado (VanDuzee, 4).

Dolores, June 18th; Estes Park, July 10th; North Park, July 20th; Steamboat Springs, July 26th; Fort Collins, September 27th on Bigelovia (Gillette). Mountains southwest of North Park, on Grizzly Creek, July 10th on Artemisia tridentata (Baker).

Bythoscopus fenestratus Fitch. Det. Osborn.

Estes Park, July 12th (Gillette).

Bythoscopus pruni Prov. Det. Osborn.

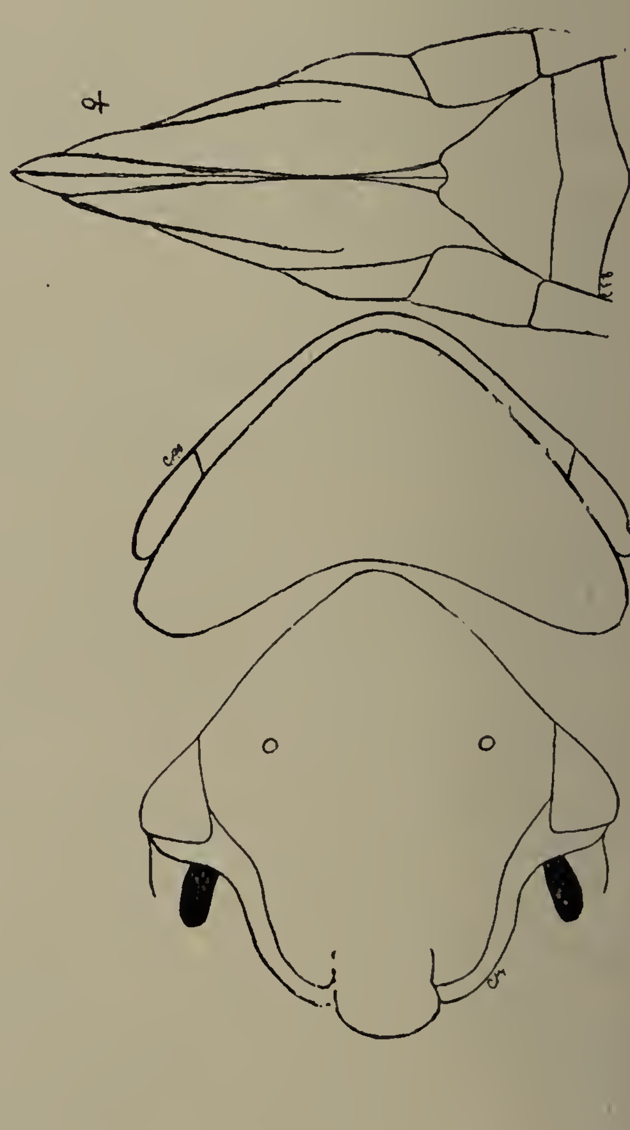
Mountains of Colorado (VanDuzee, 4).

The Rustic, Larimer County, August 11th (Gillette).

Pediopsis bifasciata VanD.

Steamboat Springs, July 15th on willow (Baker). Montrose. June 24th (Gillette).

Pediopsis erythrocephala n. sp.



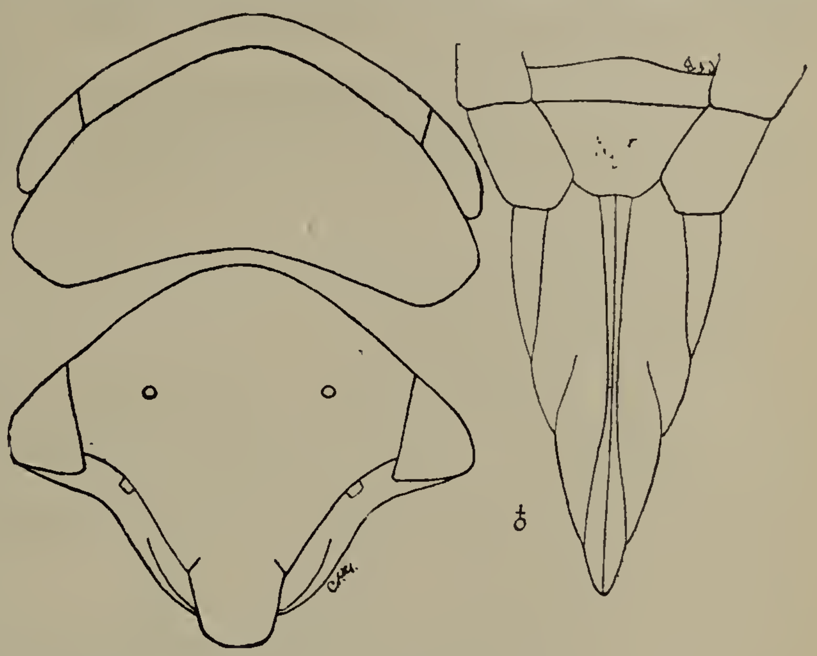
Female: Large and robust. Face nearly as long as wide; clypeus short and broad, suddenly broadened and widely depressed before the rounded apex, sides parallel on basal two-thirds; front slightly constricted before antennae, rapidly narrowing towards clypeus. Clypeus, face, vertex, pronotum, and scutellum, feebly rugose. Vertex one-third longer at eyes than at middle, width between eyes nearly twenty times length at middle. Pronotum little more than twice wider than long, curvature nearly the entire length. Last ventral segment with hind margin distinctly notched. Head. pronotum, and scutellum dull red, concolorous. Elytra hyaline. Abdomen greenish. Eyes reddish brown. Legs greenish shading into reddish towards base. Propleura with a large black spot.

Length 6 mm. Described from two females.

Fort Collins, August 11th (Baker). Colorado Springs, August (Tucker).

Pediopsis fumipennis n. sp.

Female: Form of bifasciata. Face little more than one-sixth wider than long; clypeus short and broad, suddenly broadened and widely depressed before the rounded apex, sides nearly parallel on basal two-thirds, but slightly broadening towards base; front slightly constricted before antennae, rapidly narrowing towards clypeus. Front and vertex finely rugose, with scattered inconspicuous punctures. Vertex one-fifth longer at eyes than at middle, width between eyes nearly eleven times length at middle. Pronotum two and one-fourth times wider than long, curvature three-fourths of length, sculpturing like that of front but coarser. Scutellum finely rugose, basal angles shagreened. Last ventral segment with hind margin slightly emarginate. Head, pronotum, legs and venter green, or yellowish green. Elytra deep smoky brown, costal margin greenish. Propleura without a black spot. Valves of ovipositor yellow at base, green at tip.



Length 5.5 mm. Described from one female.

Steamboat Springs, July 15th (Baker).

Pediopsis sordida VanD. Det. VanDuzee.

Colo. (VanDuzee, 4).

Estes Park, July 12th; North Park, July 20th; Steamboat Springs, July 26th; Gore Pass, July 29th (Gillette). Steamboat Springs, July 15th on willow (Baker).

Pediopsis viridis Fitch.

Canon City; Clear Creek Canon, on willow (Uhler, 5). Colorado (Uhler—see VanDuzee, 1). Colorado (VanDuzee, 4).

Dolores, June 18th (Gillette). Fort Collins, August 11th; Steamboat Springs, July 15th on willow (Baker). Colorado Springs, August (Tucker). Some slightly smaller, more yellowish specimens from Montrose, June 24th (Gillette), we had considered distinct, but aside from these differences there are no characters on which they can be separated.

Idiocerus alternatus Fitch.

Colorado (VanDuzee, 4). West Cliff, Custer County, July 31st; also high alpine (Cockerell, 10).

Spring Canon, May 11th; Horsetooth Gulch, April 21st to May 18th; Rist Canon, June 12th; Fort Collins, June 14th; Estes Park, July 12th; Steamboat Springs, July 26th; Leadville, August 23d; Trinidad, May 14th; Montrose, June 24th (Gillette). Fort Collins, October 7th; Dixon's Canon, May 6th; Steamboat Springs, July 15th, on willow (Baker).

A common species everywhere. There seems to be considerable variation in the form of the last ventral segment in the female.

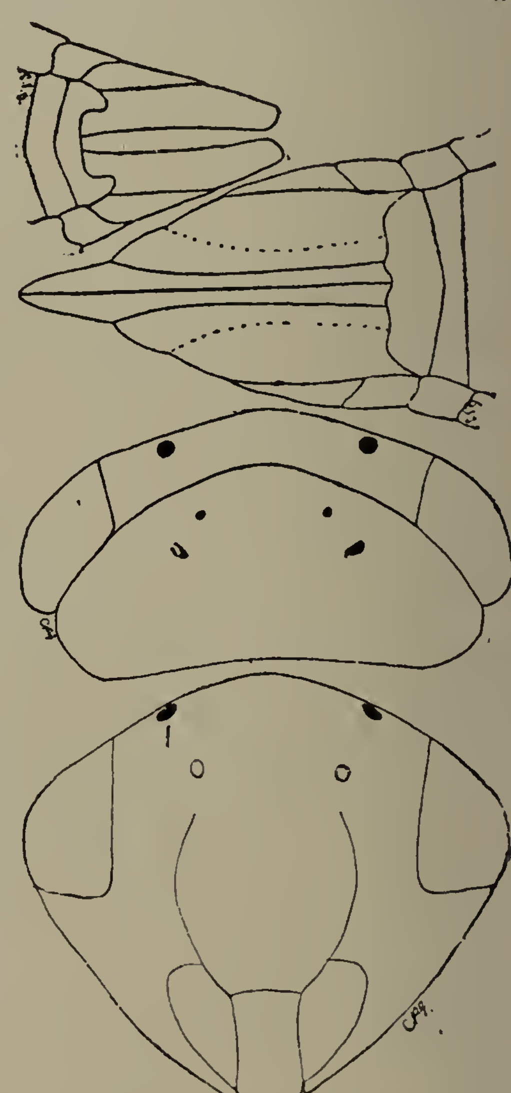
Idiocerus amoenus VanD. Det. VanDuzee.

Colorado (VanDuzee, 4).

Horsetooth Mountain, July 4th; Steamboat Springs, July 26th; Montrose, June 24th (Gillette). On Red Stone Creek twelve miles south-west of Fort Collins, August 1st (Baker).

Idiocerus interruptus n. sp.

Female; Face about a ninth wider than long; clypeus one-half longer than broad, gradually broader towards the almost truncate apex, basal suture straight; lorae a little longer and almost as broad as the clypeus; genae rather narrow, the outer margins straight, attaining tip of clypeus, moderately broad below the lorae; front one-fourth longer than broad and nearly three times as long as the clypeus. Face, pronotum and scutellum finely shagreened. Vertex finely, transversely wrinkled, about one-fourth longer at the eyes than at the middle, distance between the eyes a little less than five and a half times the length at the middle. Pronotum a little more than twice as broad as long, and three and a half times the length of the vertex; the curvature a little more than two-thirds the length of the pronotum; transverse groove of scutellum angularly bent forward and obsolete at the center, appearing as two oblique lunate depressions. Last ventral segment with the hind margin shallowly notched and the posterior angles obliquely cut off. Color pale yellow marked with brown and black; face mottled above with brown; eyes brown. Vertex brown with a yellowish white line next the eyes, and a median longitudinal white line, and a small black spot on either side. Pronotum brown with a broad median longitudinal white band, anterior margin whitish with about four small blackish spots on either side; scutellum whitish with a large black spot just within the basal angles on either side; a median brown line between base and transverse groove, forked beyond and extending nearly to the tip; a small black spot on either side just before the ends of the transverse groove. Elytra whitish subhyaline, with an oblique brown band on the middle extending down and forward, veins brown interrupted with white, a large white spot on the middle of the clavus, with a smoky spot in front and another on the tip; all beneath unicolorous, legs slightly washed with rufous, propleura with a black spot. Length 5 mm.

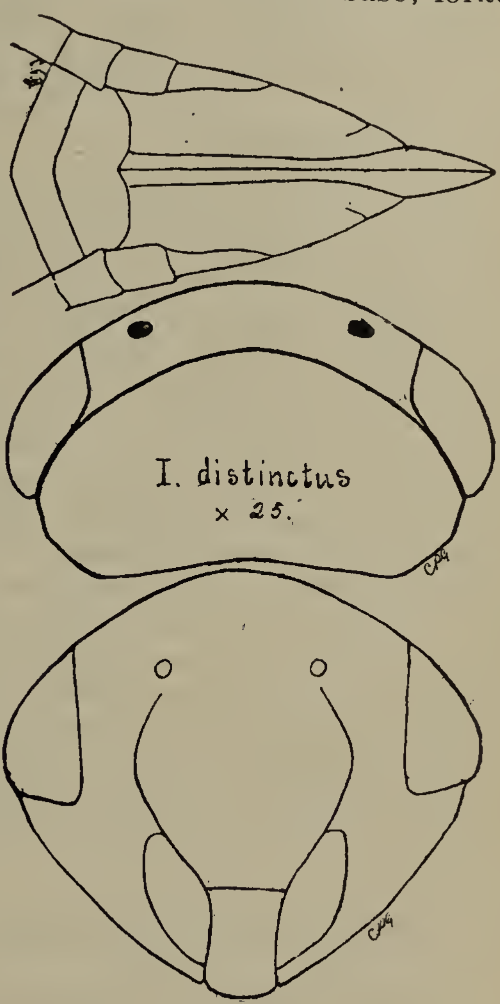


Male: Differs from female as follows: Below deeper yellow, white lines next the compound eyes obsolete, other light marking on the vertex and pronotum yellowish, most of the dark markings darker; front margin of anterior coxae with a large black spot, and narrow black lines on the outer sides of all the tibiae; compound eyes jet black; black

spots on propleura much larger. Length 4.75 mm.
Described from two females and one male.

Idiocerus distinctus n. sp. *

Female: Form that of a small and slender alternatus. Face a little less than one-eighth wider than long; clypeus two-fifths longer than broad, broadest at base; lorae a little longer than clypeus, and two-thirds as broad; genae rather deeply depressed beneath the eyes, lateral margins nearly straight, attaining the tip of the clypeus and broad beneath the lorae. Front but little longer than broad, two times as long as the clypeus, rapidly narrowing below the antennae; face rather coarsely shagreened. Vertex finely transversely wrinkled, length at the middle the same as at the eyes, width between eyes a little less than five times the length at the middle, apex very broadly rounded. Pronotum two times as broad as long, three times as long as vertex, curvature little more than two-thirds of the length; slightly concave behind; disc finely transversely shagreened, transverse groove as in interruptus. Last ventral segment with the hind margin broadly rounded, notched at the center, posterior angles rounded. Color brown and white above, yellowish beneath. Face and vertex pale yellow washed with pale rufous. Vertex with small round black spots on crest. Pronotum pale brown with about eight or ten small pale bluish spots. Scutellum rufous, dark near the posterior angles, with two small spots on the disc, and the apex pale. Elytra white next to scutellum and at tip of clavus deep smoky; two or three lines on the nervures below tip of clavus, and nervures at tip of corium, blackish. Venter yellow. Legs pale yellow, concolorous.



Length 4.75 mm. Described from one female.

Steamboat Springs, July 15th on willow (Baker).

Fort Collins, September 26th on elm (Baker), and September on grass (Gillette).

Variety A. We have a single female, identical in all respects with this species except that it is strongly suffused

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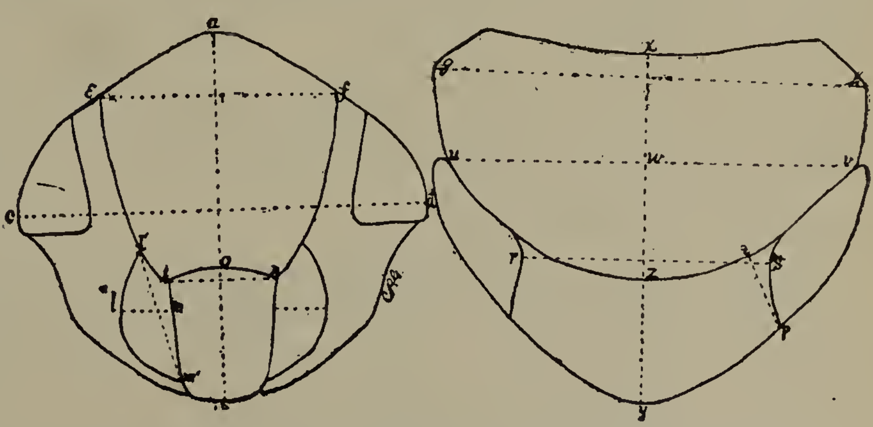


*The lines drawn on the accompanying figure indicate where the measurements which are given in these descriptions are made. For example, a-b would be the length and c-d the breadth of the face; a-o the length and e-f the breadth of the front, &c. The width of the clypeus is always taken at its base, and the width of the lorae where they are widest measured at right angles to the median line of the front. By length of vertex at the eye, we mean the shortest distance across the vertex at this point. By curvature is meant the distance w-z. The width of the front is always given where it is greatest. In Idiocerus the length of the front is taken from base of clypeus to the ocelli.

with rufous throughout and has no black on the propleura. Colorado Springs, August 3d (Gillette).

Idiocerus lachrymalis Fitch. Det. VanDuzee.

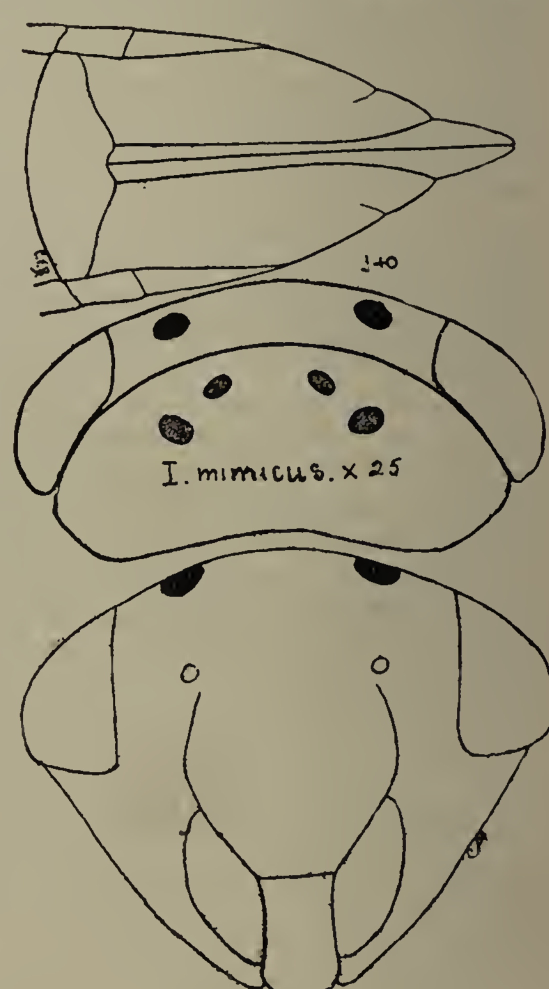
Colorado (VanDuzee, 4).

Estes Park, July 12th; Steamboat Springs, July 26th; Rist Canon, July 30th (Gillette).

Idiocerus mimicus n. sp.

Female: Face one-fifth wider than long, faintly shagreened; clypeus a little less than two-thirds longer than broad, moderately broadened at the rounded apex; lorae considerably longer and almost as broad as the clypeus; genae moderately depressed beneath the eyes, lateral margins straight, attaining tip of clypeus, broad beneath lorae; front slightly longer than broad, nearly twice as long as the clypeus. Vertex finely transversely wrinkled, length at middle same as next the eyes; width between the eyes five times the length at middle. Pronotum finely transversely shagreened, a little more than two and one-third times broader than long, three times longer than vertex, curvature little more than two-thirds of the length. Scutellum finely shagreened and with the transverse groove as in interruptus. Last ventral segment as in rufus. Color pale yellowish brown, unicolorous except two distinct black spots on the crest of the vertex, and the nervures of wings and basal angles of scutellum rufous.

Length 4.5 mm. Described from one female. Form of alternatus but more robust.



Fort Collins, August 18th on black-walnut (Baker).

Idiocerus nervatus VanD. Det. VanDuzee.

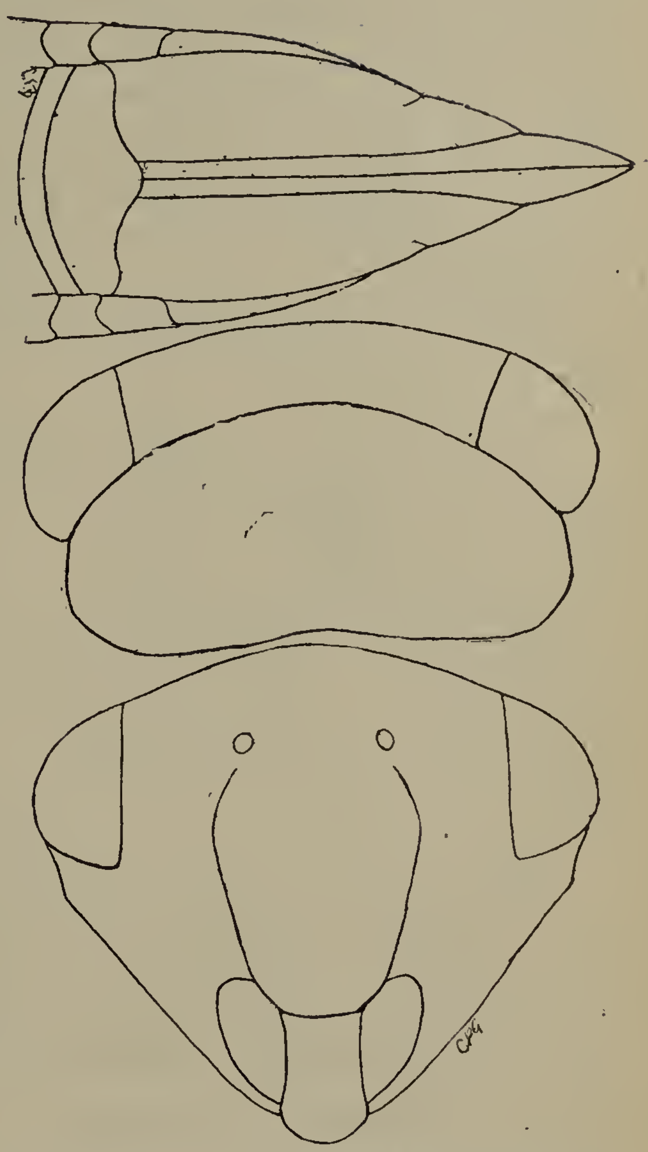
Colorado (VanDuzee, 1).

Lamar, May 7th; Trinidad, May 14th (Gillette). On Redstone Creek, twelve miles southwest of Fort Collins, August 1st; Fort Collins, September 14th on Solidago (Baker). The dark nervures of the wings are not a distinguishing characteristic of this species as certain forms of pallidus also possess them.

Idiocerus pallidus Fitch.

Quite common in Clear Creek Canon, also near the South Platte and its tributaries near Denver, and at Manitou and Colorado Springs, chiefly upon willows, August 6th to 18th (Uhler, 5). Mountains, June (Carpenter—see Uhler, 6). Colorado (VanDuzee, 4).

Female: Face an eighth wider than long, finely shagreened; clypeus one-half longer than broad, broadest near the tip where it is suddenly widened, apex rounded and broadly



depressed within; lorae as long as clypeus and narrower than clypeus at base; genae narrow, narrowly but rather deeply depressed next to the compound eyes and beneath the antennae, lateral margins almost straight, slightly concave, not attaining the tip of clypeus, moderately broad beneath the lorae; front one-third longer than wide, two times the length of the clypeus, sides below the antennae nearly straight but rapidly incurved near the clypeus. Vertex minutely transversely wrinkled, apex very broadly rounded, length at middle slightly less than that at the eyes, width between the eyes four and a half times the length at the middle. Pronotum two and five-sevenths times the length of vertex, two and one-fourth times broader than long, curvature five-ninths of the length, posterior margin slightly concave, disc minutely transversely rugulose. Scutellum finely indistinctly shagreened, transverse groove rather broadly depressed and strongly angled forward. Last ventral segment with hind margin moderately produced at the middle, truncate, the edge either side gently curving to the rounded lateral angles. Color uniform pale green. Eyes brown. Basal angles of scutellum sometimes pale yellow. Nervures of elytra and wings colorless.

Length 5.5-6.5 mm. Described from seven females.

Male: With the greenish color below much more pronounced. Spots at basal angles of scutellum sometimes nearly obsolete.

Length 5 mm. Described from five males.

Colorado Springs August 3d (Gillette). Fort Collins August 26th on Helianthus annuus; Steamboat Springs, July 15th on willow (Baker). These specimens were examined by Mr. VanDuzee and said by him to be identical with the eastern form generally known under the name pallidus.

Variety A. We also have numerous males and females which correspond exactly in structure and general coloration with this species, which have the dark wing nervures of nervatus. Steamboat Springs, July 15th on willow (Baker).

Variety B. We have further three females which also correspond in structure, but are quite yellowish and have large spots within the basal angles of the scutellum black, and the tips of the elytra smoky. Leadville, August 23d (Gillette).

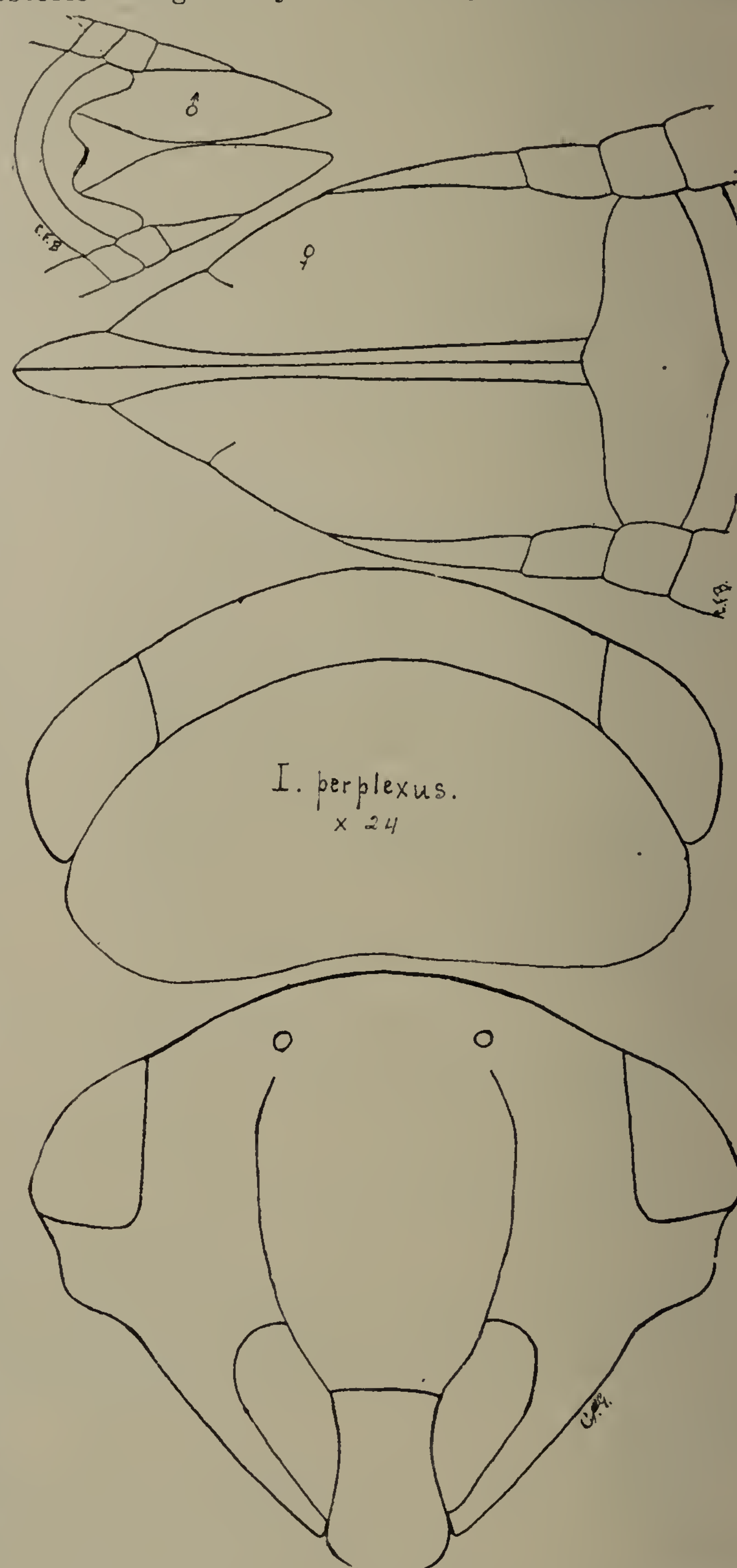
Idiocerus perplexus n. sp.

Near pallidus, differing from that species as follows: Genae sharply incurved beneath the eyes, then rounded to clypeus, and the clypeus more broadened out towards the tip. Last ventral segment produced on posterior margin very much as in pallidus, but rounded at extreme tip, not truncate. Color pale yellow, unicolorous throughout. This may prove to be only a variety of pallidus but the specimens we have examined seem quite distinct.

Length of female 6-7.5 mm., of male 5.25-6 mm. Described from two females and one male.

Fort Collins, August 26th on cottonwood, and September 20th ovipositing in box-elder (Gillette). Cheyenne Canon, Colorado Springs, August (Tucker).

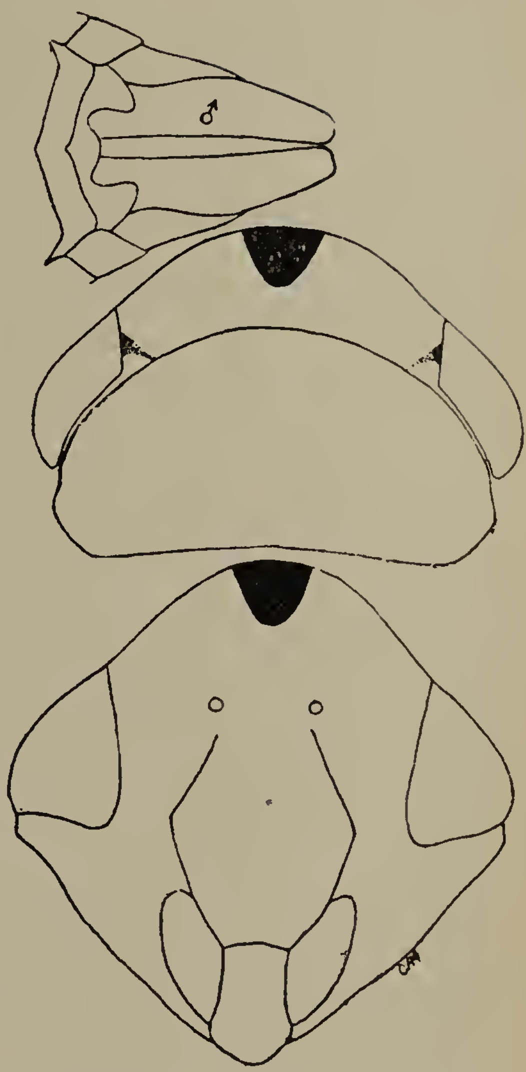
We have one male of the same structural characters, quite distinctly greenish. Colorado Springs, August 3d (Gillette).



Idiocerus productus n. sp.

Male: Face as long as wide, finely shagreened; clypeus four-fifths longer than broad, much widened towards the rounded apex, basal suture curved; lorae slightly longer and nearly as wide as the clypeus; genae deeply depressed beneath the eyes, lateral margins straight, not attaining tip of clypeus and narrow below the lorae; front nearly one-half longer than wide, a little less than twice the length of clypeus. Vertex finely transversely wrinkled, length at middle a half longer than next the eyes, width between the eyes little more than three times the length at the middle, apex rounded, but the angle nearly a right angle. Pronotum slightly more than twice as wide as long and two and one-fifth times as long as the vertex, curvature little less than five-sevenths of the length, disc finely transversely shagreened. Scutellum finely shagreened, transverse groove as in interruptus, except that it is more strongly depressed and with several transverse wrinkles just back of it. Color yellowish below, whitish above. Crest of vertex with a large black median longitudinal spot, disc whitish with a small black spot on either side next the compound eyes. Pronotum black with the posterior margin and a few small spots on disc whitish. Scutellum black with more or less of the lateral margins and apex, and two small spots next the pronotum whitish. Elytra dark smoky, nervures black, on inner margin at middle of clavus a white spot, on second sector of corium two small white spots, and an indistinct whitish transverse band on the corium just beyond the tip of the clavus. Venter blackish, tips of basal segments and all of the last two segments yellow. Legs sordid yellow, tibiae slightly infuscate, femora having a black line on outer margin, tarsi infuscate.

Length 6 mm. Described from two males. Differs from all other species of the genus in the remarkable form of the head.



Leadville, August 23d (Gillette). Steamboat Springs, July 15th on willow (Baker).

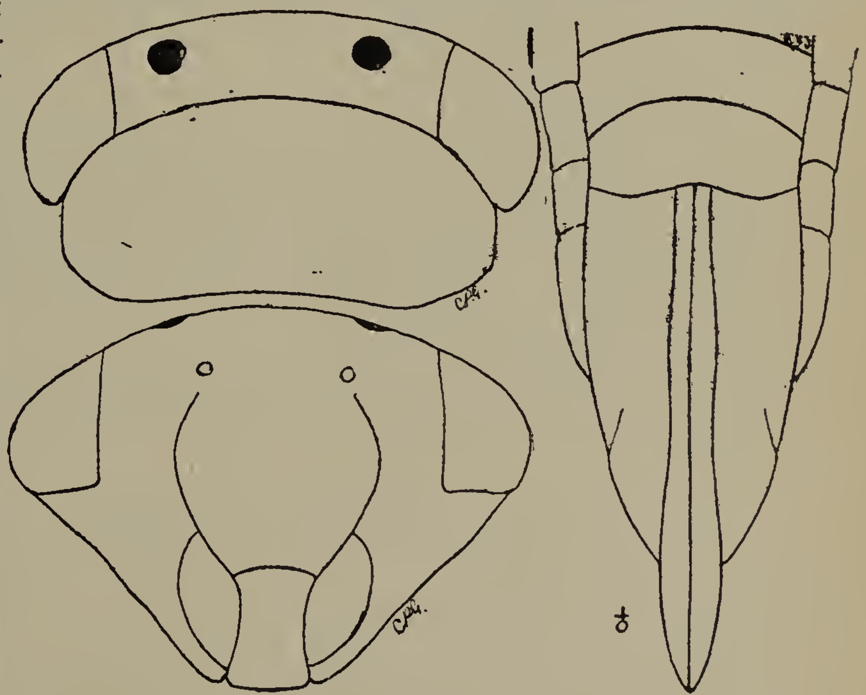
Idiocerus ramentosus Uhl. Det. VanDuzee.

On willows in Denver; also in Clear Creek Canon and at Manitou (Uhler, 5). Colorado (VanDuzee, 4).

Steamboat Springs, July 15th (Baker). Spring Canon, May 11th to June 30th; Estes Park July 12th; Steamboat Springs, July 26th; Manitou, September 29th on willow (Gillette).

Idiocerus snowi n. sp.

Face slightly more than one-third wider than long, indistinctly shagreened, and sparsely set with short, white, very weak hairs; clypeus slightly more than one-half longer than broad at tip, nearly as broad at base as at apex, strongly constricted at middle, truncate at the tip, basal suture nearly straight; lorae slightly longer and somewhat narrower than the clypeus; genae broad, outer margin slightly concave, attaining tip of clypeus and moderately broad below the lorae; front as long as broad. Vertex finely transversely rugose, as long at middle as next eyes, width between the eyes three and five-sevenths times the length at middle. Pronotum very minutely transversely wrinkled, with numerous fine scattered punctures, two and one-third times broader than long, two and one-fourth times the length of the vertex, curvature a little less than two-thirds of the length. Scutellum with the transverse groove as in interruptus. Last ventral segment with the hind margin broadly rounded. Color



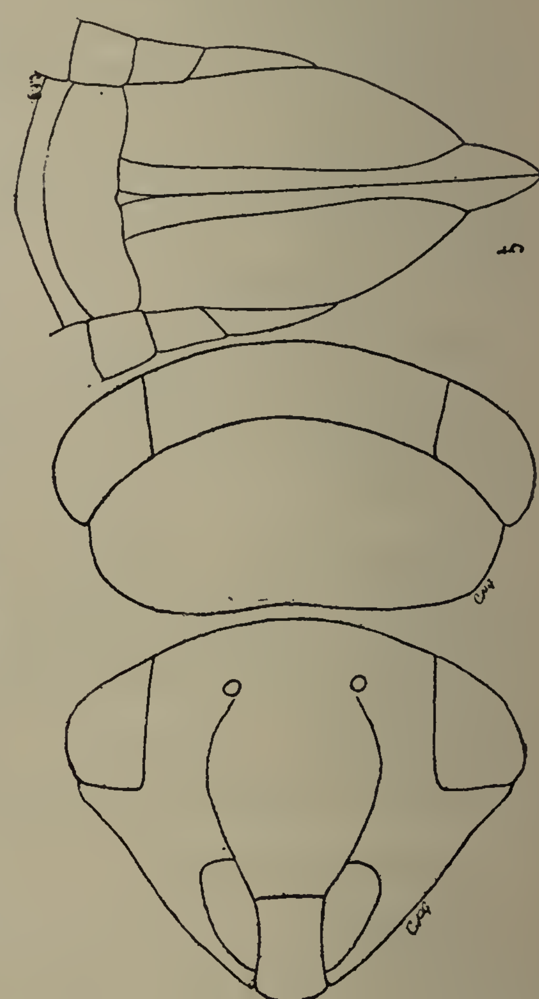
pale green, tips of tibiae, tarsi and pygofers, bluish green. Vertex with two round black spots on either side near anterior edge, nearer to the compound eyes than to the median line.

Length of female 6 mm., of male 5 mm. Described from three females and two males. Readily distinguished from pallidus by the two black spots on the vertex.

Idiocerus rufus n. sp.

Female: Face one-fifth wider than long, finely shagreened; clypeus little less than one-half longer than broad, broadened towards the rounded tip; lorae a little longer and nearly as broad as the clypeus; genae slightly depressed beneath the eyes, the lateral margins almost straight, attaining the tip of the clypeus, broad beneath the lorae; front about one-fifth longer than broad and twice the length of the clypeus. Vertex finely transversely wrinkled, length at the middle the same as at the eyes, width between the eyes nearly four times the length at the middle. Pronotum finely transversely shagreened, with numerous shallow, scattered punctures, slightly more than twice as broad as long, two and one-half times as long as the vertex, curvature slightly less than three-fifths of the length. Scutellum finely shagreened, transverse groove as in interruptus. Last ventral segment with hind margin broadly rounded, with a narrow median notch. Color bright chestnut, with the face, three small spots either side of the pronotum, a few spots on the scutellum, venter and all below, except the pygofers and sometimes the legs light yellowish.

Length 5 mm. Described from two females. Form of alternatus.



Rist Canon, September 27th on Solidago; Manitou, September 29th on oak (Gillette).

Colorado Springs, August (Tucker).

Idiocerus suturalis Fitch. Det. VanDuzee.

Colorado (VanDuzee, 4).

Spring Canon, June 30th; Estes Park, July 12th; Steamboat Springs, July 26th (Gillette). Steamboat Springs, July 12th (Baker). Manitou, July (Tucker).

Idiocerus verticis Say.

Upon willows at Denver, August 9th to 18th (Uhler, 5). Colorado (VanDuzee, 4).

Estes Park, July 12th (Gillette).

Agallia novella Say.

Colorado (VanDuzee, 4).

Agallia 4-punctata Prov. Det. Gillette.

Fort Collins, June 4th to 14th (Gillette).

Agallia sanguinolenta Prov. Det. VanDuzee.

Colorado, July 19th to September 6th; Eagle River, August; Denver, June (Carpenter—see Uhler, 6). Inhabits summits of high mountains (Uhler, 6).

Fort Collins, hibernating under boards during March; Spring Canon, March 12th under stones; Fort Collins, October 15th; Montrose, June 24th; Dolores, June 18th (Gillette). Fort Collins, May 16th to June 9th on alfalfa; Steamboat Springs, July 12th, on Solidago (Baker). Colorado Springs (Tucker).

Agallia uhleri VanD. Det. VanDuzee.

Fort Collins, May 7th to October 15th, and August 15th at electric light; foot-hills five miles west of Fort Collins, July 12th to September 1st; Colorado Springs, August 2d; Manitou, June 25th; Lamar, May 7th; Trinidad, May 14th; Dolores, June 18th; Grand Junction, August 26th on sugar beet; Glenwood Springs, August 24th (Gillette). Fort Collins, June 8th on Sisymbrium canescens, May 16th to July 14th on alfalfa, and July 29th on cultivated beet (Baker).

Oncometopia costalis Fabr. Det. VanDuzee.

Widely distributed throughout the region of Colorado less remote from the foot-hills. Extraordinarily numerous near Colorado Springs on low plants August 13th to 17th. On low hills west of Denver, near Golden, in Clear Creek Canon and in Manitou Park, less abundant (Uhler, 5). Larva at Boulder, June 29th (Packard—see Uhler, 5). Colorado (Uhler, 6). Ula, Custer County, November 12th; West Cliff, March 31st; also subalpine (Cockerell, 10). Manitou Park (Snow—see VanDuzee, 5).

Steamboat Springs, July 26th; Colorado Springs, August 1st; Leadville, August 23d; Minturn, August 24th; Fort Collins, March 20th to May 16th (Gillette). Fort Collins, during winter hibernating under dead leaves, stones, and boards, coming out to bask in the sun on warm bright days; taken copulating on March 2d (Baker).

Oncometopia limbata Say.

Custer County, midalpine (Cockerell, 10). Colorado (VanDuzee, 4).

Tettigonia hieroglyphica Say. Det. Osborn and VanDuzee.

Beaver Brook Gulch, near Golden, in Denver, abundant near Colorado Springs, at Manitou, in Manitou Park, and less common near the mouth of the canon of the Arkansas (Uhler, 6). Foot-hilis and plains, August to October (Carpenter—see Uhler, 6).

Horse-tooth Gulch, May 18th to June 5th; Rist Canon, May 19th to August 8th; The Rustic, Larimer County, August 11th; Steamboat Springs, July 26th; Colorado Springs, August 3d; Manitou, June 25th to September 29th on willow and oak; Montrose, June 24th; Dolores, June 18th (Gillette). Fort Collins, June 13th to October 7th; on Redstone Creek, twelve miles south-west of Fort Collins, August 1st, exceedingly abundant, flying up in a cloud as one walked through the low herbage (Baker).

Diedrocephala mollipes Say.

Very abundant on grass and weeds in low spots near Denver, and near Golden, August 5th and later in the month (Uhler, 5). Colorado (Uhler, 6). Custer County, midalpine (Cockerell, 10).

Diedrocephala novaeboracensis Fitch. Det. VanDuzee.

Near East River, August 29th (Carpenter—see Uhler, 6). More particularly a foot-hill and mountain spocies; Clear Creek Canon and Golden, Audust 5th to 7th; west of Denver, August 9th (Uhler, 5). Colorado (VanDuzee, 4).

Glenwood Springs, August 24th; Steamboat Springs, July 26th; Fort Collins, September 27th on grass and Carex (Gillette). Steamboat Springs, July 12th on Carex (Baker).

Helochara communis Fitch. Det. VanDuzee.

Very common in grassy marshy spots in the bed of the creek passing through Denver, also in similar situations on farms west of Denver (Uhler, 5).

Fort Collins, April 7th to October 15th; Steamboat Springs, July 26th; Dolores, June 18th (Gillette). Steamboat Springs, July 12th on Carex; Fort Collins and the adjoining foot-hills, during winter, hibernating under stones and boards (Baker). Colorado Springs, August (Tucker).

Xerophloea peltata Uhl. Det. VanDuzee.

Clear Creek Canon, August 7th (Uhler, 5). Custer County, midalpine (Cockerell, 10). Colorado (VanDuzee, 4).

Fort Collins, June 14th to October 15th; foot-hills five miles west of Fort Collins, March 12th to September 1st; Glenwood Springs, August 24th (Gillette). On Redstone Creek, twelve miles south-west of Fort Collins, August 1st; Fort Collins, August 26th on Helianthus annuus (Baker).

Gypona angulata Spang. Det. VanDuzee.

Colorado (VanDuzee, 4).

Dolores, June 16th; Rist Canon, June 12th (Gillette.)

Gypona cinerea Uhl.

Near Manitou, August 13th (Uhler, 5).

Gypona flavilineata Fitch. Det. Osborn.

Colorado Springs, August 3d (Gillette.)

Gypona octolineata Say.

Clear Creek Canon, August 7th; Denver; Manitou, August 13th; in the mouth of the canon of the Arkansas (Uhler, 5). Foot-hills and plains (Carpenter—see Uhler, 6).

Eagle River and Two Elk Creek, Eagle County, September 7th (Cockerell—see Riley, in litt.).

Gypona rugosa Spang. Det. VanDuzee.

Colorado (VanDuzee, 1).

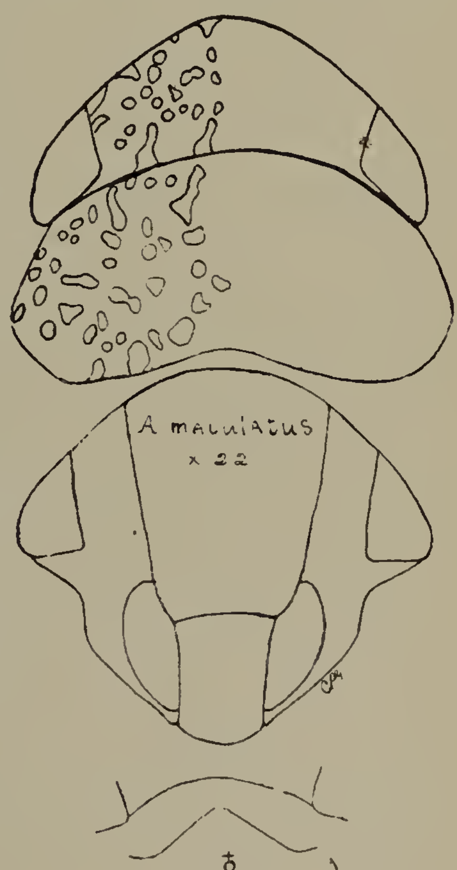
Fort Collins, September 30th (Baker). Manitou, September 29th, on oak (Gillettte).

Penthimia americana Fitch. Det. Osborn.

Fort Collins, May 16th (Gillette).

Acocephalus maculatus n. sp.

Female: Face one-tenth wider than long; clypeus rectangular, once and a third as long as broad, rounded anteriorly, narrowly depressed before apex, medially elevated on posterior half; lorae as long and two-thirds as broad as clypeus. Entire head and scutellum finely shagreened. Front about one-fifth longer than wide, little less than two times the length of the clypeus, with sides rectilinear and almost parallel, gradually converging towards clypeus. Vertex with anterior margin distinctly elevated, length at middle once and three-fifths that at eyes, width between the eyes little less than two times the length at middle. Pronotum two and one-fifth times broader than long, once and a half the length of the vertex, curvature three-eighths of length, finely transversely wrinkled on posterior two-thirds, finely shagreened on anterior third except on the extreme anterior margin which is transversely wrinkled and without punctures, posterior margin broadly emarginate. Scutellum with a distinct transverse groove at middle. Elytra smooth, entirely without rugae. Last ventral segment with the hind margin deeply notched. Entire body, except the venter and elytra, black, irregularly marked with numerous small light yellow spots. Eyes black margined with reddish yellow. Ocelli rufous. Elytra black with tips paler, small white spots along the nervures and paler areas between. Venter black, tip of last segment yellowish. Legs less spotted than other portions.



Length 5 mm. Described from two females.

Ouray, June 22d; Dolores, June 18th (Gillette).

Paramesus vitellinus Fitch.

(*Paramesus twiningi Uhl.*)

Estes Park, July 12th; Manitou, June 25th; Colorado Springs August 3d (Gillette).

The type of twiningi is a slightly faded male of vitellinus. In this species the second transverse nervure between the first and second sectors of the elytra is sometimes absent.

Paramesus jucundus Uhl.

(*Eutettx jucundus Uhl.*)

Manitou, August 13th (Uhler, 5). Colorado (VanDuzee, 4).

Manitou, June 25th (Gillette).

Parabolocratus viridis Uhl. Det. VanDuzee.

Near Golden, and on highlands west of Denver. Apparently rare (Uhler, 5). Colorado (VanDuzee, 4).

Lamar, May 7th; Dolores, June 18th; Rist Canon, June 13th (Gillette). Fort Collins, July 29th (Baker).

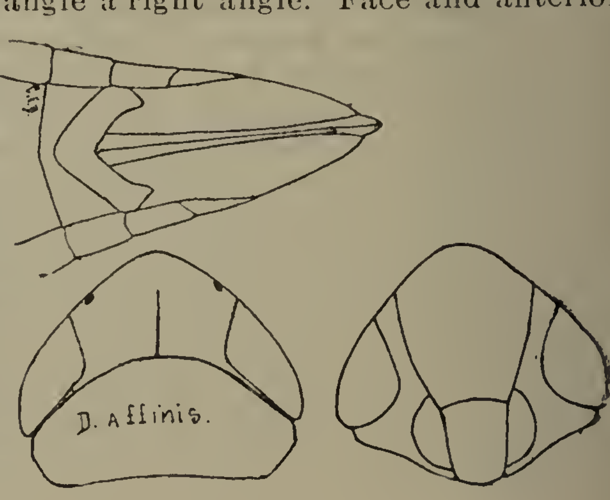
Platymetopius acutus Say. Det. VanDuzee.

Manitou, August 13th, swept from herbage near Fountain creek (Uhler, 5).

Rist Canon, June 12th to August 8th; Fort Collins, September 27th on Rhus trilobata; Steamboat Springs, July 26th; Manitou, July 24th on Clematis, and September 29th on oak; Grand Junction, August 26th on sugar beet (Gillette). Fort Collins, August 18th; Steamboat Springs, July 14th (Baker).

Deltocephalus affinis n. sp.

Female: Face one-seventh wider than long; clypeus one-third longer than broad, somewhat more than one-half the length of the front, gradually narrowing to the rounded apex, basal sutures nearly straight; lorae subovate, as long and one-half as broad as the clypeus, genae broadly obtusely angled below the eye, rather broader than usual below the lorae, attaining the tip of the clypeus; front one-seventh longer than wide, gradually narrowing to clypeus, superior angle a right angle. Face and anterior half of vertex finely shagreened. Vertex one-half longer on the middle than at the eyes, width between the eyes once and a fourth the length at the middle, disc with the two depressed areas near the hind margin. Pronotum two and one-fourth times wider than long, but little longer than the vertex, curvature three-fifths of the length, posterior margin very slightly concave, anterior third glabrous with two distinct pits near the median line, posterior two-thirds indistinctly rugose. Scutellum as usual, transverse groove quite indistinct. Elytra barely exceeding abdomen. Last ventral segment with the hind margin very deeply and broadly notched



posterior angles subacute and somewhat inclined towards the center. Color pale ashy green. Face slightly dusky with indistinct lighter transverse lines above. Genae with a small black spot near the loral suture. Vertex and pronotum concolorous, with a broad light median stripe and a dark stripe on either side, on the vertex the median light stripe with a median dark line. Scutellum darker on the disc. Elytra ashy subhyaline with a few faint fuscous markings along the middle of the disc and on the median portion of the clavus. Venter pale yellowish. Legs pale yellow.

Length 3.25 mm. Described from one female. Related to melsheimeri.

Leadville, August 23d (Gillette).

We have also a single male which probably belongs to this species. It differs from the female as follows: Front one-fourth longer than wide, two and a half times as long as the clypeus. Face darker on discs of clypeus and genae, front very light chocolate brown, the light transverse lines above distinct. Elytra with costa and veins more distinctly yellowish, the apical cells faintly margined with fuscous. Venter black. Legs as in monticola.

Length 3.5 mm. Described from one male.

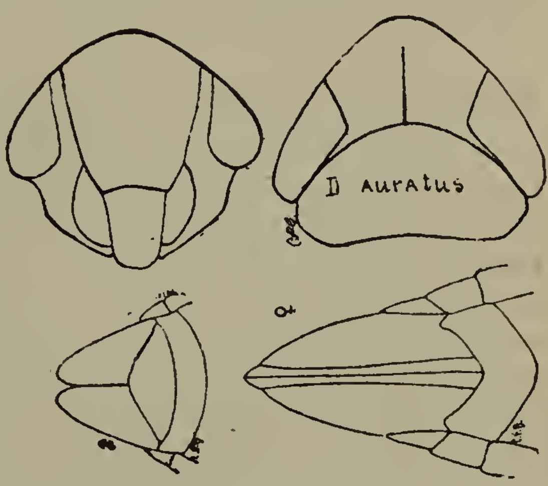
Estes Park, July 12th (Gillette).

Deltocephalus argenteolus Uhl.

Quite common on willows at Colorado Springs and near Manitou (Uhler, 5). Colorado (VanDuzee, 4).

Deltocephalus auratus n. sp.

Female: Face an eleventh wider than long. Clypeus about a third longer than wide, gradually narrowed to the rounded apex. Lorae subovate, as long as the clypeus and half as broad. Genae broadly and very obtusely angled, attaining the end of the clypeus. Front one-eighth longer than wide, about two times the length of the clypeus, sides nearly straight, rapidly narrowing to the clypeus below, superior angle rather strongly produced and rather more than a right angle. Face and anterior third of vertex finely shagreened. Disc of vertex with a depressed area on either side next the compound eye, length at middle once and a half that next the eye, width between eyes once and a seventh times the length at middle. Pronotum twice wider than long, as long as vertex, curvature two-thirds of length, with the glabrous anterior margin somewhat elevated, posterior margin slightly concave, posterior three-fourths obscurely rugose and sparsely and indistinctly punctate. Scutellum broader than long, very minutely sculptured. Last ventral segment with the hind margin deeply and broadly notched, posterior angles rounded. Color pale yellow throughout. Tip of rostrum, eyes, spots at bases of tibial spines, and ungues, black. Ocelli rufous. Elytra exceeding abdomen by somewhat less than one millimeter, yellowish subhyaline, nervures lighter.



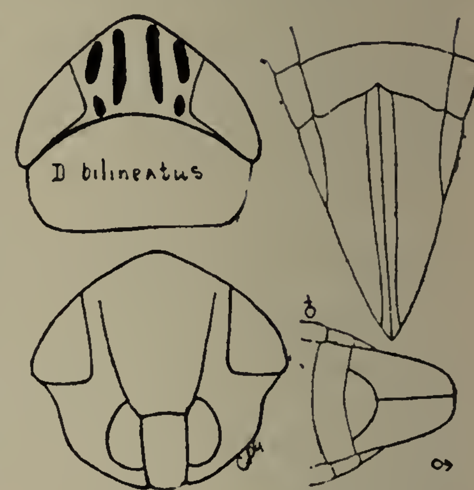
Male: Differs from female as follows:—Color deep golden yellow. Elytra yellowish subhyaline, nervures and costa bright yellow. Genital organs below tipped with black.

Length 3.25 mm. Described from two males and one female.

Fort Collins, June 14th (Gillette). Steamboat Springs, July 15th (Gillette).

Deltocephalus bilineatus n. sp.

Face a twelfth wider than long; clypeus long and narrow, one-half longer than broad, nearly one-half as long as the front, sides parallel, apex rounded, basal suture straight; lorae subovate, nearly as broad and long as the clypeus; genae very broadly and obtusely angled outwardly, attaining the end of the clypeus; front two-fifths longer than wide, sides rectilinear, gradually narrowed towards the clypeus, superior angle rather long, and more than a right angle. Face and vertex finely shagreened. Disc of vertex with two distinct pits near the eyes, nearer to the eyes than to each other, length at middle a half longer than that next the eye, width between the eyes equal to the length at middle. Pronotum twice as wide as long, one-seventh longer than the vertex, curvature four-ninths of the length, posterior margin very slightly concave, anterior one-fourth glabrous, posterior three-fourths transversely subobsoletely wrinkled and with scattered indistinct punctures. Scutellum broader than long, shagreened more coarsely than the face. Last ventral segment with the hind margin broadly and deeply notched, the sides of the notch slightly sinuated. Color ashy gray sometimes tinged with fuscous. Face light yellow to dusky, the sutures sometimes darker. Two broad dark longitudinal lines extending over vertex and pronotum, these bands on the anterior two-thirds of vertex bordered internally with black, and adjoined externally by a black spot. Vertex with a fine black median line on the posterior two-thirds. Scutellum varying from brown-marked to black. Elytra little longer than the abdomen, whitish, nervures white throughout, bordered with dusky or testaceous, apex with three black spots, one internally and two externally, each elytron with seven white spots, two on the external apical border, two in the center, one large one basally and two on the internal border of the clavus. Venter light to dark yellow, sometimes bordered with blackish, the last segment with black spots on the sides of the notch. Legs yellow, tibial spurs arising from black spots, posterior tibiae black tipped internally.

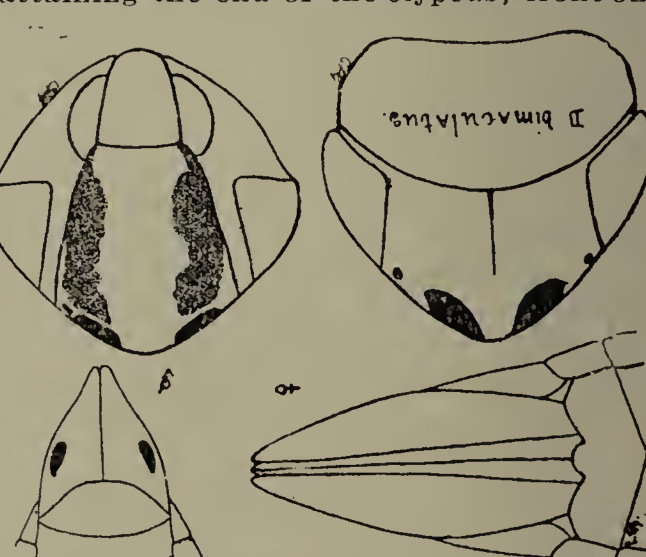


Length of female 4 mm., of male 3.5 to 3.75 mm. Described from four males and three females.

Steamboat Springs, July 12th on Carex (Baker).

Deltocephalus bimaculatus n. sp.

Female: Face about as long as wide; clypeus short and broad, one-seventh longer than broad, not quite half as long as the front, gradually narrowing towards the rounded apex, basal suture straight; lorae subovate, two-fifths as wide and nearly as long as the clypeus; genae broadly rounded outwardly, attaining the end of the clypeus; front one-eighth longer than wide, sides almost straight, superior angle nearly a right angle. Face and vertex roughly shagreened. Disc of vertex slightly transversely depressed, length at middle once and a half that next the eye, width between eyes once and two-sevenths the length at middle. Pronotum two times wider than long, length slightly less than that of vertex, curvature nearly one-half of length, posterior margin very slightly concave, anterior fourth glabrous, posterior three-fourths very finely transversely wrinkled. Hind margin of last ventral segment with a broad short tooth, on either side of which is a shallow notch, posterior angles rounded, obtuse. Pale yellowish green. Face with sutures black, four or five transverse black dashes on either side of the front above, which may run together forming a longitudinal band just within the margin. Vertex with two large oval black spots on the apex nearer the center than the eyes. Elytra greenish, subhyaline. Tergum black. Venter black with lateral and apical margins of segments yellowish. Ovipositor black, pygofers more or less streaked with black longitudinally. Legs light yellow.



Male: Differs from the female as follows: Front without black markings except in some specimens a spot on either side beneath antennae. Front two and a half times as long as the clypeus. Sutures, other than those bounding the front, lighter. A small black spot on either pygofer.

Length of female 4.5 mm., of male 4 mm. Described from three females and ten males.

Estes Park, July 12th (Gillette). Steamboat Springs, July 13th on Carex and willow (Baker).

Deltocephalus concentricus VanD. Det. VanDuzee.

Mountains of north-western Colorado (Gillette—see VanDuzee, 3). Colorado (VanDuzee, 4).

North Park, July 20th (Gillette).

Deltocephalus configuratus Uhl. Det. Osborn.

Steamboat Springs, July 14th (Baker).

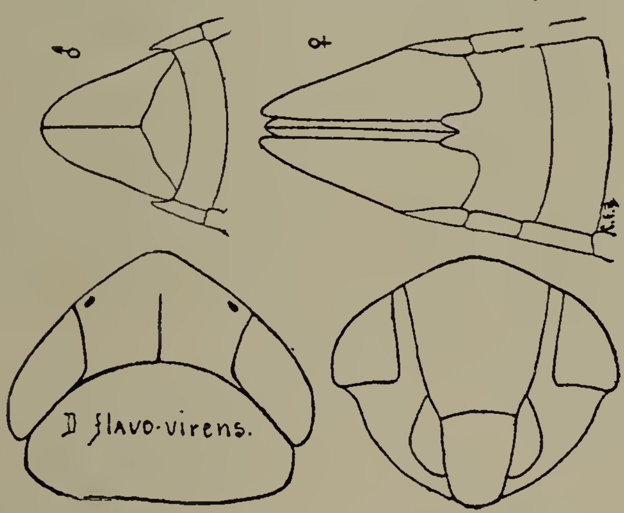
Deltocephalus debilis Uhl. Det. VanDuzee.

Sides of high mountains, and near Fair Play, South Park, July (Carpenter—see Uhler, 6). Colorado (VanDuzee, 4).

Horsetooth Gulch, June 5th; North Park, July 20th; Steamboat Springs, July 26th; Estes Park, July 12th; Graymont, July 16th (Gillette). Steamboat Springs, July 13th on Carex and Solidago (Baker).

Deltocephalus flavo-virens n. sp.

Face one-seventh wider than long; clypeus one-fourth longer than broad, about three-fifths the length of the front, gradually narrowing to the rounded apex, basal suture slightly convex; lorae subovate, nearly as long and about one-half as broad as the clypeus; genae broadly rounded at the sides, attaining the apex of the clypeus and broad below the lorae; front nearly as wide as long, sides straight past the antennae, narrowing to the clypeus below, superior angle considerably more than a right angle. Face and anterior margin of vertex finely shagreened. Disc of vertex rather strongly depressed on posterior half, length at middle about once and a half that next the eyes, width between the eyes about one and a third times the length at middle. Pronotum nearly twice wider than long, about one and a fourth times the length of the vertex, curvature four-sevenths of the length, posterior margin very slightly concave, anterior fourth glabrous, posterior three-fourths very faintly transversely wrinkled. Scutellum faintly scabrous. Last ventral segment with the hind margin greatly produced at the center, ending in two short acute points. Color greenish yellow. Face smoky with lighter concentric lines above, sutures of the front black. Vertex yellow, ocelli with a very small black spot on the sides next the eyes. Pronotum greenish yellow, darker on the disc. Scutellum immaculate. Elytra yellowish hyaline, nervures yellow. Basal segments of venter with apical and lateral margins narrowly yellowish, the apical segments yellow, the last one with the produced part black. Ovipositor black, pygofers very hairy. Legs yellow, except small black spots at base of tibial spines.



Length, female, 4.75 mm., male, 4.25 mm. Described from one male and one female.

Steamboat Springs, July 12th on Carex (Baker).

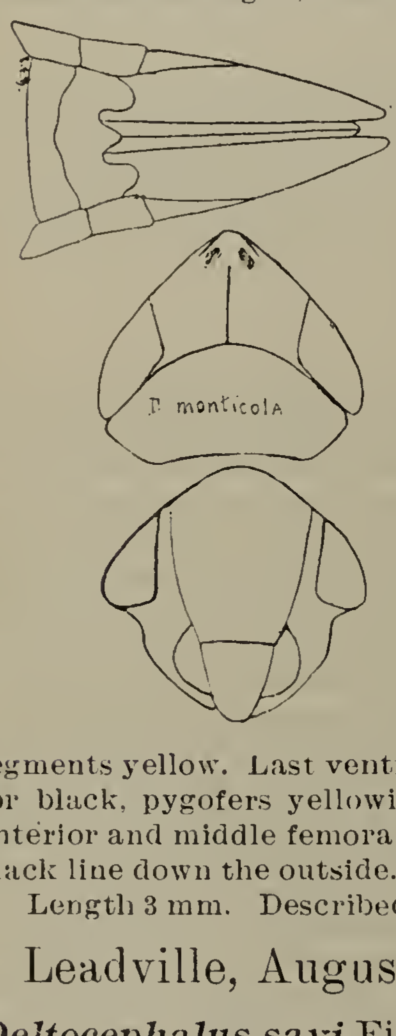
Deltocephalus melsheimeri Fitch. Det. VanDuzee.

Colorado (VanDuzee, 4).

Fort Collins, June 4th to October 15th; Horsetooth Gulch, June 5th; Rist Canon, April 25th to June 12th; North Park, July 20th; Steamboat Springs, July 26th; Lamar, May 7th; Minturn, August 24th; Montrose, June 24th; Dolores, June 18th (Gillette). Fort Collins, May 16th to June 13th on alfalfa; Steamboat Springs, July 12th on Carex and Solidago (Baker).

Deltocephalus monticola n. sp.

Female: Face nearly as long as wide; clypeus nearly as broad as long, slightly more than three-sevenths the length of the front, rapidly narrowing to the rounded apex, basal suture straight; lorae subovate, nearly as long, and two-fifths as broad as the clypeus; front one-sixth longer than wide, sides nearly straight above, superior angle obtuse, more than a right angle. Face and anterior half of vertex finely shagreened. Disc of vertex flat, length at middle once and two-thirds that next the eye, width betweeen the eyes one-fifth more than the length at middle. Pronotum two and one-eighth times wider than long, length about the same as that of the vertex, curvature about three-fifths of the length, posterior margin very slightly concave, smooth on the anterior third, posterior two-thirds feebly rugose. Scutellum minutely sculptured. Elytra scarcely exceeding the abdomen. Hind margin of last ventral segment with a large median tooth, posterior angles strongly produced, swollen, rounded and somewhat exceeding the tooth. Color yellowish green, about the same as in melsheimeri. Face smoky with concentric broken light lines above. Disc of clypeus, margins of lorae, and genae next the eyes, dark brown. Vertex light, with four short oblique black dashes on the apex. Pronotum darkened on the disc. Elytra pale greenish subhyaline, nervures lighter. Venter except last segment, with apical and lateral margins of the segments yellow. Last ventral segment yellow at the sides and black on the disc. Ovipositor black, pygofers yellowish green and slightly streaked with black. Legs yellowish, anterior and middle femora spotted and annulated with black. Posterior femora with a black line down the outside. Tibiae more or less spotted with black.



Length 3 mm. Described from one female. Near melsheimeri.

Leadville, August 23d (Gillette).

Deltocephalus sayi Fitch. Det. VanDuzee.

Colorado (VanDuzee, 4).

Fort Collins, July 4th (Gillette). Steamboat Springs, July 14th (Baker).

Deltocephalus sexmaculatus n. sp.

Female: Face nearly as long as wide; clypeus about a fourth longer than broad, half as long as the front, considerably narrowed towards the rounded apex, basal suture straight; lorae large, subovate, as long and one-half as broad as the clypeus; genae unusually narrow, narrow below the lorae and attaining the tip of the clypeus. Front two-ninths longer than wide, broad below, the superior angle more than a right angle. Face and anterior third of vertex coarsely shagreened. Disc of vertex deeply depressed, length at middle once and about two-thirds that next the eye, width between the eyes once and a fifth the length at middle. Pronotum two and one-sixth times wider than long, length slightly less than that of the vertex, curvature about one-half of the length, posterior margin slightly concave, anterior fourth glabrous, posterior three-fourths obscurely transversely wrinkled with scattered feeble punctures. Scutellum finely scabrous. Last ventral segment with the hind margin very broadly and deeply emarginated, the emargination nearly rectangular at the bottom, posterior angles obliquely sloping backward. Color ash gray, head and pronotum tinged with rufous. Face black, clypeus with one median and two lateral light spots, lorae with one median light spot, and genae with a transverse light spot next the lorae. Front with about six short transverse light lines on each side. Eyes black. Vertex with two large black spots posteriorly, in front of these two smaller black spots on either side, the anterior ones extending nearly to the crest of the vertex and a narrow median line not attaining the apex. Pronotum dusky rufous. Scutellum with four large black spots on the disc. Elytra scarcely exceeding the tip of the abdomen, pattern of coloration the same as in bilineatus, white spots at base very small. Venter dark, marked with yellowish. Legs yellowish, coxae and basal half of anterior and middle femora blackish, posterior femora with a longitudinal black stripe beneath. Tibiae all dark with a longitudinal yellowish stripe on the outer margin. Tarsi blackish.

Length 3 mm. Described from one female. Readily separated from weedi by the form of the last ventral segment in the female.

Leadville, August 23d (Gillette).

Deltocephalus signatifrons VanD. Det. VanDuzee.

Colorado (VanDuzee, 4).

Fort Collins, July 2d on beans; Horsetooth Gulch, June 5th; Estes Park, July 12th; Steamboat Springs, July 26th; Lamar, May 7th; Trinidad, May 14th; Montrose, June 24th (Gillette). Fort Collins, May 16th on alfalfa; Steamboat Springs, July 14th (Baker).

Deltocephalus unicoloratus n. sp.

Female: Differs from the female of auratus as follows: Face one-twentieth longer than wide; clypeus nearly as wide as long and rapidly narrowing to the rounded tip; front one-fifth longer than wide and two times as long as the clypeus. Vertex greatly produced, the angle in front slightly less than a right angle, once and two-thirds as long at the middle as next the eyes, width between the eyes the same as the length at the middle, with a narrow black median line on the posterior two-thirds. Ocelli jet black, margined on the side towards the eyes by a small black spot. Hind margin of last ventral segment truncate with a median, slightly sunken, obtuse tooth, the immediate region of the tooth thin and coriaceous, posterior angles obtuse. Color light lemon yellow.

Length 3.25 mm. Described from one female. Distinctly separated from auratus by the last ventral segment and by the proportions of the head.

Pleasant Valley, six miles north-west of Fort Collins, June 12th (Gillette).

Deltocephalus vanduzei n. sp.

Female: Face one-ninth wider than long; clypeus two-fifths longer than broad, three-fifths the length of the front, gradually narrowing to a rounded apex; lorae subovate nearly as long and two-thirds as wide as clypeus; genae normal except the outer margin which is strongly obtusely angled, attaining the end of the clypeus. Front as long as wide, sides below the antennae rapidly narrowing to the clypeus, superior angle more than a right angle, obtusely rounded. Face and vertex coarsely shagreened. Disc of vertex slightly convex, sloping to the margins, length at the middle once and a half that next the eye. Pronotum two and a fourth times wider than long, an eighth longer than the vertex, curvature half of the length, posterior margin slighly concave, anterior fourth finely scabrous and elevated, posterior three-fourths very finely transversely wrinkled, disc with two small distinct pits near the anterior margin. Scutellum finely scabrous. Hind margin of last ventral segment with a broad deep median notch, posterior angles rounded. Color dark smoky above, black below. Eyes black. Face black, above with a row of transverse light dashes on either side, genae mostly margined with yellowish. Vertex yellow with two large black spots behind the apex which is margined with black, a broad black transverse median band, produced posteriorly at the sides to near the hind margin, running between ocelli and along the margins of the eyes, and two black spots on either side within the hind margin near to each other, posteriorly a dark median longitudinal line. Ocelli black on a circular yellow field. Pronotum dark yellowish smoky, anteriorly with a black spot near the median line, and laterally, near the anterior margin, two elongate black dashes. Scutellum with a median spot and two spots within the basal angles black, extreme posterior point jet black. Elytra smoky, nervures lighter, narrowly margined with darker. Venter black. Legs black, extreme tips of coxae, distal half of anterior and extreme tips of middle and posterior femora yellow, anterior tibiae yellow, infuscated; middle tibiae yellow annulate with black, hind tibiae black with spines yellow, tarsi all dark.

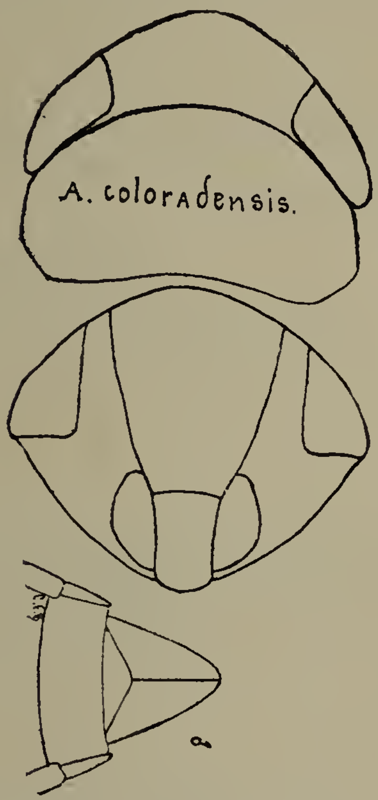
Male: Differs from female as follows:—Clypeus somewhat longer. Yellow markings on the face much heavier, a small yellow spot on the median line of the front near the clypeus, also two on the clypeus near the basal angles. The parts of the transverse band near the apex of the vertex of the female are here separated as two large rectangular black spots.

Length of female, slightly exceeding 2.5 mm., of male 2.5mm. Described from one male and one female. Near weedi.

Leadville, August 24th (Gillette).

Allygus coloradensis n. sp.

Male: Clypeus less than twice as long as broad, constricted in the middle, nearly as broad at apex as at base, half as long as the front, basal suture somewhat curved; lorae subovate, as long and as broad as the clypeus; genae gently and evenly rounded at the sides and attaining the tip of the clypeus; front a fifth longer than wide, sides inwardly curved at the antennae, narrowed towards the clypeus, superior angle very obtuse; face and anterior margin of vertex finely shagreened. Disc of vertex slightly transversely depressed, length at middle nearly once and a half that next the eyes; pronotum broadly rounded in front, distinctly concave behind, twice as broad as long, posterior angles very broadly rounded, opaque, not distinctly sculptured. Scutellum broader than long, transverse suture arcuated. Color dull smoky yellow; eyes dark; face somewhat smoky with narrow concentric light lines above; on genae at middle of loral suture a small black spot; vertex smoky yellow mottled with darker shades; two small black spots within hind margin near compound eyes and a narrow black median line; pronotum with anterior fourth lighter, and with four short black dashes on either side, posterior three-fourths heavily and somewhat transversely mottled with dark; scutellum yellowish with basal angles and transverse groove blackish; elytra subhyaline, nervures dark brown, clavus with cells mottled with blackish and with three distinct pearly white spots on the inside margin, two more indistinct ones on the outside; disc of elytra with scattered black mottling within the cells; transverse veins on costal margin broadly black; elytra pearly, wings brilliantly iridescent; venter yellow with apical margins of segments black; legs light yellow, anterior coxae with a large black spot on anterior portion, anterior femora with numerous small black spots; tibiae with spines arising from black spots, posterior tarsi annulate with black.



Length 4 mm. Described from one male.

Glenwood Springs, August 24th (Gillette).

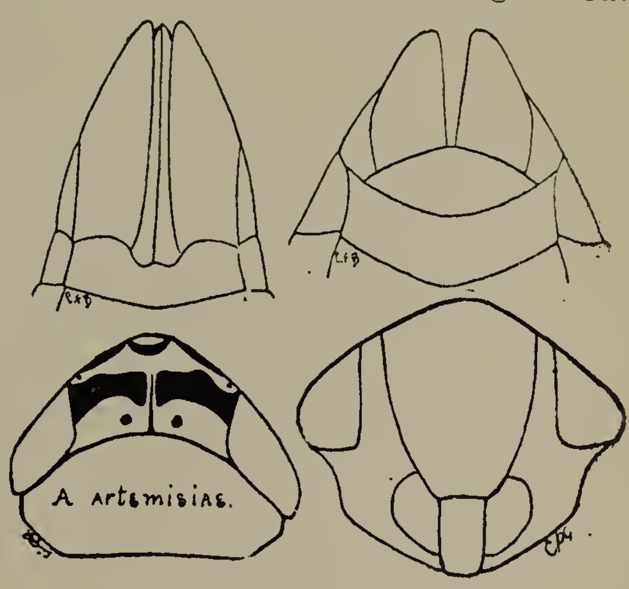
Athysanus anthracinus VanD. Det. VanDuzee.

Colorado (VanDuzee, 4).

Montrose, June 24th (Gillette).

Athysanus artemisiae n. sp,

Female: Clypeus one-half longer than broad, broadly and shallowly depressed below the middle, sides nearly parallel, tip truncate; lorae about as long but not quite as broad as the clypeus; genae broad, scarcely depressed beneath the eyes, outer margin broadly angled, attaining the tip of the clypeus and broad beneath the lorae; front one-fifth longer than broad, superior angle rounded and more than a right angle, face and anterior half of vertex finely shagreened; eye with a narrow and acute emargination within near the antennae; disc of vertex not depressed, sloping at sides, length at middle once and a half that at eyes. Pronotum with two small approximate pits near the anterior margin, posterior two-thirds very indistinctly transversely wrinkled; scutellum finely shagreened; hind margin of last ventral segment with posterior angles broadly rounded, slightly produced, with a rather large narrow notch having at its center a small blunt tooth. Color black; front with about six



narrow transverse yellowish lines on either side; clypeus with a small yellow spot on either basal angle; genae laterally margined near the eyes with yellow. Vertex with a broad transverse band on the posterior margin between the eyes, and a narrow band along anterior margin of vertex yellow, the latter having three black spots upon it, one at the middle and one at either end. Pronotum and scutellum yellowish, indistinctly mottled with black; elytra dark smoky with the nervures and central portions of cells paler; abdomen black; legs black, knees and tibiae yellowish, the tarsi streaked with black.

Length 3 mm. Described from one female.

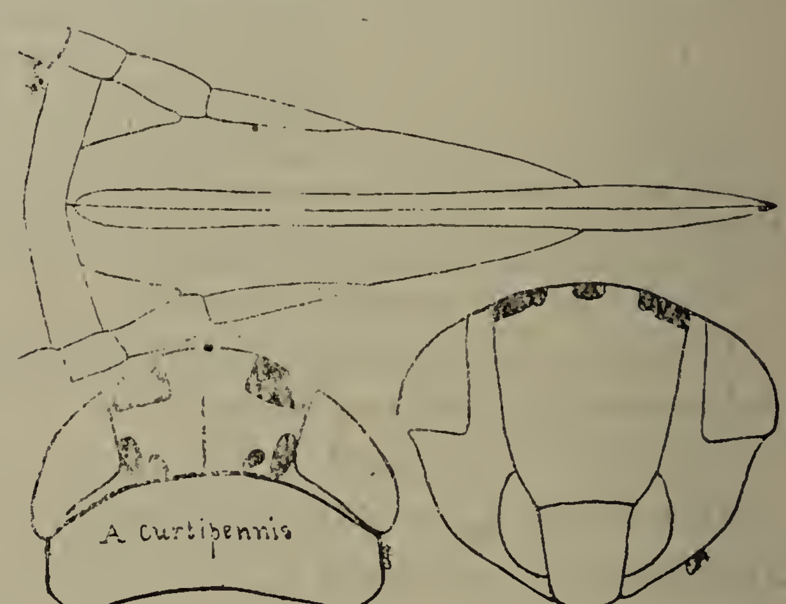
On Grizzly Creek, in mountains south-west of North Park, July 10th, on Artemisia tridentata (Baker).

Athysanus comma VanD. Det. Osborn.

Fort Collins, July 4th (Gillette), and July 24th to August 18th (Baker).

Athysanus curtipennis n. sp.

Female: Clypeus about one-fourth longer than broad, transversely depressed before the tip, sides nearly parallel, apex truncate, basal suture slightly curved; lorae as long and nearly one-half as broad as the clypeus; genae broad, strongly depressed beneath the eyes, outer margin broadly and evenly rounded, attaining tip of clypeus and rather broad beneath the lorae; front one-eighth longer than broad and twice the length of the clypeus; superior angle broadly rounded; face finely shagreened. Disc of vertex smooth and shining, broadly transversely depressed on posterior half, length at middle once and one-third that at eyes. Pronotum short and broad, somewhat shorter than the vertex, anterior one-fourth very finely rugose, posterior three-fourths rather coarsely rugose with broad scattered punctures. Scutellum very small, shorter than pronotum, transverse groove wanting. Elytra subquadrate, as broad as long, not attaining the tip of the second segment. Hind margin of last ventral segment with posterior angles long and subacute, entire central portion between the angles wanting; ovipositor, beneath, half the length of the whole body; valves a third longer than pygofers, the latter with a row of short stout spines, the former with numerous fine hairs near the tip. Color pale yellowish with dark markings; front with several short transverse darker lines on either side, lower angles each with a black spot; vertex with a large black spot on either side at crest and a small black spot at the apex; disc of vertex with two large black spots near the middle and with a narrow black line next the compound eyes; pronotum almost concolorous, a rather distinct dark spot just back of the compound eye and another outside of the basal angle of the scutellum, two minute approximate black spots close to anterior margin; scutellum concolorous; elytra with about four longitudinal dark lines on corium between the nervures; tergum with three longitudinal black bands on either side, outer ones narrow, inner broadest and containing a row of irregular pale green spots; venter with middle portion of three basal segments black; pygofers with two black lines on sides, valves black, margins brown; legs concolorous.



Length 5 mm. Described from one female.

Colorado Springs, August 3d (Gillette).

Athysanus gammaroides VanD. Det. VanDuzee.

Colorado (Gillette—see VanDuzee, 3). Colorado (VanDuzee, 4).

Foot-hills, five miles west of Fort Collins, April 25th (Gillette).

Athysanus instabilis VanD. Det. VanDuzee.

Colorado (VanDuzee, 4).

Steamboat Springs, July 26th; Leadville, August 23d (Gillette).

Athysanus plutonius Uhl.

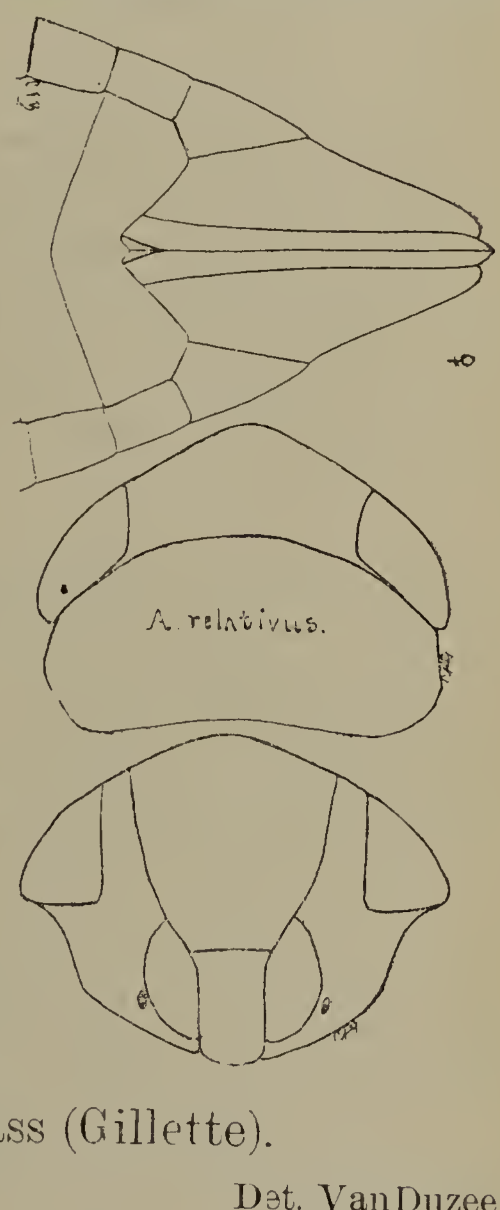
Clear Creek Canon, August 6th (Uhler, 5). Colorado (VanDuzee, 4).

Athysanus relativus n. sp.

Near obsoletus. Female: Clypeus fully one-third longer than broad, sides nearly parallel, apex nearly truncate; lorae as long and nearly as broad as clypeus; genae broad, slightly depressed, outer margin broadly rounded, attaining tip of clypeus and moderately broad beneath the lorae; front as long as broad, less than twice as long as the clypeus, superior angle rather sharply rounded; face and anterior third of vertex rather coarsely shagreened, posterior two-thirds of vertex medially longitudinally wrinkled; disc of vertex nearly flat, at middle nearly two-thirds longer than at the eyes. Pronotum smooth on anterior third, transversely wrinkled on posterior two-thirds, width more than twice the length, anterior margin broadly rounded, posterior rather strongly concave, posterior angles rounded, sides feebly carinated. Scutellum coarsely shagreened, transverse groove curved forwards. Hind margin of last ventral segment with posterior angles produced, acute, with a broad shallow median notch, having a short blunt tooth at the center. Color pale sordid yellowish; face with six smoky transverse lines on the front; vertex unicolorous; pronotum without distinct marking; scutellum with two small, more or less distinct, darker spots near base; elytra with nervures whitish, areoles more or less distinctly broadly margined with fuscous or blackish; venter yellow; lateral margins and apex of last ventral segment black; legs nearly concolorous, spots at bases of tibial spines black, tarsi infuscate. Length 5 mm.

Male: Clypeus a little narrower than in female; venter sometimes almost entirely black.

Described from two females and one male.



Fort Collins, September 27th on grass (Gillette).

****Athysanus 6-vittatus*** VanD. Det. VanDuzee.

Colorado (VanDuzee, 4).

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*In Trans. Amer. Ent. Soc, XIX, Mr. VanDuzee separates Athysanus on "Elytra short, without an appendix," giving no exceptions. In his arrangement of the species of the

Acinopterus acuminatus VanD. Det. VanDuzee.

Colorado (VanDuzee, 4).

Steamboat Springs, July 26th (Gillette).

Scaphoideus immistus Say. Det. VanDuzee.

Fort Collins, August 18th, on black walnut (Baker).

Phlepsius cinereus VanD. Det. VanDuzee.

Colorado (VanDuzee, 4).

Fort Collins, August 25th (Baker).

Phlepsius excultus Uhl.

Denver, August 18th; Pueblo (Uhler, 5). Colorado (VanDuzee, 4).

Phlepsius irroratus Say.

Suburbs of Denver and Valley of the Arkansas (Uhler, 5).

Phlepsius ovatus VanD. Det. VanDuzee.

Colorado (VanDuzee, 4).

Horsetooth Gulch, ten miles south-west of Fort Collins, April 25th to May 18th; Rist Canon, eight miles north-west of Fort Collins, June 13th; Dolores, May 18th (Gillette). Fort Collins, October 7th; foot-hills five miles west of Fort Collins, during the winter hibernating under stones (Baker).

Thamnotettix atridorsum VanD. Det. VanDuzee.

Colorado (VanDuzee, 4).

Spring Canon and Dixon's Canon, June 30th; Montrose, June 24; Dolores, June 18th (Gillette).

Thamnotettix belli Uhl. Det. VanDuzee.

Manitou (Uhler, 5). Colorado (VanDuzee, 4).

Fort Collins, May 8th; Soldier Canon, five miles west of Fort Collins, May 19th; Estes Park, July 11th; North Park, July 20th; Steamboat Springs, July 26th; Trinidad, May 14th; Silverton, June 20th; Ouray, June 22d; Dolores, June 18th (Gillette). Fort Collins. May 18th to August 18th on alfalfa and July 29th on cultivated beet; Horsetooth Gulch,

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genus in Can. Ent. XXV, p. 285, one division is stated as having "longer elytra with well developed appendix." It would seem that in the former paper the genus is properly characterized while, between those species which have elytra as long as abdomen or longer and with a well developed appendix, such as anthracinus, bicolor, striatulus, instabilis and obtutus, and some species of the genus Thamnotettix, we find no good generic differences.

ten miles south-west of Fort Collins, May 21st; mountains south-west of North Park on Grizzly Creek, July 10th, on Artemisia tridentata; Rabbit Ears Pass, Routt County, July 20th; Steamboat Springs, July 12th, on Artemisia tridentata (Baker).

Thamnotettix citrinifrons n. sp.

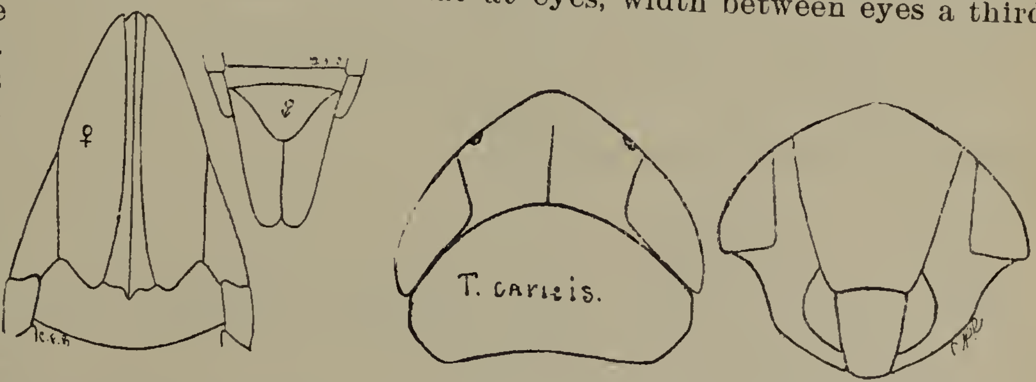
Face one-ninth longer than broad; clypeus two-thirds longer than broad, constricted at the sides, widened near the apex, basal suture curved; lorae as long and nearly as wide as the clypeus; genae very slightly depressed below the eyes, feebly rounded at the sides, attaining the tip of the clypeus, moderately wide below the lorae; front one-fourth longer than broad, once and three-fourths the length of the clypeus, gradually narrowing below, superior angle very obtusely and evenly rounded. Face and anterior one-half of vertex finely shagreened. Disc of vertex slightly depressed, length at middle but little more than at the eyes, width between the eyes two and one-fifth times the length at middle. Pronotum about twice wider than long, length about twice that of the vertex, curvature five-ninths of the length, slightly concave behind, sides short and not carinated. Scutellum shagreened. Color yellow and deep smoky. Face, anterior and middle legs, and posterior femora, deep yellow. Vertex yellow with a transverse black band not attaining the eyes. Pronotum dark smoky, the tip tinged with yellow. Elytra smoky subhyaline, nervures darker. Tergum and venter black with narrow lateral and apical margins yellow. Posterior tibiae and tarsi dark smoky yellow. Sternum black.

Length 4.5 mm, Described from one male.

Leadville, August 23d (Gillette).

Thamnotettix caricis n. sp.

Female: Face somewhat more than one-eighth wider than long; clypeus about one-fourth longer than broad, gradually narrowed to the rounded apex, basal suture nearly straight; lorae one-half as wide and nearly as long as the clypeus; genae broad, hardly depressed beneath the eyes, outer margin evenly rounded, attaining the tip of the clypeus but much wider below the lorae than in longula; front one-eighth longer than broad, twice the length of the clypeus, gradually narrowing below, superior angle obtuse and broadly rounded. Face and anterior third of vertex finely shagreened. Disc of vertex flat, sloping, length at middle once and three-fifths that at eyes, width between eyes a third greater than the length at middle. Pronotum two times wider than long, the length once and a third that of the vertex, curvature three-fifths of length, finely transversely wrinkled and with scattered shallow punctures on the posterior three-fourths, hind margin very slightly concave, sides short and not carinated. Scutellum coarsely shagreened. Hind margin of last ventral segment with the posterior angles produced, medially but little produced, with two blunt, short and broad, black teeth. Color pale yellowish green. Face slightly dusky with indistinct transverse lines on either side of the front. Vertex pale yellowish with a



median dark line on the posterior three-fourths, and a small more or less distinct dark spot on either side of the center close to the posterior margin. Ocelli black. Pronotum greenish on the disc, the margin yellowish. Scutellum yellow. Elytra hyaline, nervures more or less yellow. Venter and eyes pale yellow. Tibial spines arising from black spots, tips of the tarsi infuscate.

Male: Face, vertex, venter, and legs sulphur yellow.

Length of female, 4.25 mm., of male 4 mm. Described from four males and one female.

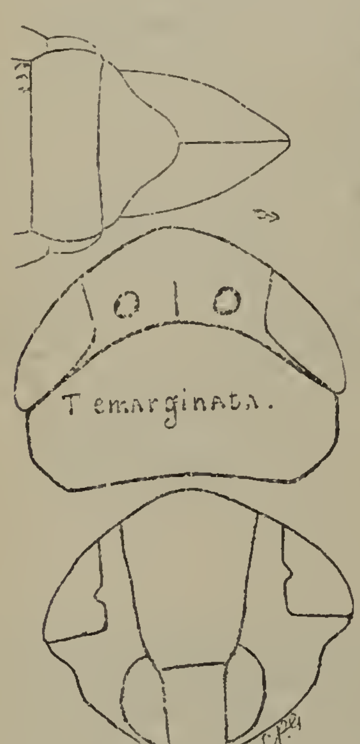
Steamboat Springs, July 12th on Carex (Baker).

Thamnotettix clitellaria Say.

Custer County, midalpine (Cockerell, 10).

Thamnotettix emarginata n. sp.

Face one-seventh wider than long; clypeus one-half longer than broad. sides parallel, apex rounded, basal suture nearly straight; lorae as long as the clypeus and two-thirds as broad; genae strongly depressed below the eyes, the outer margin strongly obtusely angled, attaining the tip of the clypeus, very narrow below the lorae; front one-fourth longer than broad, once and three-fifths the length of the clypeus, gradually narrowing below, rapidly near the clypeus, the superior angle broadly rounded. Face and anterior half of vertex finely shagreened. Eye distinctly and narrowly emarginate within at the antennae. Disc of the vertex flat, length at the middle once and a third that at the eyes, width between the eyes one and four-fifths times the length. Pronotum twice wider than long, the length once and three-fifths that of the vertex, curvature one-half of the length, indistinctly transversely wrinkled posteriorly, hind margin concave, sides short and very feebly carinated. Scutellum finely rugose, transverse groove curved forward. Color pale greenish yellow. Face pale yellow with a small speck on the genae next the lorae and a large spot beneath the antennae, black. Front slightly infuscate, with about six pale dashes on each side. Vertex yellow with a large dark spot near the compound eyes just within the hind margin. Pronotum yellow, disc darker. Scutellum unicolorous. Elytra smoky subhyaline, veins yellowish basally, smoky apically. Venter yellow, with the middle basal portion and narrow lateral margins of each segment, black. Pronotum and meso-sterna black. Legs yellow, bases of tibial spines and tips of tarsi blackish.



Length 5 mm. Decribed from one male.

Steamboat Springs, July 26th (Gillette).

Thamnotettix flavicapitata VanD. Det. VanDuzee.

Colorado (VanDuzee, 4).

Steamboat Springs, July 26th (Gillette).

Thamnotettix flavomarginata n. sp.

Face one-fourth wider than long; clypeus one-half longer than broad, sides concave, apex obtusely rounded, basal suture nearly straight, lorae subovate, three-fourths as broad and four-fifths as long as the clypeus; genae not distinctly depressed beneath the

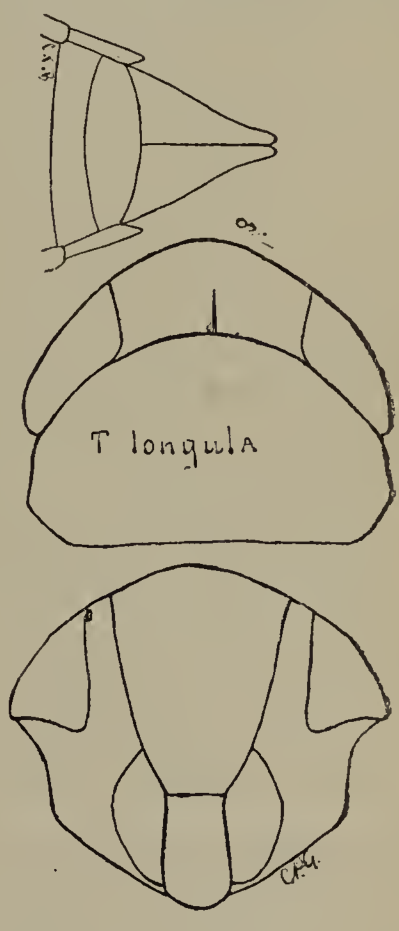
eyes, outer margin broadly angled, attaining the tip of the clypeus, unusually broad beneath the lorae; front one-sixth longer than broad, twice as long as the clypeus, gradually narrowing below, superior angle rather broadly rounded. Face and vertex finely shagreened. Eyes with a small but distinct emargination at the antennae. Disc of the vertex shallowly and broadly depressed, length at middle once and one-third that at the eyes, width between the eyes once and a third the length at the middle. Pronotum about two and two-fifths times wider than long, length one-seventh greater than that of the vertex, curvature two-fifths of the length, feebly wrinkled on the posterior three-fourths, slightly concave behind, sides short and not carinate. Scutellum finely shagreened. Hind margin of the last ventral segment truncate, with a median slit, the hind angles produced and broadly rounded. Color black, with yellow markings. Front with five light dashes on either side and the lower margin yellowish. Crest of the vertex yellow, back of this are two black and two yellow lines extending from eye to eye, a black median line on posterior one-half. Pronotum with a median transverse band and the hind margin yellow. Scutellum with the sides yellow. Elytra dark smoky, nervures and a broad line on the costal margin bright yellow, middle of the cells paler. Abdomen black. Propleura with a yellow spot. Legs black, distal end of anterior femora and a line on outside of posterior tibiae, yellow.

Length 4.5 mm. Described from one female.

Leadville, August 23d (Gillette).

Thamnotettix longula n. sp.

Face one-ninth wider than long; clypeus two-thirds longer than broad, gradually broadening to the apex, sides nearly straight; lorae as wide as the clypeus, and one-fourth longer; genae broad, nearly flat beneath the eyes, outer margin sharply rounded, hardly attaining the tip of the clypeus, very narrow below the lorae; front one-fourth longer than broad, twice the length of the clypeus, gradually narrowing below, superior angle obtusely rounded. Face and vertex finely shagreened. Disc of vertex flat, sloping, one-third longer at the middle than at the sides, width between the eyes little less than twice the length at the middle. Pronotum one and three-fourths times wider than long, length two and one-fourth times that of the vertex, curvature about one-half of the length, smooth on anterior one-fourth, finely transversely wrinkled and with shallow scattered punctures on posterior three-fourths, hind margin slightly concave, sides carinate. Scutellum finely shagreened, transverse groove curved forwards. Color fulvous brown, nearly immaculate. Face with about six indistinct transverse bands on either side of the front. Vertex with a median dark brown line, and a dark spot near the compound eyes on either side just within the posterior margin. Pronotum with a faint yellow longitudinal line, anterior margin whitish in the center. Scutellum with two longitudinal pale lines running forwards from ends of transverse groove, between these lines are two dark spots, tip pale. Elytra uniform smoky subhyaline with nerves and central portions of cells pale. Venter and legs unicolorous.



Length 5 mm. Described from two males.

Fort Collins, September 26th on Carex (Gillette).

Thamnotettix geminata VanD. Det. VanDuzee.

Colorado (VanDuzee, 4).

Dolores, June 18th (Gillette).

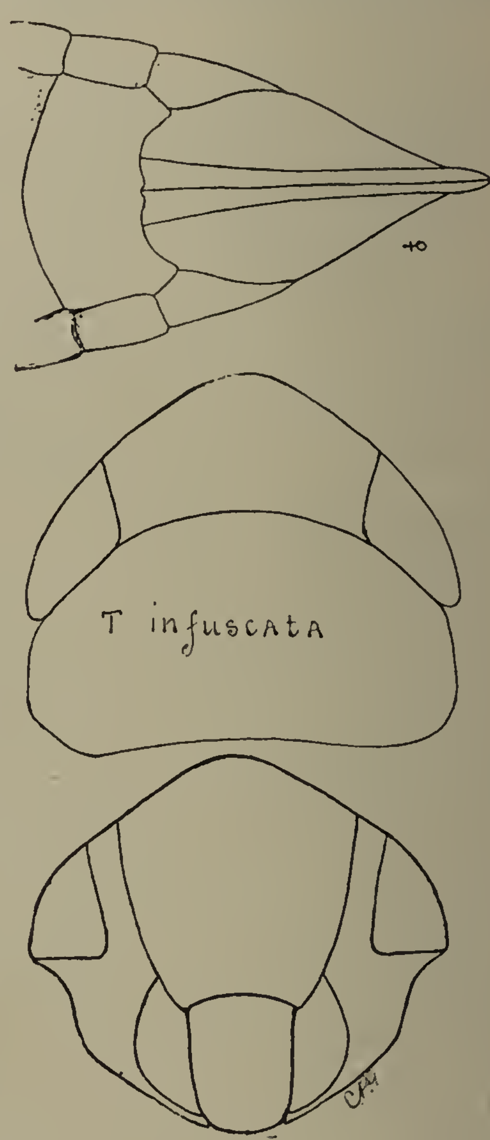
Thamnotettix gillettei VanD. Det. VanDuzee.

Colorado (Gillette—see VanDuzee, 2). Colorado (VanDuzee, 4).

Steamboat Springs, July 26th (Gillette).

Thamnotettix infuscata n. sp.

Face about an eighth wider than long; clypeus one-fourth longer than wide, not at all contracted in the middle, sides parallel, very slightly narrowed towards the tip, basal suture slightly curved; lorae as long and slightly more than one-half as broad as the clypeus; genae broad, somewhat concave below the eyes, outer margin evenly rounded; front scarcely longer than broad, four-fifths longer than the clypeus, gradually narrowing below, superior angle little greater than a right angle and rather pointed. Face and anterior half of vertex shagreened. Disc of vertex with a transverse median depression and with a small pit on either side basally close to the eyes, length at the middle once and two-thirds that next the eyes, width between the eyes once and three-fourths the length at the middle. Pronotum eight-ninths wider than long, length once and two-thirds that of the vertex, curvature five-elevenths of the length, smooth anteriorly, posterior two-thirds finely transversely wrinkled and with numerous scattered subobsolete dark punctures, posterior margin slightly concave, sides little longer than in T. atridorsum, and with a distinct carina. Scutellum finely shagreened, the transverse groove curved forwards. Last ventral segment with hind margin concave, posterior angles subacute, obliquely cut off. Color yellowish. Face and vertex smoky yellow. Pronotum dark with yellow anterior and lateral margins. Scutellum yellow, within the posterior angles smoky, two dark dots before the posterior line. Elytra dark smoky, subhyaline, darker on the shoulders, veins yellowish. Abdomen with segments black, margined apically and laterally with yellow. Venter with two last segments and pygofers yellow. Legs sordid yellow, tips of tarsi infuscate, black spots at base of tibial spines.



Length 6 mm. Described from one female.

Estes Park, July 12th (Gillette).

Thamnotettix kennicotti Uhl. Det. VanDuzee.

Colorado (VanDuzee, 4).

Fort Collins, May 8th; Spring Canon, May 11th (Gillette).

Thamnotettix laeta Uhl. Det. VanDuzee.

From mountains near Beaver Brook, August 6th (Uhler, 5). High mountains, June 19th to September 6th (Carpenter—see Uhler, 6). Colorado (VanDuzee, 4).

Steamboat Springs, July 26th (Gillette).

Thamnotettix longiseta VanD. Det. VanDuzee.

North-western Colorado (Gillette—see VanDuzee, 2). Colorado (VanDuzee, 4).

Steamboat Springs, July 26th (Gillette).

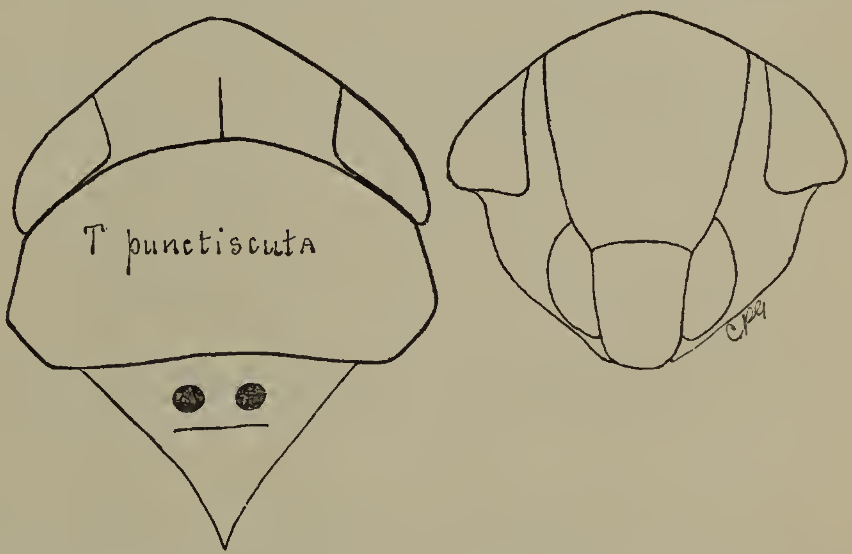
Thamnotettix montanus VanD. Det. VanDuzee.

Mountains of South-western Colorado (Gillette—see VanDuzee, 2). Colorado (VanDuzee, 4).

Steamboat Springs, July 26th (Gillette). Steamboat Springs, July 14th on Carex, Solidago and Delphinium occidentale (Baker).

Thamnotettix punctiscuta n. sp.

Face about one-ninth wider than long; clypeus one-third longer than broad, sides almost parallel, broadly rounded at the apex, basal suture nearly straight; lorae two-thirds as wide and almost as long as the clypeus; genae moderately depressed beneath the eyes, outer margin evenly rounded, attaining the tip of the clypeus, very narrow below the lorae; front nearly as broad as long, once and three-fifths the length of the clypeus, rapidly narrowing below, superior angle very obtuse. Face and vertex finely shagreened. Disc of vertex flat, sloping, length at the middle once and a half that at the eyes, width between the eyes once and four-fifths the length at the middle. Pronotum twice wider than long, length once and three-fourths that of the vertex, curvature three-sevenths of the length, posterior two-thirds finely transversely wrinkled and with scattered shallow punctures, hind margin slightly concave, sides rather long and carinate. Scutellum finely shagreened, transverse suture nearly straight. Color yellowish and smoky. Face yellow with sutures and a spot beneath the antennae black, a small brown spot on the upper end of the lorae and one on the genae beneath the eyes. Vertex yellow with two small approximate brown spots on the disc. Pronotum with disc dark green, front and lateral margin yellow. Scutellum yellow with two black spots in front of the transverse groove. Elytra smoky tinged with green, nervures yellow. Tergum black, margins yellow. Venter black, segments apically margined with yellow, next to the last segment with two large yellow spots on either side. Genital organs yellowish below. Legs light yellow.



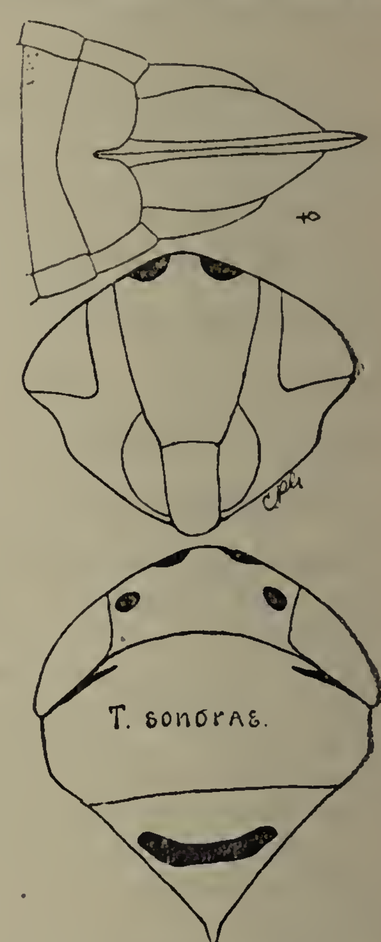
Length 5 mm, Described from one male.

Steamboat Springs, July 26th (Gillette).

Thamnotettix sonorae n. sp.

Face one-sixth wider than long; clypeus one-half longer than broad, slightly constricted at the middle, basal suture curved; lorae three-fourths as broad as the clypeus and slightly longer; genae broad, hardly depressed beneath the eyes, outer margin broadly rounded; front a third longer than broad, two times the length of the clypeus, gradually narrowing to the clypeus, superior angle rather sharp. Front and anterior half of vertex rather coarsely shagreened. Disc of the vertex scarcely depressed, a third longer at the middle than next the eyes, width between the eyes twice the length at the middle. Pronotum two times wider than long, length little less than twice that of the vertex, curvature one-half of the length, scattered shallow punctures on the posterior two-thirds, posterior margin concave, sides short. Scutellum with a small depression just before the apex. Last ventral segment with the hind margin truncate with a deep narrow notch. Color pale yellow. Face pale yellow. Two small transverse spots on the base of the clypeus, and a large spot beneath the antennae, black. Vertex pale yellow with two large approximate black spots on the apex, and a small black spot on either side back of the ocelli. Pronotum greenish yellow washed with sulphur yellow. Scutellum pale sulphurous yellow with transverse groove broadly black. Elytra smoky subhyaline, nervures sometimes darker towards the tip. Venter pale yellow, first segment black. Legs pale yellow, tips of tarsi infuscate.

Length 4.5 mm. Described from two females.



Dolores, June 18th (Gillette).

Thamnotettix (Jassus) tenella Uhl. Det. VanDuzee.

Grand Junction, August 26th, common on sugar beet.

This species, the description of which we have not seen, is referred to Thamnotettix on Mr. VanDuzee's suggestion, though it seems to be a Limotettix.

Eutettix clarivida VanD. Det. VanDuzee.

Colorado (VanDuzee, 4).

Montrose, June 24th (Gillette).

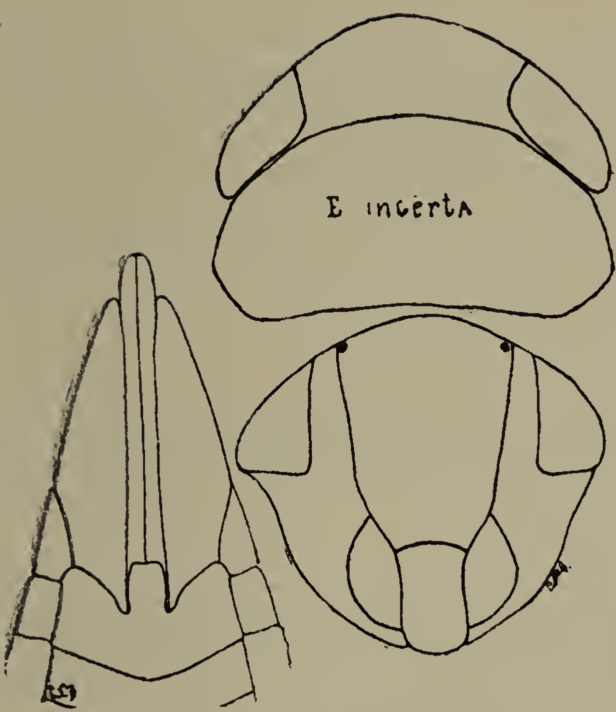
Eutettix (Limotettix) exitiosa Uhl.

Colorado (VanDuzee, 4).

Colorado Springs, August (Tucker).

Eutettix incerta n. sp.

Face one-eleventh wider than long; clypeus fully one-half as long as broad, considerably constricted on the basal two-thirds, broadest near the rounded apex; basal suture curved; lorae as long and nearly as broad as the clypeus; genae broad, feebly depressed



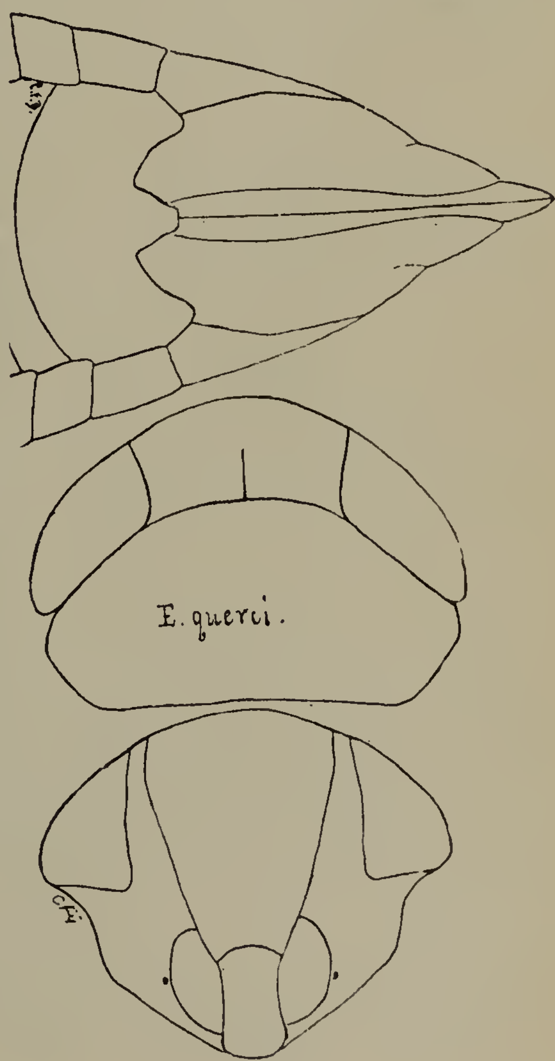
beneath the eyes, outer margin concave near the eyes, broadly rounded below, attaining the tip of the clypeus quite narrow below the lorae; front two-fifths longer than broad, twice as long as the clypeus, superior angle very obtuse and evenly rounded. Face and vertex finely shagreened. Disc of vertex not depressed, one-third longer on the middle than next the eyes, width between the eyes twice the length at the middle. Pronotum two and one-eight times as broad as long, length once and six-sevenths that of the vertex, curvature three-sevenths of the length, smooth anteriorly, posteriorly with scattering obsolete punctures. Scutellum as in querci. Hind margin of the last ventra segment with the tooth more nearly rectangular than in querci. Color fuscous. Vertex, anterior margin of pronotum, and all beneath pale yellowish. Elytra smoky subhyaline with an indistinct darker band extending down and forward from the tip of the clavus. Inner margin of the clavus with two oblique pale spots.

Length 5 mm. Described from one female. Near querci.

Manitou, July (Tucker).

Eutettix querci n. sp.

Female: Face one-sixth wider than long; clypeus fully two-thirds longer than broad, constricted in the middle, broad near the apex, basal suture curved; lorae as long and four-fifths as broad as the clypeus; genae broadly expanded laterally, a broad shallow furrow extending from eyes to lorae, outer margin sharply rounded; front nearly one-third longer than broad, fully twice as long as the clypeus, rapidly narrowing below the antennae, superiorly very obtuse and evenly rounded. Face and vertex finely shagreened. less distinctly on the latter. Disc of the vertex transversely and narrowly depressed just back of the anterior margin, slightly longer on the middle than next the eyes, width between the eyes once and five-sixths the length at the middle. Pronotum little more than twice wider than long, length two times that of the vertex, curvature six-elevenths of the length, anterior one-fourth smooth, posterior three-fourths faintly transversely rugose, posterior margin slightly concave. Scutellum with the black transverse groove curving forward. Hind margin of the last ventral segment with two deep sharp notches, including between them a large blunt median tooth, posterior angles rounded. Color fulvous brown. Face and vertex pale yellow, a small black spot on the genae next to the lorae, vertex with an indistinct brown mottling. Pronotum fulvous brown, yellowish on the anterior margin, with an indistinct pale median line. Scutellum yellowish with the basal angles, two spots between, and apex, fulvous brown. Elytra uniform pale smoky brown, subhyaline. Abdomen except the first ventral segment, yellowish brown, pygofers reddish, pale on the lower margin, with whitish hair arising from black spots. Prosternum with a large black spot. Legs pale yellow, tibial spines arising from black spots, tips of tarsi infuscate.



Male: Differs from the female as follows:—Generally darker colored. Basal joint of antennae distinctly margined internally with black. Vertex more strongly depressed. Elytra with veins dark brown. Venter black with tips of segments yellowish. Plates yellowish brown streaked with black. Black spots on tibiae larger.

Length of female 6-6.5 mm, of male 5 mm. Described from seven females and one male.

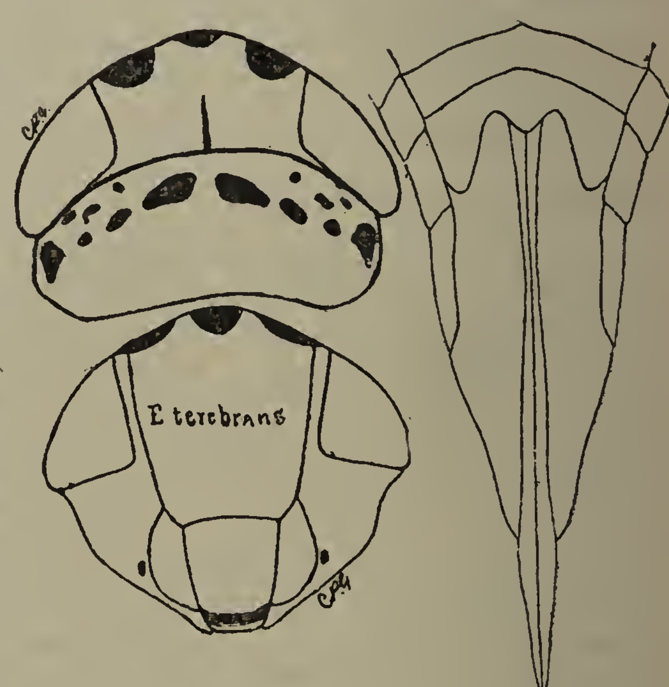
Glenwood Springs, August 24th; Manitou, September 29th on oak (Gillette).

Eutettix seminuda Say.

Montrose, June 24th; Fort Collins, September 11th on apple (Gillette).

Eutettix terebrans n. sp.

Face one-eighth wider than long; clypeus one-sixth longer than broad, narrowing to a truncate apex, deeply transversely depressed near the apex and broadly and shallowly depressed near the base, the lateral margins curved; lorae as long and one-half as broad as the clypeus; genae slightly depressed near the eyes and toward the lorae, outer margin rounded, strongly margined, and slightly exceeding the clypeus; front scarcely longer than broad, once and four-fifths the length of the clypeus, gradually narrowing to near the clypeus, superior angle obtusely rounded. Face and anterior third of vertex coarsely shagreened with scattering shallow punctures. Disc of the vertex with a small depression at the tip and a broad transverse depression before the tip and between the compound eyes, length at the middle once and a fourth that next the eyes, width between the eyes once and a half the length at the middle. Pronotum considerably more than twice as broad as long, length once and a fourth that of the vertex, curvature about one-half of the length, shagreened on the anterior third, transversely wrinkled on the posterior two-thirds, posterior margin slightly concave. Scutellum coarsely shagreened, slightly shorter than the pronotum. Last ventral segment with the hind margin broadly and very deeply notched, the notch with a short, strong, rounded tooth at the center, the lateral angles produced and subacute. Ovipositor extremely long, as long as the body back of the head, exceeding the pygofers by about 1 mm., and the wings by .3 mm. Color tawny yellow. Face light brownish yellow, about six transverse dark dashes on either side of the front; genae with a dark spot below the eyes and a dark point near the lorae. Vertex with a large rectangular spot either side next the eyes and a smaller one at the apex, the sunken pit just back of this spot blackish, and about four indistinct infuscated spots between the eyes near the hind margin. Pronotum with two small transverse black spots near the median line and about one-third of the length back of the front margin, back of the compound eyes on either side are about six small black spots, back of these spots the disc is brownish yellow. Scutellum yellowish, transverse groove black. Elytra yellowish subhyaline. Tergum yellowish with six longitudinal black bands. Venter yellowish with basal segment black. Pygofers yellow streaked with black, valves yellow on the lower margins, black at the sides. Legs dirty yellow, tibial spines brown, tips of tarsi infuscate. Propleura with a black spot.



Length 4.75 mm. Described from one female. This unique form introduces a very novel element into the genus Eutettix.

North Park, July 20th (Gillette).

Eutettix vanduzei n. sp.

Face two-elevenths wider than long; clypeus one-third longer than broad, slightly constricted at the middle, nearly as broad before the apex as at the base, basal suture curved; lorae somewhat shorter and much narrower than the clypeus; genae broad, nearly flat, very broadly rounded outwardly; front about one-fourth longer than wide almost twice the length of the clypeus, gradually narrowing to the clypeus, superior angle very broadly rounded. Face and vertex finely shagreened. Disc of the vertex flat, two shallow pits immediately back of the large black spots near the anterior edge, once and a half as long on the middle as next the eyes, width between the eyes little more than twice the length at the middle. Pronotum two and a sixth times wider than long, length once and a half that of the vertex, curvature about one-half of the length, posterior two-thirds finely transversely wrinkled, with scattering shallow black punctures, posterior margin shallowly concave. Scutellum finely shagreened. Last ventral segment of the female with the hind margin nearly truncate, posterior angles obliquely cut off. Color pale greenish yellow. Face light yellow, sutures, spot beneath antennae, two transverse spots at the extreme base of the clypeus, two V-shaped marks on the genae, and two large curved spots immediately beneath the crest of the vertex, black. Vertex pale yellow with two large black spots on the disc, a little nearer to the eyes than to each other. Pronotum yellowish, with two more or less distinct transverse black lines, one just before the middle and the other next the posterior margin. Scutellum light yellow, transverse suture black. Elytra greenish subhyaline with nervures yellowish. Tergum black, with broad lateral and narrow apical margins yellow. Venter pale yellow with median basal portions of first two segments black. Ovipostor black. Legs pale yellow with minute black spots at bases of tibial spines, tips of tarsi infuscate.

Length 5 mm. Described from one female.

Rabbit Ear Pass, Larimer County, July 20th (Baker).

This species may prove to be Thamnotettix (sensu strict.). It is certainly congeneric with E. clarivida.

Chlorotettix unicolor Fitch. Det. VanDuzee.

Steamboat Springs, July 26th; Colorado Springs, August 3d (Gillette).

Neocoelidia n. gen.

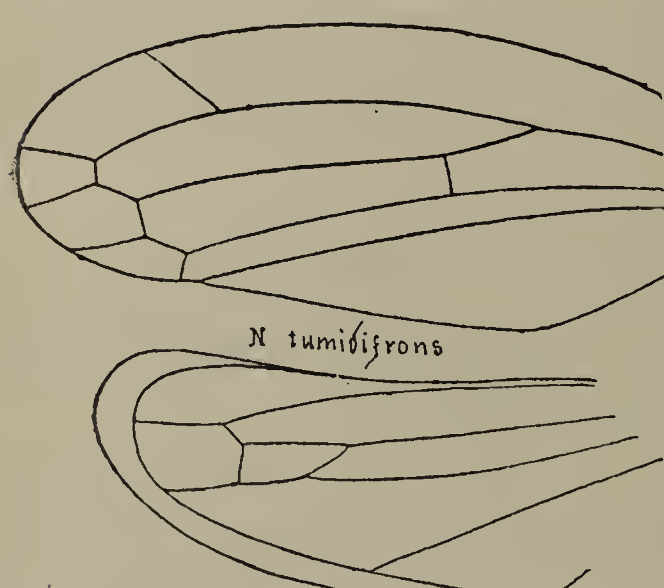
Allied to Tinobregmus. Body short and robust. Head narrower than pronotum, short conical, rather obtuse and tumid; vertex expanded posteriorly behind the eyes, ocelli on extreme front edge, front very broad below, the sides nearly parallel. Antennae as long as head, pronotum, and scutellum together. Pronotum short, length at middle four-fifths that of vertex, anterior and posterior margins nearly parallel. Scutellum large, normal. Elytra semicoriaceous, without an appendix, but extending beyond the tip of the abdomen; the first sector but once forked in the proximal two-thirds, the inner branch connected with the second sector by a single transverse nervure, the latter entering an anteapical cell; apical areoles four. Wings well developed, margined, the nervures very strong, second and third sectors uniting before the marginal nervure, thus forming but one apical cell; a transverse nervure between second and third sectors forming a single, short, triangular, apical cell. Rostrum longer than the clypeus. Posterior tibiae outwardly with two rows of moderate spines. Type, N. tumidifrons.

Neocoelidia tumidifrons n. sp.

Face a thirteenth wider than long; clypeus two-thirds longer than broad, sides nearly parallel, apex nearly truncate, basal suture strongly curved; lorae nearly as long and two-thirds as broad as the clypeus; genae broad, somewhat depressed below the eyes, outer margin broadly rounded, very broad below the lorae; front tumid, sides nearly parallel, broad below, one-fourth longer than broad, nearly twice the length of the clypeus, superiorly obtusely rounded. Face shagreened. Vertex tumid, elevated, coarsely shagreened, a shallow longitudinal depression on either side, three-fifths longer on the middle than next the eyes, width between the eyes once and two-sevenths the length at the middle. Pronotum coarsely transversely rugose, three times as broad as long, four-fifths the length of the vertex, curvature three-sevenths of the length. Scutellum with lateral margins broadly, sharply, and deeply depressed, the scutellar suture subobsolete, nearly straight. Last ventral segment long, narrowing to an acute point, nearly equalling the pygofers. Color light green, unicolorous below, except the black tips of the pygofers. Two small black spots within the basal angles on the edge of the elevated portion of the scutellum.

Length 3.5 mm. Described from two males.

Fort Collins, June 6th (Baker). Pleasant Valley, seven miles north-west of Fort Collins, June 12th (Gillette).

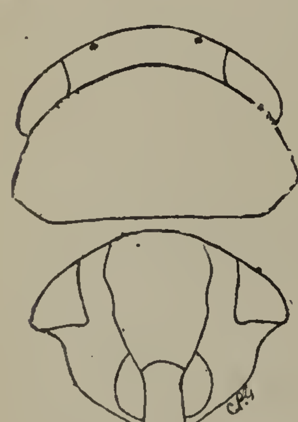


Gnathodus abdominalis VanD.
Det. VanDuzee.

Colorado (VanDuzee, 4).

Colorado Springs, August 2d; Glenwood Springs, August 24th; Grand Junction, August 26th, on sugar beet (Gillette). Fort Collins. June 9th on barley; Steamboat Springs, July 16th (Baker). Colorado City, August (Tucker).

Gnathodus confusus n. sp.



Face one-fifth wider than long; clypeus twice as long as broad, basal suture strongly curved, somewhat constricted near the base, broadest near the tip; lorae about three-fourths as broad and three-fourths as long as the clypeus; genae broadly depressed beneath the eyes, margin beneath the eyes inverted, broadly rounded below, moderately broad below the lorae and attaining the tip of the clypeus; front one-fifth longer than broad, once and two-thirds the length of the clypeus, superiorly broadly rounded. Face, vertex, and pronotum finely shagreened. Vertex scarcely longer on the middle than next the eyes, width between the eyes slightly more than four times the length at the middle. Pronotum slightly less than twice as broad as long, length nearly four times that of the vertex, curvature about one-half of length, considerably wider than the head, hind margin slightly concave. Transverse groove of scutellum black. Hind margin of last ventral segment of female truncate. Color yellowish green. Face sordid yellow, basal angles of the clypeus with an infuscated spot. Vertex of the same color as the face, with three indistinct longi udinal smoky bands, the ocelli in light areas. Pronotum light yellowish green on the anterior and lateral margins, darker green on the middle, two dark brown spots medially just back of the anterior margin, the latter in some specimens entirely obsolete. Scutellum pale yellow, basal angles darker. Elytra greenish subhyaline, slightly maculate with brown near the clavus, somewhat smoky towards the tip. Tergum black with the apical margins of the segments yellow. Venter yellow with the first two or three segments black at the base, pygofers yellowish. Sternum black. Legs yellowish throughout, with infuscated lines on the outside of the femora.

Length 3.75 mm. Described from seven females.

Pleasant Valley seven miles north-west of Fort Collins, June 12th; Estes Park, July 12th (Gillette). Steamboat Springs, July 12th on Carex (Baker).

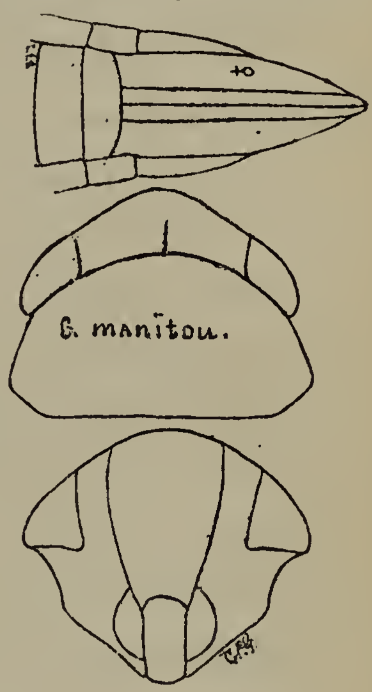
We have a single female specimen which seems distinct from this species, but to which at this time we hesitate giving a name. It differs as follows: The color more yellowish. Pronotum distinctly less than twice broader than long. Length 4 mm.

Estes Park, July 12th (Gillette).

Gnathodus manitou n. sp.

Face finely shagreened, a seventh wider than long; clypeus nearly twice as long as broad, rounded at the tip, slightly constricted before the base, basal suture strongly curved; lorae nearly as long and three-fourths as broad as the clypeus; genae moderately broad, rather deeply depressed beneath the eyes, outer margin angularly incised below the eyes, sharply rounded below, attaining the tip of the clypeus; front one-half longer than broad, twice as long as the clypeus, gradually narrowing below, obtusely rounded above. Vertex one-half longer on the middle than next the eyes, width between the eyes two and one-half times the length at the middle. Pronotum five-sixths broader than long, two and three-fifths times longer than the vertex, curvature two-fifths of the length, posterior margin very slightly concave, anteriorly smooth, posteriorly with scattered feeble punctures, on the posterior median portion finely obliquely rugose, the lines converging backwards. Last ventral segment feebly rounded behind, nearly truncate, pygofers with numerous stout hairs along the whole length. Color pale green, unicolorous. Elytra hyaline.

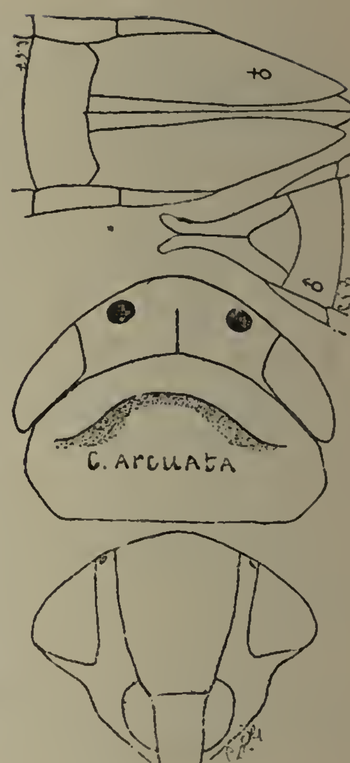
Length 5 mm. Described from one female.



Manitou, July (Tucker).

Cicadula arcuata n. sp.

Female: Face finely shagreened, one-sixth wider than long; clypeus one-half longer than broad, sides parallel, rounded at the apex, basal suture curved; lorae three-fourths as long and one-half as wide as the clypeus; genae moderately broad, somewhat depressed beneath the eyes, outer margin angled above, straight below, attaining the tip of the clypeus, moderately broad below the lorae; front one-fourth longer than broad, once and three-fourths the length of the clypeus, superiorly very obtusely and evenly rounded. Vertex a third longer on the middle than next the eyes, width between the eyes two and one-third times the length at the middle, finely shagreened anteriorly. Pronotum little less than twice as broad as long, and little more than twice the length of the vertex, curvature one-half of the length, posterior margin straight, disc with scattered shallow punctures. The black scutellar suture nearly straight. Hind margin of the last ventral segment nearly truncate, posterior angles obliquely cut off, pygofers with stout hairs on the distal half. Color greenish yellow. Face yellow, sutures of the front and clypeus and sockets of the antennae black, above dusky with several rather indistinct transverse lines. Vertex yellowish to brownish with a fine black median line on the basal half, and two large black spots anteriorly between the compound eyes. Pronotum greenish yellow, anteriorly with a transverse black line nearly parallel with the anterior margin, its lateral ends bent forward. Elytra pale greenish, hyaline, nervures yellowish. Tergum black, segments narrowly margined with yellowish. Venter and pygofers yellow, valves black. Sternum black. Legs pale yellow.



Male: Sutures of the face more heavily black, the face above darker with a small black spot on either side above antennae. Vertex with a black line margining the eyes. Basal angles of the scutellum with black spots within. Venter black, posterior margins of segments broadly yellow. One specimen lacks entirely the black arc on the pronotum.

Length of female 4.75 mm., of male 4.5 mm, Described from two males and one female.

Estes Park, July 12th; Leadville, August 23d (Gillette). Steamboat Springs, July 12th, on Solidago (Baker).

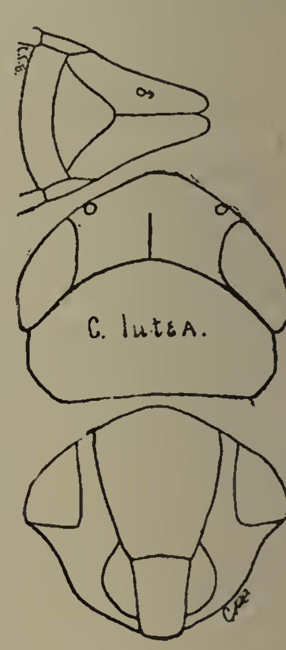
Cicadula divisa Uhl.

Abundant upon low herbage in damp fields near Denver, and near Sloan's Lake, west of Denver, August 17th (Uhler, 5).

Estes Park, July 12th; Leadville, August 23d; Minturn, August 24th (Gillette). Fort Collins, September 2d, on Solidago; Steamboat Springs, July 12th, on Carex (Baker). Colorado Springs (Tucker).

This species will probably prove to be, at the most, but a form of C. 6-notata.

Cicadula lutea n. sp,



Face one-seventh wider than long; clypeus one-third longer than broad, tapering to the rounded apex, sides nearly straight; lorae a little shorter and about one-half as broad as the clypeus; genae broad, outer edge incurved beneath the eyes, broadly rounded below, moderately broad below the lorae; front one-sixth longer than broad, three-fourth slonger than the clypeus, superiorly broadly rounded. Face finely shagreened. Vertex shagreened, punctured on a small median area, with an oblique pit on either side near the hind margin, one-third longer on the middle than next the eyes, width between the eyes little more than once and a half the length at middle. Pronotum smooth anteriorly, posteriorly finely transversely wrinkled with scattered punctures, four-fifths wider than long, one-half longer than the vertex, curvature six-tenths of the length

Color deep lemon-yellow. Face and all below concolorous. Vertex with a narrow median lineand a smallspot in the position of each ocellus black. Pronotumposteriorly dark greenish yellow. Scutellum greenishyellow. Elytra hyaline, nervures yellow, wings iridescent. Tergum black, with narrow apical margins of segments and the whole of the last segment yellow. Extreme tips of valves black.

Length 3.5 mm. Described from one male.

Steamboat Springs, July 12th, on Carex (Baker).

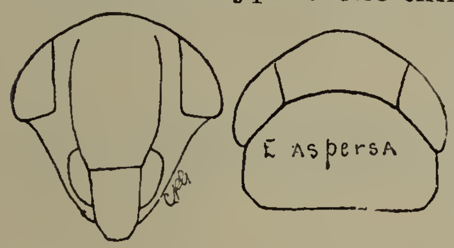
Cicadula 6-notata Fall. Det. VanDuzee.

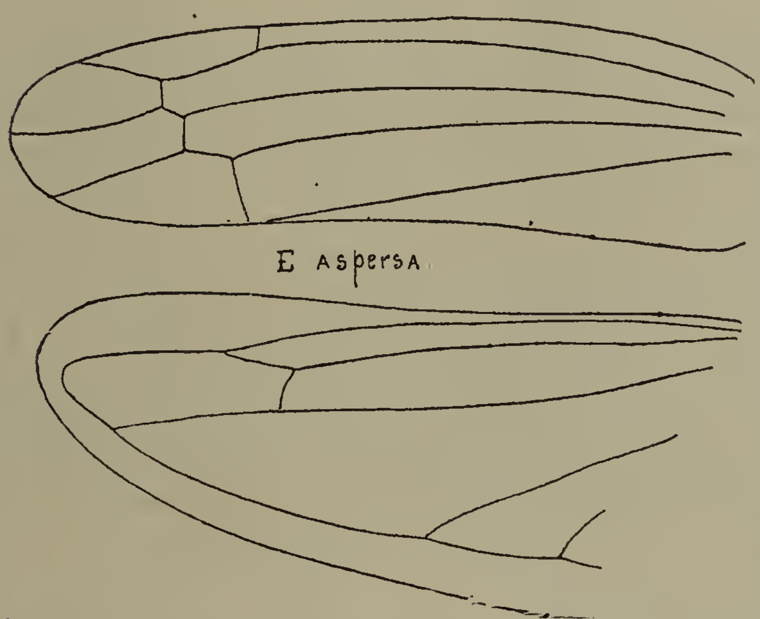
Montrose, June 24th; Colorado Springs, August 1st (Gillette). Fort Collins, July 24th (Baker).

Cicadula variata Fall.

Leadville, August 23d (Gillette). Steamboat Springs, July 16th (Baker).

Empoasca aspersa n. sp.





Female: Clypeus one-third longer than broad, basal suture straight; lorae half as broad and two-thirds as long as the clypeus; genae long and narrow, moderately furrowed beneath the eyes, the furrow extending to the lorae, outer margin somewhat concave; front two-thirds longer than broad, twice as long as the clypeus, superior angle little more than a right angle and broadly rounded. Face and vertex without sculpturing, the latter glabrous. Disc of vertex once and a half as long on the middle as next the eyes; pronotum slightly less than twice wider than long, front margin broadly rounded, hind margin slightly concave, disc very finely longitudinally aciculate. Scutellum broader than long, transverse groove straight and black. Last ventral segment with the hind margin evenly rounded and the posterior angles sloping. Color greenish; face yellowish green, front more or less distinctly marked with a pale median line and with transverse concentric pale lines; vertex and pronotum whitish or pale yellowish green, with about four more or less distinct deeper yellowish green and variously bent, nearly longitudinal lines, sometimes orange on the former and dusky on the latter; scutellum with basal angles dark or yellowish green, median portion whitish mottled with greenish; elytra greenish, hyaline at tip, nervures whitish, basal two-thirds finely spotted with dusky green; tergum black with more or less of sides and apical margins yellowish; venter pale green, pygofers darker; legs pale greenish shading to bright blue at tips. Length 3 mm.

Male: Markings which in the female are dark yellowish green, are dusky here.

Described from six females and two males.

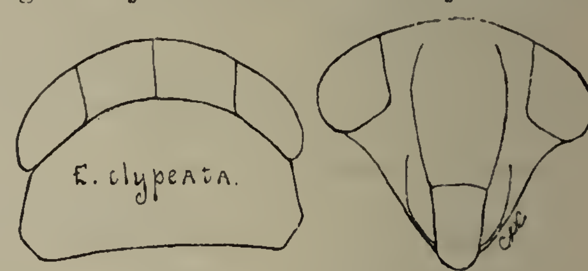
Fort Collins, on Bigelovia, September 27th (Gillette). In mountains south-west of North Park July 10th, and at Steamboat Springs July 12th, on Artemisia tridentata (Baker).

Empoasca aureo-viridis Uhl.

In large numbers at Denver and in Clear Creek Canon, on willows, August 7th to 18th (Uhler, 5). Colorado (VanDuzee, 4).

Empoasca clypeata n. sp.

Male: Clypeus one-half longer than broad, basal suture straight; lorae as in T. sanguinea; genae very narrow, attaining the clypeus as a very narrow line, lateral margins nearly straight; front nearly twice as long as its greatest width between the eyes, twice the length of the clypeus, superior angle very broad and obtusely rounded. Face and vertex finely shagreened. Disc of vertex flat, sloping, scarcely longer on the middle than next the eye. Pronotum slightly wrinkled on posterior two-thirds, glabrous in front, slightly more than twice as broad as long, anterior margin broadly rounded, posterior margin concave, posterior angles sharply rounded, sides long. Scutellum normal, transverse suture straight. Color yellowish; in light specimens, face, vertex, pronotum, and scutellum yellowish, concolorous; in dark specimens front with a median white line, pronotum dusky on posterior half, scutellum with basal angles and transverse groove dark; elytra in light specimens yellowish subhyaline, in dark specimens shaded into deep smoky subhyaline; venter and legs entirely pale yellow, sometimes tibiae and tarsi slightly smoky.

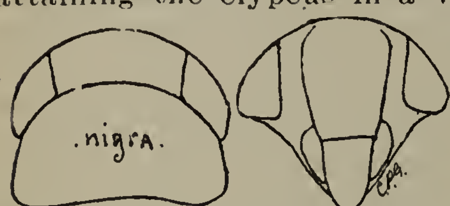


Length 4.5 mm. Described from six males.

Estes Park, July 10th (Gillette). Steamboat Springs, July 10th on willow (Baker)

Empoasca nigra n. sp.

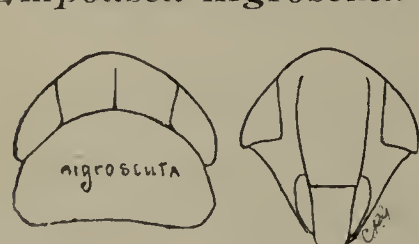
Male: Clypeus about one-half longer than broad, basal suture straight; lorae as in T. sanguinea; genae suddenly broadening close to eye, lateral margin almost straight, attaining the clypeus in a very narrow line; front nearly one-half longer than broad, once and two-thirds the length of clypeus, superior angle broadly obtusely rounded. Face coarsely and obsoletely shagreened. Disc of vertex sloping, with a slight median depression on the posterior half opening into a slight depression on the anterior margin of the pronotum, length at the middle slightly more than next the eyes. Pronotum opaque, on anterior third smooth, on posterior two-thirds indistinctly transversely rugose; slightly less than twice as broad as long, anterior margin broadly rounded, posterior margin somewhat concave, posterior angles sharply rounded. Scutellum opaque, with a median pit just in front of the transverse groove, posterior half irregularly wrinkled. Color black; antennae whitish; ocelli surrounded by a narrow pale margin; elytra black, posterior third fading into smoky subhyaline; anterior tibiae, and all the tarsi, smoky.



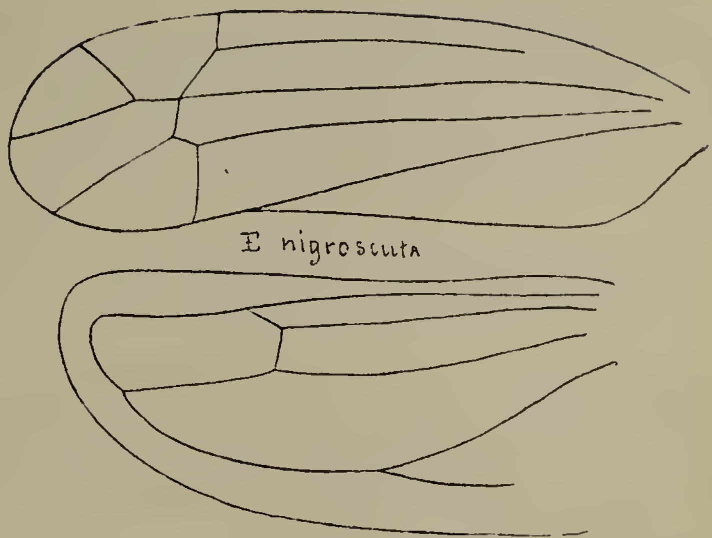
Length 2.75 to 3 mm. Described from five males.

Mountains south-west of North Park, July 10th, on Artemisia tridentata (Baker).

Empoasca nigroscuta n. sp.



Female: Clypeus minutely transversely rugose, one-half longer than wide, basal suture straight, apex rather pointed; lorae two-thirds as long, and one-half as wide as clypeus, distant from tip of clypeus; genae narrow, a deep sunken furrow beneath the eyes extending to the lorae, not attaining tip of clypeus, outer margin nearly straight, very narrow below lorae; front smooth, nearly twice longer



than wide, once and three-fourths the length of the clypeus, superior angle somewhat greater than a right angle, rather sharply rounded. Disc of vertex smooth, once and a half as long on middle as next eyes. Pronotum very minutely transversely wrinkled on posterior three-fourths, anterior margin broadly rounded, hind margin nearly straight, sides short. Scutellum broader than long, transverse groove slightly curved backward. Last ventral segment with hind margin nearly truncate, Color pale yellow marked with smoky; face and vertex pale yellowish, posterior one-half of latter with a median black line; pronotum pale yellow on anterior and lateral margins, remainder darker; scutellum black. basal angles sometimes yellowish; elytra yellowish, subhyaline, apex smoky, clavus with a large deep smoky blotch at tip; venter blackish, last segment yellow; tergum blackish, with tips and lateral margins of segments more or less yellowish; prosternum black; legs pale yellow.

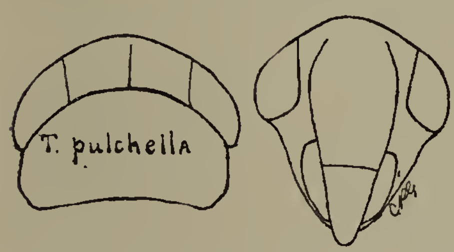
Length 3 mm. Described from two females.

Dolores, June 18th (Gillette).

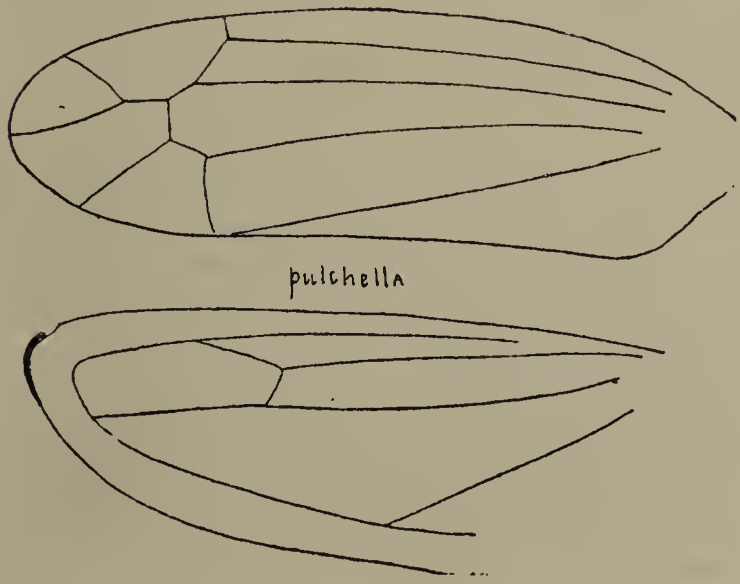
Empoasca obtusa Walsh. Det. Gillette.

Fort Collins, June 23d on Virginia Creeper; Estes Park, July 12th; Colorado Springs, August 23d; Manitou, September 29th, on willow; Minturn, August 24th; Leadville, August 23d (Gillette). Fort Collins, June 9th. on alfalfa, and August 4th on cottonwood; Steamboat Springs. July 15th, on willow (Baker). Colorado Springs, August (Tucker).

Empoasca pulchella n. sp.



Female: Clypeus a third longer than wide, basal suture straight; lorae long and narrow, scarcely grooved, attaining the end of the clypeus; front two-thirds longer than broad, nearly twice the length of the clypeus, superior angle obtusely rounded. Face and vertex without sculpturing, opaque. Disc of vertex scarcely longer on the middle than at the sides. Pronotum twice as wide as long, front margin broadly rounded, hind margin decidedly concave, posterior angles broadly, rounded, sides rather short, without distinct sculpturing but with two small pits near the median line one-fourth of the distance back from the anterior margin. Scutellum broader than long, transverse groove black. Last ventral segment with the hind margin deeply and broadly notched, posterior angles rounded. Color steel blue varied with smoky and orange; head pale orange, genae and a large triangular mark on front extending onto and across vertex medially, ivory white; disc of vertex with a black median line on posterior twohirds; ocelli rufous and distant from the eyes; pronotum pale blue washed



with white and pale orange on anterior and lateral margins; scutellum orange with whitish mottling; elytra subhyaline, smoky at base across median portion, and at tip, forming three broad indistinct transverse bands, clavus and corium posteriorly, each with a pale orange stripe, veins whitish apically; last ventral segment almost entirely whitish, pygofers rufous below; legs sordid white.

Length 3 mm. Described from one female.

In mountains south-west of North Park, July 10th, on Artemisia tridentata (Baker).

Although we would think it unadvisable, as a rule, to describe Typhlocybidae from single specimens, we have concluded to do so with a few well marked uniques that we took the past season.

Empoasca pura Stal. Det. Gillette.

Fort Collins, June 24th, and September 27th on Clematis ligusticifolia; Manitou, September 29th, on oak (Gillette).

Our specimens referred to this species may prove to be new as we have not seen types. Our specimens answer to the description of pura.

Empoasca (*Kybos*) *smaragdula* Fall. Det. Gillette.

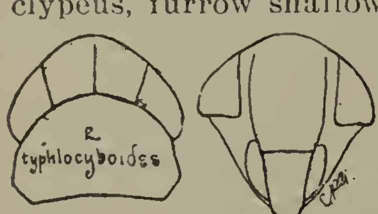
Colorado (VanDuzee, 4).

Spring Canon, eight miles south-west of Fort Collins, June 30th to July 12th; The Rustic, Larimer County, August 11th (Gillette). Steamboat Springs, July 15th on willow (Baker). Cheyenne Canon, Colorado Springs, July (Tucker).

The genus Kybos must fall under the older name Empoasca. Specimens of K. smaragdulus received through Mr. VanDuzee from France (Lethierry) show a typical Empoasca wing and elytron and we can find no generic characters to separate it from that genus.

Empoasca typhlocyboides n. sp.

Male: Clypeus subacute at apex, one-fifth longer than broad, basal suture straight; lorae one-half as wide and two-thirds as long as clypeus; genae narrow, not attaining tip of clypeus, furrow shallow, outer margin slightly concave over coxae, slightly convex along lorae; front one-fourth longer than broad, nearly twice the length of clypeus, superior angle broadly rounded. Face and vertex nearly smooth. Length of vertex at middle nearly once and a half that next the eyes. Pronotum slightly less than twice as broad as long, posterior two-thirds minutely transversely rugose, front margin broadly rounded, hind margin concave, posterior angles broadly rounded. Scutellum broader than long, transverse groove straight. Color pale bluish or yellowish green; face and vertex pale yellow: pronotum pale yellow



or bluish green, with front and lateral margins yellowish, hind margin sometimes whitish; disc of pronotum sometimes with three faint longitudinal orange lines; scutellum yellowish, sometimes posterior angles bluish, elytra milky subhyaline, clavus with two faint longitudinal orange marks, another near tip, a faint broken longitudinal orange line on corium, veins whitish towards apex; abdomen pale greenish yellow; legs pale yellow at base shading into deep blue at tips.

Length 2.5 mm. Described from three males.

Steamboat Springs, July 12th, on Artemisia tridentata (Baker).

Empoasca viridescens Walsh. Det. Gillette.

Fort Collins, September 27th, on Solidago spectabilis (Gillette).

Typhlocyba bifasciata n. sp.

Near tricincta. Female: Clypeus once and a quarter as long as broad, basal suture straight; genae long and narrow, with a broad deep groove from eye to clypeus, slightly concave outwardly, broadest at eye, attaining tip of clypeus; lorae as long and somewhat narrower than clypeus; front three-fourths longer than broad between eyes, three times as long as clypeus, superior angle more than a right angle and broadly rounded. Face and vertex very finely and obsoletely punctured, more distinctly on upper part of front. Disc of vertex, flat, sloping, slightly less than one-half longer at middle than at eyes. Pronotum slightly less than twice as broad as long at middle, broadly rounded before, slightly concave behind, posterior angles rather sharply rounded, lateral margins long; disc of pronotum with anterior third smooth, posterior two-thirds very indistinctly transversely rugose; scutellum slightly shorter than pronotum, broader than long, transverse groove straight, black, ends bent backwards; last ventral segment with hind margin broadly rounded. Color yellow; face, vertex, and pronotum, light lemon yellow, concolorous; scutellum dark smoky; elytra light lemon yellow with a broad smoky transverse band just in front of middle, broader on inner margins, another broad smoky band at apex, lighter on middle portion; venter pale yellow; legs pale whitish yellow. Length 4 mm.

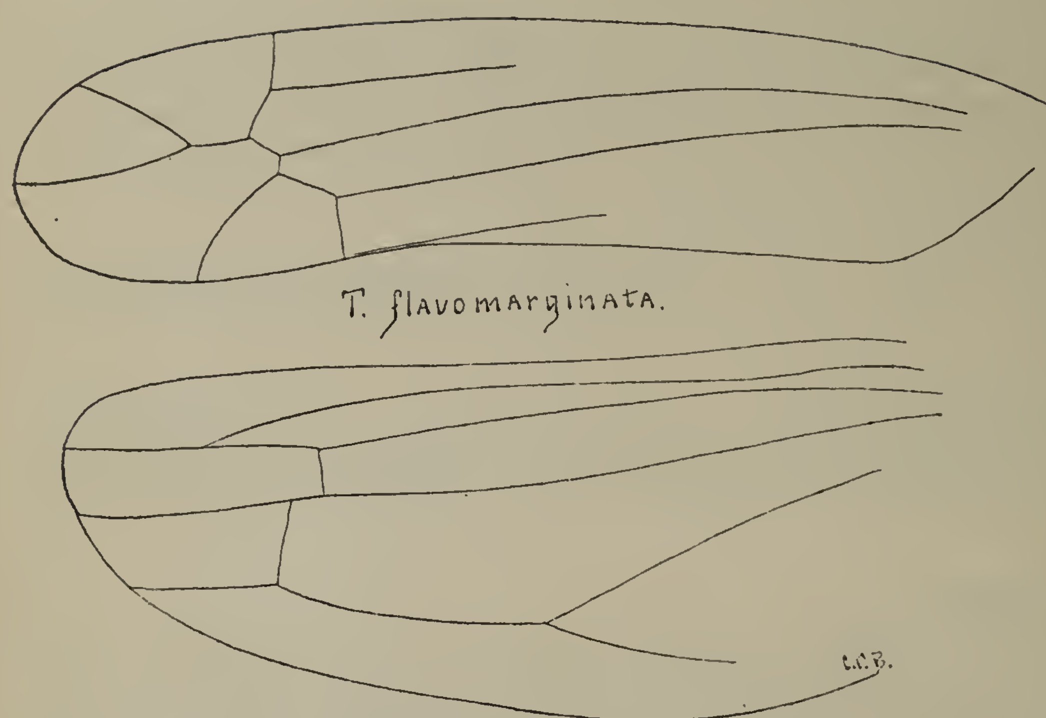
Described from one female. Minturn, August 24th, (Gillette). We also have specimens from New York (Lintner) Illinois (Forbes) and Iowa (Osborn).

Typhlocyba comes Say. Det. Gillette.

Canon City, August 31st, on plum; Manitou, September 29th on oak (Gillette).

Typhlocyba flavomarginata n. sp.

Female: Clypeus a third longer than broad, basal suture straight, sides nearly parallel; lorae and genae as in bifasciatus: front three times the length of clypeus, one-third broader than long, superior angle greater than a right angle, broadly rounded. Face, vertex, and pronotum, sculptured as in bifasciatus. Proportions of vertex, pronotum and scutellum, same as in bifasciatus. Last ventral segment with posterior angles produced, acute, a broad deep emargination between them, the base of which is



notched. Color pale yellow or whitish; face, vertex, and pronotum whitish, concolorous, scutellum whitish with basal angles darker; elytra whitish subhyaline, nervures lighter, costal and internal margins flavescent, deeper on inner margin; venter and legs pale yellow; pygofers, sheaths of ovipositor, prosternum, and tip of rostrum tinged with flavescent.

Length 4 mm. Described from three females.

Manitou, September 29th, on oak (Gillette).

Typhlocyba obliqua Say. Det. Gillette.

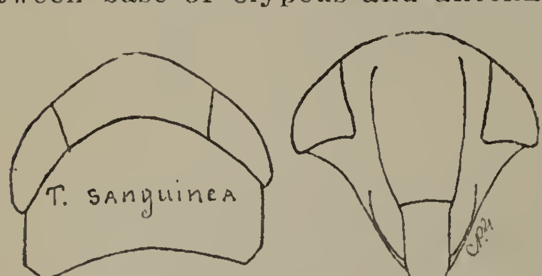
Foot-hills, five miles west of Fort Collins, April 25th; Canon City, August 31st, on plum; Manitou, September 29th, on oak (Gillette).

Typhlocyba rosae Harr. Det. Gillette.

Fort Collins, October 11th, on apple; Denver, September 1st, on apple; Manitou, September 29th, on oak (Gillette). Cheyenne Canon, Colorado Springs, July (Tucker).

Typhlocyba sanguinea n. sp.

Near coccinea. Female: Clypeus one-half longer than broad, basal suture straight; lorae very long and narrow, a half longer than clypeus, reaching half the distance between base of clypeus and antennae; genae long and narrow, lateral margin concave, slightly grooved along sides of lorae. Front nearly twice longer than wide at widest place between eyes, two and one-fifth times as long as clypeus, superior angle greater than a right angle, very obtusely rounded; face and anterior half of vertex very finely rugose; length at middle of disc of vertex one-fourth more than length at eyes. Pronotum glabrous with obscure transverse wrinkles on posterior one-half, four-fifths broader than long, anterior margin broadly rounded, posterior margin distinctly concave, sides normal; scutellum broader than long; last ventral segment with hind margin broadly produced, very slightly notched at apex. Color pale yellow; face tinged with sanguineous above; vertex, pronotum except at sides, and scutellum, bright sanguineous; elytra hyaline, veins very light yellow; vertex at sides, and tergum, tinged with sanguineous; legs unicolorous.



Length 4 mm. Described from one female.

Manitou, September 29th, on Salix (Gillette).

Typhlocyba tricincta Fh. Det. Gillette.

Fort Collins, September 27th, on grass (Gillette).

Typhlocyba vitifex Fh. Det. Gillette.

Fort Collins, September 4th, on Virginia Creeper (Baker). Fort Collins, September 27th, on grass; Spring Canon, eight miles south-west of Fort Collins, May 11th (Gillette).

Typhlocyba vitifex Harr. var. ***coloradensis*** Gill. Det. Gillette.

Fort Collins (Gillette, 6).

Fort Collins, March 8th, hibernating under dead leaves in vineyard (Baker). Fort Collins, May 18th to August 19th, on grape (Gillette).

Typhlocyba vitis Harr.

Colorado (Van Duzee, 5).

This record is certainly a doubtful one, and probably refers to vitifex.

Typhlocyba vulnerata Fitch. Det. Gillette.

Spring Canon eight miles south-west of Fort Collins, May 11th; Fort Collins, June 23d on Virginia Creeper (Gillette). Fort Collins, March 8th, hibernating under leaves in vineyard, and September 4th on Virginia Creeper (Baker).

Psylla coryli Riley Ms. Det. Riley.

Steamboat Springs, July 26th (Gillette). Manitou, July (Tucker).

Psylla gillettei Riley Ms. Det. Riley.

Fort Collins, May 23d; Rist Canon, April 10th (Gillette). Rist Canon, April 20th on willow; Fort Collins, May 7th on alfalfa; Cameron Pass July, 5th, above timber on a dwarf Salix (Baker).

Psylla negundinis Riley Ms. Det. Riley.

Fort Collins, June 4th (Gillette). Fort Collins, June 9th on alfalfa (accidental), and September 26th, abundant on box-elder; on the latter date a black ant was found carrying a living specimen from the tree to the ground (Baker).

Psylla purshiae Riley Ms. Det. Riley.

Rist Canon, May 29th; Steamboat Springs, July 26th; Trinidad, May 14th (Gillette).

Psylla 4-lineata Fitch. Det. Riley.

Soldier Canon, five miles west of Fort Collins, May 19th (Gillette).

Psylla ribis Riley Ms. Det. Riley.

Spring Canon, May 11th and June 5th; Fort Collins, October 15th and May 9th; Trinidad, May 14th (Gillette). Dixon's Canon, May 6th on Ribes cereum (Baker).

Pachypsylla celtidis-umbilicus Riley. Det. Riley.

Golden, April 30th (Gillette).

Euphyllura arctostaphyli Riley Ms. Det. Riley.

Spring Canon, July 24th, imagos and nymphs on Arctostaphylos uva-ursi (Cowen).

Aphalara angustipennis Riley Ms. Det. Riley.

North Park, July 20th; Steamboat Springs July 26th; Montrose, June 24th; Fort Collins, July 4th; Dolores, June 18th; Estes Park, July 11th; Colorado Springs, August 2d (Gillette). Fort Collins, June 12th, on alfalfa (Baker).

Aphalara calthae L. Det. Riley.

Fort Collins, May 8th; Rist Canon, May 29th (Gillette). Fort Collins, May 16th to 31st on alfalfa, and May 7th on gooseberry; Steamboat Springs, July 12th on Carex (Baker). Canon City, October 15th in all stages on tomato (John Gravestock). Green Mountain Falls, Colorado Springs, July (Tucker).

Aphalara epilobii Riley Ms. Det. Riley.

Ouray, June 22d (Gillette).

Aphalara harrisii Riley Ms. Det. Riley.

Near West Cliff, Custer County (Cockerell, 10).

North Park, July 19th; Fort Collins, June 14th; Estes Park, July 12th (Gillette).

Aphalara marginata Riley Ms.

Custer County, midalpine (Cockerell, 10).

Aphalara occidentalis Riley Ms. Det. Riley.

Ouray, June 22d (Gillette).

Aphalara solidaginis Riley Ms. Det. Riley.

Fort Collins, July 4th (Gillette).

Aphalara utahensis Riley Ms. Det. Riley.

Steamboat Springs, July 12th on Artemisia tridentata (Baker). Green Mountain Falls, Colorado Springs, July (Tucker).

Trioza amelanchieris Riley Ms. Det. Riley.

Horsetooth Gulch, May 21st (Baker).

Livia vernalis Fitch. Det. Riley.

Trinidad, May 14th; Fort Collins, June 4th (Gillette).

*Chermes sp.**

"Winged female: Body very dark brown, about 1 mm. long. Alar extent about 3.75 mm. Antennae about 0.20 mm. long, the third, fourth and fifth joints with about nine annulations each. Wings rather long and narrow. Fore wing with subcostal vein wavy, first and second discoidals slender, stigmatal obsolete at base, stigma sharp pointed and oblique at base. Hind wings with the discoidal obsolete. Legs short."

Fort Collins, June 19th, winged and wooly apterous individuals on Pseudotsuga douglassi (Cowen).

Pemphigus fraxinifolii Riley.

Fort Collins, July 17th in typical pseudo-galls on Fraxinus americana. Mostly wingless (Cowen).

Pemphigus populicaulis Fitch.

Fort Collins, July 12th, in typical galls on Populus monilifera. In several cases Chaitophorus populicola was found associated with this species in the partly open galls (Cowen).

Pemphigus populi-conduplifolius Cowen n. sp.

"Winged viviparous female: Length 1.8-2.2 mm. Alar expanse 6.85 mm. Nearly black, pruinose. The abdomen is deep green when the glaucous matter is removed by placing the insect in alcohol. Antennae 1 mm. long, joints slender, fifth and sixth with about six or seven annulations each. Stigma short and broad. Unguis usually with a constricted neck. Similar to ramulorum but larger and the antennal joints not nearly so strongly annulated.

Apterous individuals yellowish, with a thick mat of wooly secretion enveloping the abdomen. Eyes black."

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*In the Aphididae all the determinations were made by Mr. Cowen, who also wrote all the decriptions and collated the records. The undetermined and undescribed species mentioned in the Custer County List (see Cockerell, 10) are not referred to except in cases where there is a probability of their being identical with species mentioned in this list.

Fort Collins, July 12th, on Populus monilifera, forming a pseudo gall by causing the upper surfaces of the leaf to fold together along the midrib(Cowen).

Pemphigus populi-monilis Riley and Monell.

In Colorado, on narrow leaved cottonwood (Riley and Monell, 1).

Fort Collins, July 17th, in typical moniliform galls on leaves of Populus angustifolia; Hotchkiss, Delta County, July 14th, on the same host plant. Only one individual was found in each gall (Cowen).

Pemphigus populi-ramulorum Riley and Monell.

On Populus balsamifera, Colorado (Riley—see Riley and Monell, 1).

Fort Collins, July 12th, on Populus monilifera, in galls at base of petiole and on twigs. Sometimes the galls of this species are far enough up the petiole to be almost distinct from the twig, and are then quite similar to those of P. populi-transversus (Cowen).

Pemphigus populi-transversus Riley and Monell.

On Populus monilifera and P. balsamifera, Colorado (Riley—see Riley and and Monell, 1).

Fort Collins, July 12th, in typical galls with transverse openings, on petioles of Populus monilifera (Cowen).

Pemphigus vagabundus Walsh.

Fort Collins, galls on Populus (Blinn).

Colopha ulmicola Fitch.

Fort Collins, July 8th, in "cockscomb" galls on Ulmus americana. Five of the specimens examined have the cubital vein of fore wings simple (Cowen).

Schizoneura americana Riley.

Fort Collins, June 17th, on Ulmus americana (Cowen).

Schizoneura lanigera Hausm.

Boulder, Denver, Canon City, Delta, and Grand Junction, on apple, common (Gillette). Hotchkiss, Delta County, August 23d, on young shoots of crab-apple (Cowen).

Schizoneura querci Fitch.

"Wingless form: Largest a little over 1 mm. long, very wooly, uniformly pale green, except eyes which are red, and black tip of beak. Beak reaching slightly beyond second coxae. Antennae smooth. No fully developed individuals were obtained, so that the determation is somewhat questionable."

Hotchkiss, Delta County, August 19th, in wooly patches on young shoots of Quercus undulata (Cowen).

Lachnus pini L.

"Length 3.15 mm., width 1.80 mm. Legs and antennae slightly pubescent with short fine hairs. Body scarcely at all pubescent. Rostrum extending beyond middle of abdomen. Lengths of antennal joints: III, 0.60 mm.; IV, 0.20 mm.; V, 0.25 mm.; VI, 0.15 mm."

Estes Park, July 15th on twigs of Pinus ponderosa var. scopulorum (Gillette). These specimens differ from the description given by C. M. Weed (Art. V. Aphididae, p 118) in the characters given above (Cowen).

Melanoxanthus bicolor Oestl.

Fort Collins, September 30th on Salix (Baker).

Melanoxanthus salicis L.

Fort Collins, October 8th on Populus balsamifera var. candicans (Baker).

Chaitophorus negundinis Thos.

Fort Collins, common on Negundo aceroides throughout the season (Cowen).

Chaitophorus nigrae Oestl.

Fort Collins, June 21st on Salix longifolia (Cowen).

Chaitophorus populicola Thos.

Fort Collins, July 5th, on Populus monilifera (Gillette). Fort Collins, June 24th, on young shoots on Populus angustifolia (Cowen).

Drepanosiphum acerifolii Thom.

Fort Collins, July 2d on under side of leaves of Acer dasycarpum. Flies quickly when disturbed in the warmer part of the day (Cowen).

Aphis albipes Oestl.

Fort Collins, July 12th, on under side of curled leaves of Symphoricarpos occidentalis (Cowen).

Aphis armoraciae Cowen n. sp.

"Apterous viviparous female: Length of body 1.90 mm. Length of antennae about 1.10 mm. Antennae, head, extremity of beak, femora, tarsi, and honey tubes, deep dusky to black. Beak reaching second coxae. Abdomen plump and obtuse, dark dusky green, with a marginal row of dots and otherwise barred and mottled with black on dorsum and pleurum. Honey tubes cylindrical, slightly larger at base than at apex, length 0.20 mm Style conical. Tibiae and upper portion of tarsi white. Younger individnals of a pale reddish brown. Winged viviparous females: Length 2 mm. Length of wing 2.90 mm. Length of antennae about 1 mm., joint III 0.25-0.32 mm., IV 0.15-0.16 mm., V 0.15-0.16 mm., VI 0.12-0.13 mm., VII 0.23-0.27 mm. Head, thorax, and greater part of appendages brownish black. Third joint of antennae with an irregular row of about ten sensoria, fourth joint with fewer sensoria. Lateral tubercles of prothorax sometimes barely apparent. Wings rather broad, second branch of cubital nearer tip of wing than to base of first branch. Abdomen rounded and plump, pale yellowish brown, with small spots of black on dorsum and a row of three larger round black spots on each pleurum. Honey tubes about 0.18 mm. long, cylindrical, broadening at base. Style short conical, acute. Tibiae and upper portion of beak white."

Hotchkiss, Delta County, July 13th in large colonies on the petioles of horse-radish (Cowen).

Aphis asclepiadis Fitch.

Hotchkiss, Delta County, August 1st in small colonies on under side of leaves of Asclepias speciosa (Cowen.)

Aphis bakeri Cowen n. sp.

"Winged viviparous female: Length 1.80 mm.. to tip of wings 3.30 mm. Antennae with all the joints annulated, third and fourth joints strongly tuberculate and with numerous sensoria, joint III 0.27 to 0.32 mm., IV 0.16 mm,, V 0.14 to 0.15 mm., VI 0.10 mm. A frontal prominence between the antennae. Head and thorax black, venter green, dorsum darker, appendages dark. Venation of wings normal, second branch of cubital midway, stigmatal curved throughout. Honey tubes short, 0.09 mm. long, and 0.045 mm, thick at the somewhat swollen lower third. Style 0.08 mm., long, conical.

Apterous female: Length 1.7 to 2 mm. Some of the smaller individuals are of a rusty color. It resembles Aphis marutea Oestl."

Fort Collins, June 20th, on stems of Trifolium pratense in large colonies (Cowen).

Aphis brassicae L.

Custer County, midalpine, on cabbage (Cockerell, 10).

Abundant on cabbage wherever cultivated. Specimens from Hotchkiss, Delta County, differ in being lighter in color (Cowen).

Aphis cephalicola Cowen n. sp.

"Winged viviparous female: Length 1.70 mm., to tip of wings 3.60 mm. Head, antennae, joints of legs, thorax, spots on abdomen, and honey tubes, dark. A large quadrangular gray to green spot on dorsum. Back part of pronotum and most of abdomen yellowish. Third joint of antennae tuberculate with numerous irregular sensoria, fourth with few irregular sensoria, all joints strongly imbricated, joints III 0.33 mm., IV 0.14 mm., V 0.12 mm., VI 0.11 mm., VII 0.24 mm. Beak hardly reaching second coxae. Thorax arched, lateral tubercle present. Second branch of cubital midway. Honey tubes 0.10 mm. Style about 0.06 mm. Tarsi 0.10 mm."

Fort Collins, June 30th, usually solitary in heads of Trifolium repens (Cowen).

Aphis cerasi Fabr.

Fort Collins, July 16th on under side of leaves of Early Richmond Cherry, not abundant. Hotchkiss, Delta County, July 28th, a single individual on the same host plant (Cowen).

Aphis cerasifoliae Fitch.

Rist Canon, July 19th on under side of leaves of Prunus virginiana, causing them to curl (Cowen).

Aphis chenopodii Cowen n. sp.

"Winged viviparous female: Length, not including style, 1.30 to 1.70 mm. Alar expanse 4.60 to 5.20 mm. Head, thorax, and the larger portion of the appendages black, thorax green. Antennae strongly annulated, with a few short hairs, third joint with numerous irregular sensoria, succeeding joints of conspicuously less diameter and without sensoria except the usual ones at tips of joints V and VI; joints III 0.30 mm., IV 0.16 mm., V 0.16 mm., VI 0.12 mm., VII 0.24 to 0.28 mm. A frontal elevation occurs between the antennae. Beak about reaching the second coxae. Thorax arched, lateral tubercle small or obsolete. Cubital obsolete for only a very short distance at base, the base of second branch midway. Stigma rounded at apex but attenuate at inner end into the subcostal. Honey tubes 0.12 mm., distinctly wider two-thirds of distance from base than at base. Style constricted towards the base, with a few long hairs, 0.14 mm. in length. Legs black at joints, shafts mostly lighter, hispid, with short hairs. Tarsi 0.14 mm. Apterous female: Length 1.60-1.80 mm. Oval and plump, green with black eyes. Antennae about 0.70 mm., third joint longest, the fourth, fifth, and sixth joints subequal."

Fort Collins and Hotchkiss, Delta County, in July, in pseudogalls on Chenopodium album, formed by the Aphids locating on the upper surface of the leaf, causing the edges to curl together.

Aphis eriogoni Cowen n. sp.

"Winged viviparous female: Length of body 1.50 mm., to tip of wings 2.70 mm. Head and thorax black, abdomen lighter, somewhat hairy, femora mostly black, tarsi white with black joints. Antennae about two-thirds the length of the body, joints III 0.40 mm., IV 0.20 mm., V 0.14 mm., VI 0.09 mm., VII 0.18 mm. Beak reaching third coxae. Second branch of cubital midway. Stigmatal vein curved uniformly. Stigma long, attenuate at basal end and acute at outer end. Border of abdomen nearly completely black, a subquadrangular patch of yellow on dorsum. Style short conical. Honey tubes 0.10 mm., long, slightly incrassate. Apterous individuals: Smaller individuals bright red with dark eyes, larger specimens nearly black, concolorous. Sensoria on third and fourth joints of the antennae quite apparent. Abdomen with honey-comb like reticulations above and below, often made more prominent by a white secretion. Interspaces about 0.02 to 0.03 mm, in diameter. Head also finely reticulated. Some parts of the thorax reticulated. The winged individuals show this reticulation, but in much less degree."

Horsetooth Mountain, July 24th, a good sized colony on the stems and inflorescence of Eriogonum altatum. Specimens of apparantly the same species were collected at Steamboat Springs, July 13th on Eriogonum umbellatum (Baker). These are somewhat smaller in size, perhaps due to alcoholic preservation (Cowen).

Aphis gillettei Cowen n. sp.

"Winged viviparous female: Length 1.70 mm. Antennal joints annulated, third joint tuberculate with numerous sensoria, joints III 0.34 to 0.36 mm., IV 0.18 to 0.23 mm., V 0.11 to 0.12 mm., VII 0.23 to 0.30 mm. A frontal prominence between the antennae. Beak nearly reaching second coxae, about 0.45 mm. long. Antennae, head, thorax, and greater portion of appendages black. Abdomen green, marked with transverse bars and with a marginal row of dots of deeper green or black, shafts of legs light. Lataral tubercle of pronotum small. Insertions of wings yellowish. Second branch of cubital nearer to apex than origin of first branch. Stigma pointed. Honey tubes slightly enlarged at base, about 0.35 mm. long. Style 0.12 mm. long. Tarsi 0.14 mm. Apterous viviparous female: Length 1.70 mm. Antennae about 1.10 mm. long. Pale green except eyes, tarsi, and tips of honey tubes, which are black. Dorsum with patches of darker green. Body broad in proportion to the length. Honey tubes about 0.33 mm. long, cylindrical. Style 0 12 mm."

Fort Collins, June 22d, on Helianthus petiolaris (Gillette). Hotchkiss, Delta County, July 24th, on Helianthus sp. in small colonies on the under side of the leaves (Cowen). The same species was found on the under side of leaves of Amarantus retroflexus, in colonies of one winged and two or three small young, at Hotchkiss, Delta County, July 26th (Cowen).

Aphis heraclii Cowen n. sp.

"Winged viviparous female: Length 1.40 to 1.50 mm. Head and thorax black, abdomen yellowish green with some deeper green spots on the dorsum, causing the whole abdomen to appear deep green. Beak nearly reaching third coxae, 0.50 mm. long. Third joint of antennae tuberculate and with numerous small sensoria, all the joints annulated, the group of sensoria at apex of fifth joint conspicuously elevated, length of joints III 0.33 to 0.40 mm., IV 0.21 to 0.23 mm., V. 0.19 to 0.20 mm., VI 0.12, VII 0.27 to 0.31 mm. Thorax arched, lateral tubercle of promotum small. Second branch of cubital vein nearer to the apex of the wing than to the origin of the first branch, Legs light except at the joints, length of tarsi 0.14 mm. Honey tubes 0.26 mm. long. Style 0.10 mm."

Fort Collins, July 9th in colonies in the umbels of Heracleum lanatum. A somewhat larger form of apparently the same species was found in the umbels of Pastinaca sativa at Fort Collins, July 28th.

Aphis maidis Fitch.

Fort Collins, September 14th on maize (Baker). Hotchkiss, July 27th on all parts of maize (Cowen).

Aphis mali Fab.

Hotchkiss, August 23d, colonies of apterous and winged individuals on young leaves and shoots of apple (Cowen). Fort Collins, on apple (Gillette).

Aphis medicaginis Koch.

Fort Collins, June 27th on Astragalus bisulcatus, principally in the racemes of flowers, and on Glycyrrhiza lepidota

(Cowen). This may be No. 900 of the Custer County List (see Cockerell, 10).

Aphis menthae-radicis Cowen n. sp.

"Apterous viviparous female: Length 2 mm. Head, thorax, and greater portion of appendages black. Beak reaching second coaxe. Antennae about one millimeter long. Tibiae and upper portion of the beak white. Abdomen green, with a marginal row of black spots and barred on the dorsum with black. This Aphis appears to be of a dull lead color unmagnified. Honey tubes about as long as the tarsi, somewhat elongated at the base. Style short conical. Winged viviparous female: Size somewhat smaller than in the apterous form. Of the same color and marking except that it is not so heavily barred and dotted with black on the dorsum. Third joint of antennae with an irregular row of sensoria, fourth and fifth joints with a sensoria, length of joints III 0.25 to 0.30 mm., IV 0.14 to 0.17 mm., V 0.13 to 0.14 mm., VI 0.10 to 0.11 mm., VII 0.20 to 0.25. Lateral tubercle of pronotum very short. Second branch of cubital midway, length of the wing 2.30 to 2.60 mm. Honey tubes about 0.15 mm., slightly incrassate. Style short and conical."

Hotchkiss, July 14th, on the roots of Mentha canadensis and on the stems near the ground.

Aphis oenotherae Oestl.

Estes Park, July 18th on Oenothera biennis (Gillette). Fort Collins, August 13th on Oenothera biennis (Baker). Hotchkiss, July 27th, on Oenothera biennis; Crawford, July 29th, on Oenothera caespitosa (Cowen).

Aphis oxybaphi Oestl.

Fort Collins, July 26th on stems of Oxybaphus angustifolius (Cowen).

Aphis rumicis L.

Fort Collins, June 27th on Rumex crispus; Hotchkiss, July 21st on Rumex crispus (Cowen). Very variable.

Aphis salicola Thos.

Fort Collins, June 20th on young twigs of Salix amygdaloides (Cowen). This may be No. 892 of the Custer County List (Cockerell, 10).

Aphis valerianae Cowen n. sp.*

"Winged viviparous female: Length 1.80–1.90 mm. Body black. Third to fifth joints of the antennae with numerous irregular warty sensoria, length of joints III 0.39., IV 0.24., mm. V 0.21 mm., VI 0.18 mm., VII 0.12-0.21 mm. Beak nearly reaching the third coxae. Lateral tubercle of the pronotum prominent. Tarsi about 0.15 mm. Honey tubes about 0.19 mm. Style 0 09 mm. Apterous female: Black; younger, half grown, with about six pairs of white circular spots on the dorsum."

Foot-hills five miles west of Fort Collins, July 19th, on stalks of Valeriana edulis (Cowen).

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*Measurements from specimens preserved in alcohol.

Aphis veratri n. sp.*

"Winged viviparous female: Length 2.20 mm. Length of wing 3.05 mm. Color black, the thorax somewhat lighter than the rest of the insect. Antennae about 1.35 mm. long, the third joint with numerous rather large sensoria, fourth often with two or three sensoria, fifth and sixth with usual groups of sensoria at the distal ends, length of joints III 0.39 mm., IV 0.25 mm., V 0 22 mm., VI 0.14 mm., VII 0.29 mm. Beak about 0.60 mm. long and reaching to the second coxae. Lateral tubercle of the pronotum prominent. Stigma elongate, second branch of the cubital nearer the apex of the wing than to the base of the first branch. Tarsi 0.12 mm. long. Honey tubes cylindrical, 0.28 mm long. Style about 0.12 mm. long. Wingless form very dark."

In south-west corner of North Park, July 22d very abundant on leaves of Veratrum californicum (Baker). This may be No. 895 of the Custer County List (see Cockerell 10).

Aphis yuccae Cowen n. sp.*

Winged viviparous female; Length 2.20 mm. Head. thorax, and greater, part of femora, antennae and honey tubes, black; abdomen dull yellow with small black dots on dorsum and pleurum. Third joint of antennae with numerous small sensoria, length of joints III 0.42 mm., IV 0.25 mm. V 0.25 mm. V 0.23 mm., VI 0.15 mm., VII 0.30 mm. Beak black and nearly reaching the third coxae. Thorax strongly arched. Lateral tubercle of pronotum present. Second branch of cubital nearer the apex of the wing than to the origin of the first branch. Stigmatal vein curved for the first half and straight or recurved for the remainder of the distance. Tibiae white, tarsi dark. Style conical, hairy at the tip, about 0.15 mm. long. Wingless individuals from uniform dark green to reddish yellow in color.

Fort Collins, July 9th on inflorescence and stems of Yucca angustifolia.

This is probably the species found occurring on Yucca at Greeley by Riley (see Riley and Monell, 1). It is also perhaps the same species as that mentioned as Aphis yuccicola n. sp. by T. A. Williams in his "Host-Plant List."

Aphis sp.*

"Winged viviparous female: Length 1.60 mm. Length of wing 2.90 mm. Color pale Stigma short. Honey tubes short and broad, about 0.9) mm. long. Style acute and about as long as honey tubes. Apterous individuals with numerous black dots on the dorsum."

Fort Collins, September 20th on cultivated radish (Baker). This may be A. brassicae.

Aphis sp.*

"Winged viviparous female: Length 1.60 mm. Length of wing 2.70 mm. Pale brown. Veins robust. Honey tubes about 0.22 mm. long. Style slender conical, about 0.11 mm long. Apterous individuals dark brown. Length about 2 mm. Antennae 1.20 mm. long. Honey tubes 0.30 mm."

Fort Collins, August 6th, on cultivated radish (Baker).

Hyalopteris arundinis Fab.

Hotchkiss, July 12th, very abundant on Phragmites com-

*Measurements from alcoholic material.

munis (Cowen).

Hyalopteris pruni Fab.

Hotchkiss, July 6th, on plum and prune (Cowen).

Siphocoryne xanthii Oestl.

Hotchkiss, July 26th, on underside of leaves of Xanthium canadense(Cowen).

Myzus ribis L.

Fort Collins, July 9th, on leaves and young shoots of Ribes aureum (Cowen).

Rhopalosiphum dianthi Schrank.

In college greenhouse, February 21st, on leaves and stems of Calla Lily (Cowen).

Rhopalosiphum nymphaeae L.* ?

"Winged viviparous female: Length 2.20 mm. Length of wing 3.10 mm. Head and thorax dark, abdomen lighter. Antennae on short frontal tubercles, third joint with numerous irregular sensoria, no sensoria on the fourth joint, length of joints III 0.30 mm., IV 0.24 mm. Beak about 0.55 mm. long. Lateral tubercle of pronotum small. Stigma elongate, widest at the base of the stigmatal vein. The second branch of the cubital near the apex of the wing. Tarsi 0.14 mm. long. Honey tubes clavate, 0.35 mm. long. Style about 0.13. mm. long."

Fort Collins, September 15th, on Sagittaria variabilis (Baker). This species is doubtfully referred to R. nymphaeae, as a description of that species is not accessible.

Nectarophora artemisiae Cowen n. sp.*

"Winged viviparous female: Length 2 mm. Wing about 3.10 mm. long. Head and thorax black, abdomen somewhat lighter with the upper dorsum marked with four longitudinal rows of black spots. Antennae on distinct frontal tubercles, about 2.90 mm. long, third joint with numerous small sensoria, length of joints III 0.65 mm., IV 0.55 mm., V 0.50 mm., VI 0.15 mm., VII 0.80 to 0.90 mm. Beak about reaching third coxae. Thorax arched. Stigma dark, elongate. Honey tubes 0.55 mm. long. Style 0.20 mm. long and curved upwards. Tarsi 0.20 mm. long."

Estes Park, July 19th, on Artemisia tridentata (Gillette). More Aphis-like than most members of this genus.

Nectarophora asclepiadis Cowen n. sp.

"Winged viviparous female: Length 3.20 mm., to the tip of the style. Length of wing 4.50 mm. Head, prothorax, abdomen, and style uniform green. Mesothorax yellow, appendages mostly dusky. Eyes brown black. Antennae longer than the body, third joint with about ten or twelve sensora in one row, length of joints III 0.90 mm., IV 0 85 mm., V 0.70 mm., VI 0.20 mm., VII 1.10 mm. Beak black tipped, hardly reaching the second coxae, about 0.50 mm. long. Honey tubes about 0.80 mm. long. Style long cylindrical. Apterous viviparous female: Length 3 mm., to the tip of the style. Uniformly green, eyes brownish-black, honey tubes and style of the same color as the abdomen. Antennae

*Description from alcoholic materal.

about 3.80 mm. long, with a few short capitate hairs, and a few sensoria on the third joint. Beak reaching the second coxae, tip black. Legs and antennae dusky. Style long and falchion sharp"

Hotchkiss, July 24th, in small colonies on underside of leaves of Asclepias speciosa (Cowen).

Nectarophora erigeronensis Thos.

Fort Collins, July 22d, on Lactuca pulchella (Cowen).

Nectarophora rosae L.

Estes Park, July 16th, on rose (Gillette).

Nectarophora rudbeckiae Fitch.

Fort Collins, July 18th, on Solidago; Hotchkiss, on an unknown composite (Cowen). No. 896 of the Custer County list may belong here (see Cockerell, 10).

Nectarophora sp.

"Winged viviparous female: Length 2.50 mm. To the tip of the wings 4.75 mm. Color green, thorax yellowish. Third joint of antennae with a slight row of sensoria, remaining joints smooth except for a few short hairs, seventh joint annulated, length of joints III 0.62 mm., IV 0.48 mm., V 0.50 mm., VI 0.10 mm., VII 1.00 mm. Stigma short and broad. Honey tubes imbricated, cylindrical, 0.35 mm. long. Style 0.15 mm. long. Apterous viviparous female: Length about 2.5 mm. Mostly green. The eyes, ends of joints of antennae, tip of beak, and tarsi, black. Lower ends of femora, and tips of honey tubes darker than the body."

Fort Collins, July 21st, on Gaura parviflora (Cowen).

Nectarophora sp.

"Only wingless individuals, singly, or in small colonies. Wholly green, except that the eyes, tarsi, and ends of joints of antennae are black. Antennae longer than the body."

Horsetooth Mountain, July 23d on Arctostaphylos uva-ursi (Cowen).

Neetarophora sp.*

"Winged viviparous female: Length 2.70 mm. Color apparently uniform green. Stigma elongate, sharp pointed. Apterous female: Length 3.20 mm. Antennae longer than the body. Beak short, not reaching the second coxae. Honey tubes about 1.00 mm. long. Style 0.45 mm. long."

Estes Park, July 16th on Epilobium spicatum (Gillette).

Nectarophora sp.*

"Winged viviparous female: Length 2.20-2.40 mm. Wing about 3.40 mm. long, uniformly pale, perhaps green, in life. Beak short, about reaching second coxae. Third joint of antennae with a number of round sensoria, length of joints III 0.60 mm., IV 0.48 mm., V 0.43 mm., VI 0.16 mm. First branch of the cubital closer than usual to the origin of the cubital. Honey tubes 0.65 mm. long. Style about 0.25 mm. long."

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*Descriptions from alcoholic material.

Fort Collins. September 15th on Mentzelia nuda (Baker).

——————————. ?

"I have also taken a very anomalous Aphid, for which I can give neither generic nor specific determination, forming a gall on the leaves of Arctostaphylos uva-ursi. Oneside of the leaf is turned back and thickened for about half its length, thereby forming a smooth oblong gall about 10 mm. long and 3 mm. in diameter, which is often of a reddish color. Only apterous individuals were observed. Length about 1.50-1.80 mm. Beak reaching the second coxae. Antennae six-jointed, the third joint longest, the sixth second in length, all of the joints beyond the third with many fine annulations, sparsely hairy; the antennae would reach a little beyond the base of the wings. Honey tubes very small, broader than long, scarcely elevated above the abdomen. Legs short. Body elongate, dull green, legs a little darker. Individuals examined later in the season, which were evidedently pupae of winged forms, have the body more ovate with numerous short hairs. Antennae distinctly seven jointed and about one-half as long as the body. Honey tubes somewhat longer."

Foothills five miles west of Fort Collins, July 19th (Cowen).

Aleyrodes pyrolae n. sp.

Pupal scale. Length 1.25 mm.; width 1 mm. Color very pale straw yellow, somewhat darker toward the center. Elliptical, slightly broader at the center. Margin entire, without fringe. Within the margin all around, finely and densely wrinkled, the wrinkles extending radially inward about half way to the median line along the sides. Central portion with ten more or less well defined horizontal folds. Folds on anterior half, four in number, first semilunate, remainder linear. Line separating first and second folds obtusely angled in center, the angle directed caudad; line separating second and third straight; line separating third and fourth obtusely angled cephalad. Folds on posterior half of dorsum linear and six in number, the line separating the first and second folds with extremities bent cephalad; last three folds bent caudad at extremities. Anal plate darker than surrounding surface, unequally triangular, the longest angle directed caudad.

Described from several scales of different ages. Four-mile Hill eight miles south of Steamboat Springs, July 19th on Pyrola rotundifolia (Baker).

Coccus cacti L. var. ***confusus*** Ckll. Det. Cockerell.

Probably this species (Acanthococcus confusus) in the midalpine of Custer County (Cockerell, 10).

Manitou, September 27th on Opuntia (Gillette).

Rhizococcus n. sp.

Under a rock at West Cliff, April 23d. Naked, pyriform, 2.25 mm long, dull lilac, legs clear red-brown, antennae reddish-brown. Caudal filaments short, but distinct (Cockerell, 10).

Dactylopius citri Boisd. Det. Baker.

On Habrothamnus and Solanum jasimoides in the college greenhouse, September 10th (Baker).

Dactylopius solani Cockerell. Det. Cockerell.

Fort Collins, August 23d on roots of Solanum rostratum (Baker). Questionably this species on the crowns of sugar beet roots at Grand Junction, August 26th (Gillette).

Kermes galliformis Riley. Det. Cockerell.

Manitou, November 27th on Quercus undulata (Gillette).

Kermes gillettei Cockerell.

"Scale of female 8 mm. long, 7.5 broad, 7 high. Distinctly segmented; dorsum with rounded tuberosities, not very shiny. Scale covered with minute dark brown specks. General color ivory-white and dark brown mottled, the extent of the white or the brown variable, but usually a distinct white dorsal band, and more or less broken-up subdorsal ones. Derm by transmitted light reddish brown, with large oval gland-pits. Young larva very elongate, subfusiform, with the greatest breadth anterior to the middle; pale purplish pink. Caudal tubercles large and broad, each presenting two stout bristles, of which the inner (mesad) one is much the shortest. There is also a moderately long bristle on the outer side of each tubercle, near its base. Segmentation distinct; each segment with a short spine or bristle on lateral margin. Antennae cylindrical, hardly at all tapering, 6-jointed; 3 and 6 equal and longest; 4 and 5 equal and shortest, these being about as long as broad; 2 very little longer than 4. and very much shorter than 3; 3 almost as long as 4 plus 5. Last joint rounded at the tip, bearing several hairs. Antennae colorless. Rostral loop extending beyond base of third pair of legs. Mentum at least two-jointed. Legs quite ordinary. Claws long, sharp, and a little curved. Tibia short.

Hab. Manitou, Colorado, U. S. A., on twigs of Quercus undulata. Collected by Prof. C. P. Gillette. Very distinct from K. galliformis, Riley, the only Kermes hitherto described from North America. Its nearest ally is evidently Kermes gibbosus, Signoret, which was found on oaks near Vienna.

The larvae described above were found inside the scale of the female."

We copy the above from a separate of Mr. Cockerell's paper in "The Entomologist," which bears no date. The practice of publishing original descriptions of single American species in foreign journals which are to a large extent inaccessible to American entomologists, cannot be too strongly condemned.

Physokermes coloradensis Cockerell.

"Female scale with the same general shape as P. abietis and attached in the same way to the twigs. Diameter 7 mm., smooth, shiney, rather pale brown, inflated, subreniform, with a median constriction. Derm yellowish brown, reticulate, the reticulations hexagonal. Large gland-pits looking like perforations. Mouthparts small, rostral loop short. Legs not to be found, apparently absent in the adult. Antennae small, six-jointed, but the joints obscure. Last joint with several hairs. Joints subequal, except the second and fifth, which are shorter; the second shortest, bearing a long hair; fourth perhaps a very little longer than third, and longest; fifth constricted, simulating second joints, the second of them shortest.

Habitat Manitou, Colorado, November 26th, 1894, on Pinus edulis. Collected by Prof. C. P. Gillette. It is attacked by a brownish Chalcidid parasite.

From European P. abietis it is distinguished by its size and by the antennae. No species of the genus has hitherto been found in America."

This species was described in "The Entomologist" with the preceding species. A spruce should have been given as the host plant instead of Pinus edulis.

Orthezia annae Ckll. Det. Cockerell.

Delta, August 30th on "greasewood" (Gillette).

Orthezia occidentalis Dougl. Det. Cockerell.

Custer County, midalpine, in the nest of a dark brown ant with large head and shiny abdomen (Cockerell).

Near Fort Collins, at various times under stones in company with certain ants (Baker).

Lecaniodiaspis yuccae Twns. var. ***rufescens*** Ckll. Det. Cockerell.

(*Prosopophora rufescens* Cockerell).

Grand Junction, October 18th, on "greasewood" (Dr. S. M. Bradbury, President West Colorado Acad. Sci.).

Pulvinaria bigeloviae Cockerell.

West Cliff, Custer County, June 16th, on Bigelovia (Frank Cusack—see Cockerell, 10).

Pulvinaria innumerabilis Rath.

Denver, June 10th on box-elder, locust, and soft maple (John Tobias). Common on soft maple and honey locust at Fort Collins.

Lecanium (***Bernardia***) ***hemisphaericum*** Targ. Det. Cockerell.

College green house, May, on Neprolepsis exaltatus and a liliaceous plant (Baker). Denver, November 24th on Cycas in green house (Gillette).

Lecanium hesperidum L. Det. Cockerell and through Howard

College green house, September 10th on Aralia, Abutilon, Ficus elastica, and Rhynchespermum jasimoides; Fort Collins, in open air on Veronica hendersonii (Baker).

Lecanium longulum Dougl. Det. Cockerell.

Denver, November 24th on rubber tree in green house (Gillette).

Lecanium (***Bernardia***) ***oleae*** Bern. Det. Cockerell and through Howard.

College green house, May, on Solanum jasimoides (Baker). Denver, November 24th on Platycerium in green house (Gillette).

Lecanium perforatum Newstead. Det. Cockerell.

Denver, November 24th on Raphis in green house (Gillette).

Lecanium sp.

Manitou, September 27th on rose (Gillette). Regarding this species Mr. Cockerell (in litt.) says: "It seems not to be rosarum, or the Santa Fe species, for its antennae are seven-jointed. In the Santa Fe species the antennae have eight joints. The antennal formula in your Manitou insect is 3 (24) (17) (56)."

Lecanium sp.

Manitou, September 27th on oak (Gillette). Regarding this species Mr. Cockerell says: "The antennae are eight-jointed and the antennal formula is 3 (24) (18) (567)."

Aspidiotus ancylus Put. Det. through Riley.

Canon City, April 30th abundant on pear (G. M. DuBois).

Aspidiotus camelliae Boisd. Det. Cockerell.

College greenhouse, September 10th on Japanese Quince, Aralia, and Ficus elastica (Baker).

Aspidiotus dictyospermi Morgan. Det. Cockerell.

College greenhouse, September 10th on Champaeropsis elegans (Baker).

Aspidiotus ficus Ashm. Det. Cockerell.

Denver, November 24th on Phormium tenax in greenhouse (Gillette).

Aspidiotus howardii Cockerell. Det. Cockerell.

Canon City, August 31st on fruit of plum (Gillette).

Aspidiotus nerii Bouche. Det. Cockerell.

On lemons exposed for sale in the shops (Cockerell, 10).

College greenhouse, September 10th on oleander and Dracaena (Baker). Fort Collins, December 28th on California lemons and oranges in the market (Gillette).

Aspidiotus perniciosus Comst. Det. Cockerell.

Fort Collins, December 30th on California pears in the market (Gillette).

Lepidosaphes* (*Mytilaspis*) *citricola Pack. Det. through Howard.

On lemons exposed for sale in the shops (Cockerell, 10).

Fort Collins, May, common on "rusted" oranges in market (Baker), and December 28th on California oranges and lemons (Gillette).

Chionaspis pinifolii Fitch. Det. Cockerell.

Fort Collins, October 6th, abundant on spruce; Manitou, September 29th on spruce (Gillette).

Chionaspis ortholobis Comst. var.

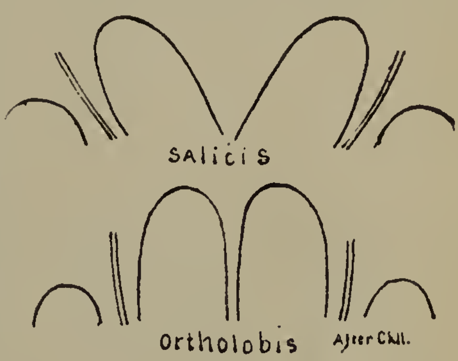
On willow at West Cliff, as C. salicis L. (Cockerell, 10).

Chionaspis ortholobis Comst. var. Det. Cockerell.

Denver, June 10th on cottonwood (John Tobias).

In regard to the above record Cockerell (in litt.) says:—"The Wet Mountain Valley salicis recorded by me, was not true salicis but ortholobis var."

Regarding the species ortholobis and salicis Cockerell (in litt.) further says:—"If you look at Comstock's descriptions you will find that he alludes to a difference in the position of the median lobes of ortholobis and salicis. Ortholobis has these lobes close together (see figure), whereas salicis has them divergent (see figure). Now we have a specimen of ortholobis from California, from Mr. B. W. Griffith, which shows the lobes close together as Comstock describes. But your Denver species show them wide apart, as in salicis. Yet your Denver scales are like the Nebraska ortholobis (see my article in Can. Ent.) to all outward appearance, and are not like salicis. But at this point we prepared some English salicis, from Mr. Newstead, and they have the lobes close together as in ortholobis. All this seems rather to confirm what I have suspected for some time, that the so-called salicis of this country is not salicis at all, but a distinct species. If so, the synonymy of the species discussed will probably stand thus:



(1.) C. salicis (L). Europe.
(2.) C. ortholobis Comst. U. S.
(3.) C. salicis-nigrae (Walsh.) U. S. or 'equals 'salicis Comst., not L.

It is by no means clear, however, that your Denver scale is specifically distinct from the Nebraska one, which we are calling otholobis (vide. Can. Ent.) and as it is certainly not true European salicis, I should advise you to call it C. ortholobis var. for the present."

Aulacaspis boisduvalii Sign. Det. Cockerell.

Denver, November 24th on palm in greenhouse (Gillette).

Palaeococcus simplex Scudder.

Fossil at Florissant (Scudder, Tert. Ins. N. A.).

SUMMARY.

Number of species previously reported from the state	298
Number of additional species reported in this list	349
Total number of described species known to occur in the state	647
Genera in the list	261
New genera described	5
New species described	111

ERRATA.

On page 64, in seventh heading for Cidada, read Cicada.

On page 85, in sixth line from bottom, for Gillette read Baker.

On page 118, line 29, for marutae read marutea.

On page 119, in fifth line from bottom, insert (Cowen) after Eriogonum alatum (not altatum). In line four from bottom for apparantly read apparently.

On page 120, line 28, for promotum, read pronotum.

On page 124, sixth species, for Neetarophora, read Nectarophora.

INSECT INDEX

PLANT INDEX.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 32.

SHEEP FEEDING IN COLORADO.

(N. B. Bulletin No. 31, "Hemiptera of Colorado," was a technical bulletin and was not generally distributed.)

Approved by the Station Council.
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

SEPTEMBER, 1895.

Bulletins will be sent to all residents of Colorado, interested in any branch of Agriculture, free of charge. Non-residents, upon application, can secure copies not needed for distribution within the State. The editors of newspapers to whom the Station publications are sent are respectfully requested to make mention of the same in their columns. Address all communications to the

DIRECTOR OF THE EXPERIMENT STATION,
FORT COLLINS, COLORADO.

Tourney Print, Denver.

The Agricultural Experiment Station,

FORT COLLINS, COLORADO.

Summary.

Colorado has 1,200,000 sheep, and raises 200,000 lambs per year. Most of her surplus lambs and sheep are sold to local butchers or shipped to Nebraska feeders. Most of the 117,000 sheep fattened for the Chicago market came from without the State.

Lambs, yearling wethers, old wethers, and old ewes are fattened in Colorado from four varieties of sheep: Old Mexican, New Mexican, Merino, and sheep of the improved mutton breeds.

Most of the native sheep of Colorado are raised on the open range, with no shelter, and but little extra feed through the winter. The cost of ranging a sheep for a year varies from 30 to 80 cents. The return is about 50 cents worth of wool, and a lamb worth from 75 to 90 cents.

The wether lambs are usually sold in the fall, but are sometimes kept and sold as yearlings, or even older. The ewes are sold at five to six years old and enough ewe lambs raised to keep the numbers good.

Sheep are brought to the feeding yards by railroad or by driving. The latter is the cheaper method for large bands of old sheep. The railroad is usually used for lambs and for all small bunches.

The Chicago market is the best for well-fattened sheep. The poorer grades are sold for local consumption, or sent to Nebraska to be fattened. Most of the sheep are fattened for the spring market, a few for the Christmas market, and fewer still are used for the production of early lambs for the spring market.

The Chicago market-price is lowest in November and gradually rises until it reaches the highest point in May. Eastern sheep are marketed first, then those between the Mississippi and Missouri rivers, and lastly those from Colorado and the far West.

The average prices are given for the Chicago market from November to May for the last four years. They show that the best time for the Colorado feeder to sell lambs is from April 15 to June 1; and the best single week about the middle of May. Older sheep are best sold a month earlier.

Fattening lambs are usually fed nothing but hay for two months; then a small amount of grain, gradually increasing to full feed of one pound per head per day by the middle of March. A lamb eats about 400 pounds of hay and 120 pounds of grain.

It does not pay usually to shear sheep that are being fattened for the Chicago market.

The death losses in feeding sheep in Colorado are very small, both absolutely and as compared with the losses in the states farther east.

It costs a dollar a head to ship sheep from Colorado to Chicago and seventy-five cents for lambs. The shrinkage in live weight during shipping is about seven per cent.

The cost of a well-fattened southern lamb laid down in Chicago is about $4; the items being $1.85 for first cost of lamb and freight, 40 cents for labor of feeding, interest and death losses, and $1.75 for cost of feed eaten.

The average price in Chicago the past season for such lambs has been $4.30, varying from $4.90 to $2.73 for large bunches. The small bunch fattened on the College farm brought $5.32 per head.

The large western lambs fed in Colorado have scarcely paid expenses, and the same is true of the older sheep, both southern and western.

There were fed to sheep sent to the Chicago market from Colorado last season 136,000 bushels of wheat, 95,000 bushels of corn, 840 tons of other grain, and 27,560 tons of alfalfa hay.

List of all feeders in Colorado who fed sheep for the Chicago market the winter of 1894-95.

At The State Agricultural College of Colorado, Fort Collins, four small bunches of sheep were fattened during the winter of 1894-95. They consisted of western yearling wethers, western lambs, Mexican yearling wethers, and Mexican lambs.

Four different feeds were used: Alfalfa hay and wheat; hay and corn; hay and sugar beets; and hay, wheat, and sugar beets.

When on hay alone, they ate quantities nearly proportional to their live weight.

All the sheep made excellent gains. The western lambs grew most rapidly, the Mexican yearlings the least.

The Mexican lambs gave the best net profit of 88 cents per head, the western lambs 71 cents, the western yearlings a loss of 18 cents per head, and the Mexican yearlings a loss of 5 cents per head.

As a return for raising and feeding the hay, the western yearlings returned $4.57 per ton for the alfalfa, the Mexican yearlings $5.22, the western lambs $8.00, and the Mexican lambs $10.94. The Mexican lambs fed on alfalfa and cracked wheat returned $12.34 per ton for the alfalfa.

It is worth about 7 cents per pound for each pound of increase in live weight put on sheep.

Sugar beets proved an acceptable feed to the sheep, and the most rapid growth was made by those that had hay, grain, and beets.

In small quantities as part of a moderate ration, sugar beets made a return of about $3 per ton. Fed all the sheep would eat, they returned but $2 per ton, too small an amount to pay for raising them.

Wheat and corn fed in equal quantities to like sheep gave just the same amount of growth, the same shrinkage in shipping, and the same dressed weight.

Wheat gave a better growth than corn during the first half of the winter, and the reverse for the latter half.

Probably the best combination is wheat the first third of the time, wheat and corn mixed during the middle of the winter, and corn for the "finishing off."

In each bunch the larger sheep grew faster and proved more profitable than the smaller.

During cold weather the sheep ate more per head than in warm weather; but the cold did not interfere with their growth.

The best gains in weight were made when the average daily temperature was below freezing.

Sheep Feeding in Colorado.

By W. W. Cooke, Agriculturist.

The statistics of the United States Department of Agriculture credit Colorado with having 1,200,000 sheep, and a lamb crop in 1894 of 200,000. The lambs saved in the spring of 1895 will be not many less than this number. It would be supposed from these figures that Colorado would fatten many sheep for market. Until within the last two years, very few sheep have been fed for market in this State and even now the number does not nearly equal the number raised. The strange fact has also come to light that most of the fat sheep sent to market from Colorado were not raised in the State. A few feeders raise the sheep they fatten and about an equal number buy Colorado-grown sheep to fatten, but the large majority of the sheep grown in the State are either used for home consumption and home markets, such as Denver, Pueblo, Colorado Springs, Leadville, etc., or are sold for fattening to Nebraska and Kansas feeders.

Out of the 117,000 sheep fattened in Colorado for the Chicago market during 1894-95, only about 17,000 were raised in Colorado. The other 100,000 were divided about equally among sheep from the south and those from the north and west. Nearly all these sheep were fed in two localities: one in the Arkansas Valley, at Rocky Ford and Las Animas, sending out 40,000; and the other about twice as many from the region of the Cache-la-Poudre and Thompson rivers, with headquarters at Fort Collins.

VARIETIES OF SHEEP.

The sheep fed in Colorado last winter represent all the kinds grown west of the Mississippi river. They may be considered in four groups: Old Mexican, New Mexican, Merino, and Mutton. Lambs, ewes, yearling wethers, and old wethers of each of these kinds were fed and as each is classed and sells differently in the market, it gives sixteen kinds of sheep handled in Colorado. The principal object of this bulletin is the comparison of these different kinds and the discussion of the question as to which is the best adapted to Colorado conditions.

The *Old Mexican Sheep* are the direct descendants of the original Spanish-Merino brought over two hundred years ago by the Spaniards to Old Mexico. They have been bred with scarcely any outcross and are a very distinctly marked breed. They have long legs, a long thin body not very deep, small rather long neck, and a long thin head carried high. The wool is fine and thin. To the eye they appear almost worthless as mutton sheep and of still less value for wool. Their good points are, that they are hardy, excellent travelers, will keep in good condition on the poorest and dryest of ranges, are fairly prolific, and can be herded in bunches of almost any size. They fatten easily, though never looking plump and fat like the northern sheep. When they reach the Chicago market, if in good condition, they outsell all other sheep, for they shrink very little in dressing, the meat has an excellent flavor, and the hide is so thin, firm, and soft as to command the highest price. A well-fattened bunch of Mexican lambs will weigh on the Chicago market from 78 to 81 pounds. Yearlings, ewes, and old wethers of this breed are in good condition if they weigh 90 pounds in Chicago.

New Mexico Sheep.—These original Mexican sheep have been largely graded with Merino rams in New Mexico and southern Colorado, and for some years were run there as grade Merinos for wool. They have not the thick, wrinkly fleece of the typical Merino and show decidedly their Mexican origin, being intermediate in length of leg, body, neck, and head, between the true Merino and the Mexican. They are a small-bodied, quick-maturing sheep, and, although never growing very large, they get very fat. It takes them longer to fatten than the better bred sheep. Never less than five and usually six months elapse from the time they are put on feed until they go to market.

The bunches of lambs brought from New Mexico run quite even in size and appearance. They are all kept under the same condition, and but few of the flocks have as yet been topped with mutton breeds so as to present any great variation from the general type. When brought to Colorado in the fall, about the first of November, the lambs weigh, in bunches, from 48 to 53 pounds. When shipped to Chicago, in May, they weigh from 80 to 84 pounds. Their frames are then not much larger than in the fall, but the body is much deeper, almost touching the ground, and they are almost as thick through, making them very plump. They easily get the highest prices on the Chicago market for the same reasons as the Mexican sheep.

Merinos.—Until within a few years ago, nearly all the sheep of Colorado, Wyoming, Utah, and Idaho were straight Merino sheep, bred for the most part from Merinos brought from the East. Some flocks originated from the Mexican or New Mexican sheep, but they were crossed so many times with such thoroughbred Merino rams as to lose the characteristics of the southern sheep. So long as these flocks were used for wool they were carefully bred by purchasing high-priced rams from the East. As the price of wool fell the profits decreased until some seven or eight years ago a point was reached where the sheep for mere wool ceased to be profitable. Many flocks were sold and those sheep men that continued in the business turned their attention to wool and mutton. Many of them still continue to use Merino rams, but the number of these flocks is constantly decreasing and, especially from western Wyoming westward, the use of rams of the mutton breeds has become almost universal. These Merino flocks from the north retain the thick fleece of the original Merino, since the climate is not hot enough to thin out the fleece as it does in New Mexico and Texas. Most of the wrinkles disappear, but a few remain around the shoulders, and the face has the Merino color distinct, being thus easily told from the southern sheep which have no wrinkles and very thin wool around the head. The lambs are short-legged and consequently not such good travelers as the southern sheep, nor do they need to be, for the Wyoming ranges will average much better than the New Mexican. The lambs appear larger than the New Mexican, but will not weigh quite so much. From 42 to 47 pounds is an average weight on the first of December. They grow a little more rapidly when put on feed than southern sheep, and will stand a little heavier feeding. In May they will weigh in Chicago just about the same as the southern lambs; and, although the price is hardly lower than for southern lambs, yet, if equal bunches were put on the market together, the southern would more rapidly find a purchaser. The ewes, yearling wethers, and older wethers of the Merino are heavier than those of the southern sheep. Yearling wethers the first of December should weigh from 80 to 90 pounds; old wethers occasionally go over 100 pounds. They fatten more quickly than the lambs—much more quickly than the southern lambs. Four months' feeding is always sufficient, and many bunches will be ready for market after three months. They should weigh in Chicago from 115 to 125 pounds.

Mutton Sheep.—There are practically no flocks of pure mutton sheep on the range. All the so-called mutton flocks have come from using pure-bred rams on the original flocks. These crosses have usually been mixed, that is, a ram of one breed has been used for two or three years and a change made to another breed. This prevents in-breeding, and is considered by some to make a larger and a hardier sheep.

The Western lambs fed at The State Agricultural College the past winter were sired by a Cotswold ram out of ewes that had one Southdown and two Shropshire crosses on the original Merino, and they are supposed to be out of the finest bunch of sheep on the whole western range.

The Cotswolds give the largest frame of any of the mutton breeds; but if much of this blood is used it gives too large legs and too coarse bones for the best and most rapid fattening, and does not command the best prices on the Chicago market. If but one breed were to be used, it is probable that the Shropshire comes the nearest to filling the demand.

Great pains have to be taken not to get too far from the original Merino blood lest the sheep do not do well on the range. Pure-bred Shropshire, Cotswold, or Southdown do their best in flocks of less than 100, and can not be profitably run in bunches of more than 200. A mixture of a small percentage of Merino blood gives them better grazing habits and enables them to be run in flocks of even five thousand, although from one to two thousand is the more common size. It is not profitable to range sheep in flocks of less than one thousand.

THE RANGING OF SHEEP.

The method of ranging sheep is much the same in the south and in the north. The more common and much safer form is to have the sheep in a corral at night. The most advantageous form is to have the corrals in the shape of a triangle, a day's journey apart, moving from one corral to another and thus not tramping over the ground so much near the corral as would happen if the sheep were herded each night in the same place. In southern Colorado the sheep have no home, but are herded by Mexican herders who camp out summer and winter without corrals and nothing but pinon timber for shelter, staying at one place but a short time, and moving from place to place with burros and dogs to keep the coyotes away at night. A band of sheep will feed from one to three miles wide when on the range. Until a few years ago, almost no feeders provided any winter feed for the sheep. A band of eleven thousand was kept north of Fort Collins for fourteen years, only needing feed once during that time and then for less than two weeks. It is much better for the sheep if they can have a sheltered place for the winter range. It used to be quite common in Colorado to have the sheep range on the plains in the summer and near the foothills in winter. Within the last four or five years it has become quite common in Colorado to bring the entire band of sheep to the home ranch for the winter, and while feeding the lambs for market and some of the old sheep, supplement the range feed with alfalfa. This puts the ewes in a better condition for lambing and gives stronger lambs with a lower death rate. Still another plan is to divide the flock, leaving the stronger sheep on the range and bringing the smaller and weaker ones to the feeding yards. All degrees can be found; from depending on the range the whole year, to ranging six months and feeding the other six. Some flock masters have even gone so far as to feed a little grain to their ewes during the severe storms of late winter, and are well satisfied with the increased vigor of ewes and lambs.

The range in eastern Colorado and in New Mexico is probably as poor as it ever will get and allow the sheep business to continue. But the western valleys of Colorado and a large part of Wyoming and Idaho still furnish good range.

Most lambs in range flocks are dropped in May. The rams are turned into the flock about the tenth of December and allowed to remain until the middle of January. This insures that the lambs shall be dropped within a few days of the same time. Some shepherds allow the rams to remain with the flock all winter and until shearing time in the spring. This saves the labor of keeping the rams penned up or sending them to another range, and is, of course, the cheaper method. It also insures a larger percentage of lambs, but it makes the lambing period extend well into the summer. If the ewes have been well cared for and fed through the summer and fall, as high as ninety per cent. will take the ram in the course of a single month. In a few cases this percentage is increased to ninety-five, though ten per cent. of barren ewes on the range is not far from the average. On poorer range these results will scarcely be reached even if the rams are allowed to run with the ewes all winter. One ram is used for every forty to fifty ewes.

Whether the flocks have been kept on the range or at the farm during the winter, about the first of May the ewes are moved to the lambing ground. This needs to be selected with much care. There should be plenty of fresh grass, running water within easy reach, and some timber for shelter. It is best, also, to have some permanent yards and sheds for an emergency. The weather during these few weeks determines in large measure the percentage of lambs that will be saved. The average of several years is about eighty lambs for each hundred ewes, that is, one hundred ewes drop ninety lambs and ten of those are lost. The variations are large, depending on the feed and care through the winter and the weather and care during lambing. During the spring of 1895, there was some severe cold storms at the most critical time, occasioning great mortality among the lambs, while hundreds of ewes also perished. Some saved only twenty per cent. of their lambs; others who saved fifty per cent. thought they were doing well.

A month after lambing comes the shearing of the ewes. This usually occurs from the first to the fifteenth of June. The nearly pure-bred Merino range ewes of Colorado shear from six to nine pounds of wool, with eight pounds of wool as about the average. At the prices of wool this season, this would have a value of from forty-five to sixty cents per head and would go far toward paying all the expenses of the flock. The smaller, thin-fleeced ewes of southern Colorado shear but four pounds of wool. The average for all sheep for the State is about seven pounds per head.

After shearing, the flock is turned out to the regular summer range for the rest of the season. One herder is required for each 1,000 to 2,500 sheep, according to the season, feed, and location of the range. From 3,000 to 4,000 with two herders is a common size of flock.

The size of the range is quite variable. Of course, the shepherd takes all he can get and, if possible, moves his flock from to time to time to fresh pastures. The range, however, is unfenced and the man who leaves a part unpastured for winter feed is liable to find that another flock has reaped the benefit. In the present condition of the prairie range of Colorado, it is considered doing well if the sheep get all the feed they want on ten sections to the thousand head of ewes with their lambs, or six acres to the head. About double this is considered liberal allowance. In the mountain valleys and parks a half to a quarter this amount is usually sufficient. When we consider that six acres of alfalfa will yield enough to keep fifty-five sheep in plenty through the year, it can be seen how scanty is the growth of vegetation on the open range.

The pure-bred Merino is a slow-maturing animal. The ewes do not drop their first lamb until they are three years old, and they are fattened for market at six years old. So a ewe is kept six years for the sake of three lambs, or, since only eighty per cent. of lambs are raised, there is a product of two hundred and forty lambs from one hundred ewes in six years. The return is about the same if the ewes drop their lambs at two years old, for then they are usually sold for mutton when five years old. The only chance for profit in such a transaction comes from the fact that the wool of the ewe each year pays nearly all expenses.

Some flockmasters breed their ewes the second December to drop lambs when two years old. On good range with extra feed and care the second winter no harm results from this procedure. An infusion of the blood of any of the mutton breeds—Shropshire, Southdown, or Cotswold—hastens the growth and makes a ewe that is fully mature at two years old. Pure-bred Shropshire ewes will take the buck at six to seven months old, but the lambs from these young dams are apt to be weakly and the dam also stunted in its growth. Whether the ewe lambs are to breed at two or three years old, it is considered advisable to give them extra care and feed the first winter.

From the statements just made it can be judged that the cost of ranging sheep will vary widely. In the South, with cheap Mexican labor and no winter feeding, the cost per year is estimated at from forty to fifty cents per head. In northern Colorado, where considerable winter feed is given, the expenses increase to nearly eighty cents per head. The principal items of these expenses are for labor and interest on investment. In southern Colorado with Mexican herders a liberal estimate of the yearly expenses per head of a band of two thousand sheep would be:

Herding	25 cents.
Interest on Investment	12 "
Dipping	2 "
Shearing	6 "
Feeding	4 "
Loss	3 "
	52 cents.

A common way of ranging sheep in southern Colorado is to let them out on shares. One man buys the sheep and turns them over to the charge and control of the shepherd, only stipulating that he shall receive a certain rental. If it is a mixed bunch of ewes, wethers, and lambs, the renter pays taxes, furnishing rams, makes original number good, and gives the owner two pounds of wool per head per year, delivered in sacks at the railroad. When all the bunch are ewes, the owner receives one-half the lambs and one-half the wool, each party paying one-half the taxes.

SELLING THE LAMBS.

The common practice in raising sheep is to sell in the fall, the wether lambs and part of the ewe lambs. Enough ewe lambs are retained to fill the places of the old ewes that are sold for mutton. On the average, there would be for each thousand breeding ewes in the flock, four hundred wether lambs to sell, together with one hundred ewe lambs and three hundred old ewes. For reasons to be given later, such exact figures are seldom reached and the sales each year from each flock are made up of a various mixture of ewe and wether lambs, yearling and older wethers, barren ewes of all ages, and old ewes. Such a mixed lot would not feed well together for fattening and would have to be sorted out in marketing. The man who is feeding on a small scale and has to sell all his surplus to one buyer must expect to receive a low price. The large grower has here the advantage in that he can sort his sheep and still have enough of each kind to make a full lot. It is better to make up into lots of lambs, yearling wethers, older wethers, and old ewes. The wether lambs sell on the range the first of November for 65 cents to $1.10 and weigh forty to seventy pounds. These prices and weights refer to Colorado-grown Merinos. These lambs, if kept a year longer, would weigh from seventy to one hundred pounds and bring from $1.25 to $1.75 per head, or an increased price of about 75 cents per head. When sheared at one year old, they produce about 50 cents worth of wool, making $1.25 that the yearling brings more than the lamb. As the cost of ranging is about 75 cents per year, there is a larger net return per head in running the sheep to the second year than in selling them as lambs. On the other hand, it requires that the owner keep his money invested one year longer before he gets any return. Or, putting it in another way, with a given capital and a given range, he will receive a higher price per head, but have only two-thirds as many sheep for sale. In the end the net profits for the capital invested, the men employed, and for each square mile of range is about the same in the two methods. The number of flocks run in the two ways is about even. In fact, most large flocks are run in each way, the earlier and stronger lambs being sold in the fall as lambs. The later and poorer ones are carried over to the next year.

These remarks do not apply to the southern sheep; for, at a year old, they are only a little larger than as lambs and after running the extra year on the range, they lose much of their aptitude for fattening and will bring as yearlings scarcely any more, and often not so much as they would have done as lambs.

The bulk of the lambs are dropped in May throughout the sheep-raising districts from New Mexico to Colorado, Wyoming, Utah, and Idaho. Of course, many lambs are dropped later than this and in the south hot weather comes on so soon that the late lambs are stunted in their growth. When the lambs are sold in the fall, about two per cent. are culled out, including these late lambs. The culls have to be carried over to the next year and sold as yearlings, so that there is always a small supply of yearlings from the south for feeding; but at least six-sevenths of the southern sheep fattened for the Chicago market are lambs.

Where crosses of mutton blood have been made on the original Merino stock, and the feed on the range is good, the lambs grow very rapidly and would make good mutton in the fall without special fattening. Individual lambs sometimes weigh ninety-five pounds when six months old, and whole bunches average over seventy pounds. Such lambs would be $2 per head on the range and there would be no profit in carrying them over to a second year. Taking the whole country together, from central Colorado north and west, the practice is about evenly divided between selling as lambs and keeping them until older.

TRANSPORTATION OF SHEEP.

Sheep are brought to the fattening yards for winter feed by railroad and by driving on foot, or, as it is called, trailing. The sheep brought from Wyoming, especially from the two centers, Rawlins and Casper, are principally driven. Farther west, from the country around Soda Springs, Idaho, they are more often brought by rail. It is not uncommon, however, for sheep to be driven from Oregon to Nebraska. One of the principal shipping points for southern sheep is Clayton, New Mexico, and they are always brought by rail from there to northern Colorado points. All shipping by rail is done on what is called a feeding-in-transit rate. The freight from Fort Collins to Chicago is $95 per car; the rate from Clayton, N.M., is the same, but, by paying $15 extra, the railroads allow sheep or cattle to be shipped from Clayton to Fort Collins, unloaded and fed for any length of time, reloaded, and shipped to Chicago. The freight from Rawlins, Wyoming, to Chicago is $105 per car and the railroad charges $30 for hauling the car from La Salle to Fort Collins and return. From Soda Springs, Idaho, the rate is $110 per car plus the $30. These rates are for standard cars thirty feet long. Ten per cent. additional is charged for 36-foot cars. As the larger car will hold about fifty more than the smaller, it is always used when it can be obtained. A 36-foot car will hold about 300 small southern lambs.

When driven on foot a band of sheep will travel about eight miles per day and feed on the road enough to keep up their condition. This seems slow as compared with railroad transportation, but in large bands it is much the cheaper method. From either Rawlins or Casper, the drive to Fort Collins would occupy about a month. Three herders will drive a band of from four to seven thousand, and their entire expenses, including horses, wagon, cook, food, wages, etc., will not exceed two hundred dollars. This makes a cost of four to five cents per head as compared with twenty cents by rail. This saving amounted to over a thousand dollars on a single band trailed to Fort Collins last fall.

A still cheaper way, if one has his plans made long enough beforehand, is to buy the sheep in June at the shearing sheds. They can then be purchased at from forty to seventy-five cents less per head than the owners would want for them the first of November. During the summer they can be herded on the range, gradually moving them toward the place where they are to be fattened. A four months drive will cost less than twenty cents per head and deliver them at the feeding sheds in the fall, not only transportation free, but with some additional saving.

It is not advisable to trail lambs, as they ought to remain with the ewes until at least the middle of September, and a few weeks longer is still better. Still, one small bunch of lambs was driven from Casper, Wyoming, to Fort Collins last fall with no apparent bad results. The lambs from New Mexico have always been brought here by rail.

SHEEP MARKETS.

The Colorado sheep feeder has open to him several markets for his well-fattened product. The Chicago market is the one generally considered the best, but is, by no means, the only one used. The people of Colorado consume a great deal of mutton which is all supplied from within the State. Most of this is inferior mutton. There is a small trade in Denver, Pueblo, and Colorado Springs that is willing to pay a first-class price for a first-class article, but the great bulk of the well-fattened sheep of the State go to the

Chicago market. The home trade is supplied through six months of the year by grass-fed sheep direct from the range, and the rest of the time by old ewes and wethers that have been fed alfalfa with a little grain. Most of this is bought by the butchers at less than three cents per pound, live weight.

A business much the same as this is the raising of sheep to be sold off the range as feeders for someone else to fatten for the Chicago market. The sale takes place in the fall, and the sheep are sold as lambs, wethers and old ewes. Most of these are bought by Nebraska and Iowa feeders; but, as already stated, some sixteen thousand head the past winter were either fattened for market by those who raised them for or were sold to Colorado parties for fattening.

The usual mode of procedure is for the lambs to be dropped in May, then in November, they are put in the feeding yards for fattening to be sold in the late spring. Older sheep are at the same time taken off the range for feeding in the yards all winter.

Variations from these methods are found among those who try to prepare sheep for the Christmas market. There is a limited demand at Christmas time for extra fat sheep. To supply this demand it is necessary to bring the sheep to the feeding pens in September and put them at once on heavy feed. The opposite of this course is carried on by a few feeders, who bring the sheep off the range in November, winter them on nothing but alfalfa, and, when the grass starts in May, drive them slowly through the valleys of the mountains to the mining camps, allowing them to feed by the way and get in good condition. Very good mutton is thus produced at small expense. The prices obtained in the camps are so small as to leave little margin of profit.

The last method of keeping sheep is for the production of early lambs for the spring market. In this case the ewes are served iu August, so as to have the lambs dropped in January. The ewes are fed hay with a little grain until they lamb, then they are crowded with the best of feed. As soon as they are old enough to eat grain, it is kept before them all the time in boxes that the ewes cannot reach. April is the best market for early lambs. A January lamb should weigh sixty pounds at three months old, and bring about five dollars if well fattened. From high-grade parents of the best mutton breeds, with the best of care and feed, it is possible to have the lamb weigh as many pounds as it is days old. A registered Shropshire lamb, born last January on the College farm weighed eighty-three pounds when three months old.

As soon as the lambs are sold the ewes are fattened for market and turned off the last of May. The sheep feeder has therefore the choice of feeding lambs, wethers, or ewes, and of feeding them for the Christmas market, for the local State market, for the Chicago market, or of raising early lambs for the spring market.

The time at which it is desired to market the sheep is the principal factor in determining what kind of sheep shall be fed. In general, the price of sheep is lowest in November. The price gradually rises through the winter, about in proportion to the value of the wool on the sheep. The February price is about twenty-five cents higher than the November price. The market price in the great centers, which is entirely governed by the Chicago price, is also lowest in November. There are almost no lambs marketed in the fall. The old sheep of the eastern states, where there is good pasturage, are easily fattened by November, if fed a little corn in September and October. As there is always a large number of old ewes to be turned off at this time of the year, the market is usually supplied with fat sheep at a low price. The price gradually rises from then to the first of June. The lamb market can hardly be said to open before the first of January. During January, February, and March the market is supplied from the East westward. In other words, the country east of the Mississippi and Missouri rivers, sells out its mutton from January 1st to April 1st; inNebraska and Kansas, from March 1st to the middle of April; and Colorado sheep from April 1st to June 1st.

The progression is due to two causes: feeding and weather. Sheep east of the Mississippi river are well fed all the time. The lambs are dropped early, and when taken off the pasture a short period of grain feeding fits them for market. The owners know that the price will be higher later in the winter; yet they can not afford to hold their sheep after they are once fat. Another reason is the weather. A fat sheep will stand cold without inconvenience, but wet weather is hard on them.

Through the sheep-feeding districts of the Mississippi valley east of the Missouri river, February and March are wet, cold, disagreeable, and unhealthy months for sheep. The feeders intend to hold their sheep as long as possible, but they have to dispose of them before the first of April. From Nebraska westward the amount of rain is so small as not to interfere with feeding. So far as weather is concerned, sheep can be carried in Colorado through to the first of June. It will be seen that the Colorado sheep feeder is at a disadvantage if he undertakes to raise sheep for the December and January markets; but he has the May markets all to himself.

The prices do not vary much on the Chicago market from November 1st until the eastern sheep are fairly well cleaned out. The eastern men have to sell, and the Chicago buyers know it. As soon as the supply from the east begins to decline, prices rise and reach a high point when Iowa sheep cease to appear on the market. From that time on until June the market remains nearly stationary for a given grade of sheep: but, as the Colorado sheep are continually getting fatter, the average price received gradually rises to the end of the season. As this point is one of vital importance to the Colorado feeder, the market prices at Chicago for the last four years have been collected and are given in the following tables. A word of explanation is needed in regard to the meaning of the figures. They represent the "top of the market" through the season. Colorado sheep bring the highest prices and each man feeds with the expectation of getting the best prices. The column marked "high," means the highest price at which the best sheep sold during the period, while "low" means the lowest price at which the best sheep sold. "Average" is the average of the prices for the best sheep. No attempt has been made to ascertain the average prices of the average sheep or the prices at which low-grade sheep sell. There are always poor sheep for sale that will scarcely bring a cent and a half a pound.

It will be noticed that "choice sheep," mostly made up of fat wethers from two to five years old, sell for fifty cents to a dollar a hundred pounds less than lambs. This relation at the present time is quite constant. A few years ago when the export trade was better, there were times when a large fat sheep for export would bring more per pound than a fat lamb. The prices for fat ewes are not given in the tables, but they will average from fifty to seventy-five cents less than the corresponding prices for choice wethers.

Prices are given only from November to June. The trade previous to November is supplied by grass-fed sheep off the range. June first is the top of the market for the year for grain-fed sheep; but by this time the pastures of the south are already supplying many thousand grass-fed "Texans," and the market is unsettled and very uncertain. Prices drop rapidly after the first of June to the summer basis.

Chicago Prices per Hundred Pounds for the Best Grades of Sheep.

	Lambs.			Sheep.		
1891.	High.	Low.	Average.	High.	Low.	Average.
November 1-15	5.25	5.00	5.20	4.70	4.60	4.67
November 16-30	5.40	5.25	5.31	4.80	4.50	4.65
December 1-15	5.50	5.00	5.25	4.85	4.50	4.74
December 16-31	6.39	5.50	5.88	5.50	4.85	4.97
Jan. 1-15, 1892	6.50	5.50	6.00	5.65	4.95	5.30
January 16-31	6.75	5.80	6.27	5.70	5.10	5.40
February 1-15	6.85	6.05	6.42	5.75	5.20	5.46
February 16-29	6.80	6.25	6.51	5.62	5.10	5.43
March 1-15	7.00	6.50	6.77	5.90	5.55	5.70
March 16-31	7.00	6.65	6.85	6.35	5.75	6.09
April 1-15	6.95	6.25	6.64	6.50	5.85	6.20
April 16-30	7.05	6.80	6.96	6.75	6.45	6.62
May 1-15	7.00	6.50	6.85	6.20	6.00	6.12
May 16-31	8.25	6.60	7.48	6.90	6.25	6.61

1892.	Lambs. High.	Low.	Average.	Sheep High.	Low	Average.
November 1-15	6.00	5.60	5.76	4.75	4.35	4.49
November 16-30	5.75	5.25	5.55	4.85	4.50	4.69
December 1-15	6.25	5.40	5.90	5.15	4.60	4.83
December 16-31	6.40	6.12	6.29	5.05	4.70	4.95
Jan. 1-15, 1893	6.25	6.00	6.12	5.40	5.05	5.19
January 16-31	6.25	5.75	6.09	5.40	5.15	5.30
February 1-15	6.45	6.10	6.20	5.25	5.15	5.21
February 16-28	6.25	6.00	6.21	5.75	5.15	5.37
March 1-15	6.60	6.10	6.44	5.50	5.30	5.37
March 16-31	6.50	6.15	6.27	5.70	5.10	5.32
April 1-15	6.85	6.40	6.57	5.85	5.60	5.71
April 16-30	6.85	6.60	6.78	5.90	5.80	5.83
May 1-15	7.25	7.10	7.21	6.30	5.60	5.85
May 16-31	7.50	7.00	7.26	6.25	5.00	5.65
1893.						
November 1-15	4.85	4.50	4.68	3.90	3.25	3.67
November 16-30	5.00	4.50	4.78	4.00	3.50	3.68
December 1-15	4.85	4.45	4.67	3.85	3.00	3.38
December 16-31	4.85	4.65	4.75	3.50	3.00	3.45
Jan. 1-15, 1894	5.00	4.75	4.87	3.75	3.10	3.50
January 16-31	4.85	4.65	4.77	3.95	3.50	3.66
February 1-15	4.75	4.50	4.61	3.75	3.40	3.53
February 16-28	4.70	4.25	4.35	3.75	3.25	3.48
March 1-15	4.30	4.00	4.19	4.00	3.50	3.92
March 16-31	4.85	4.15	4.50	4.50	3.75	4.23
April 1-15	5.75	5.00	5.49	5.40	4.65	5.06
April 16-30	5.75	5.00	5.40	5.20	4.50	4.93
May 1-15	6.50	6.00	6.25	4.90	4.50	4.61
May 16-30	6.50	5.30	5.84	5.40	4.40	4.82
June 1-15	5.60	4.75	5.09	4.65	3.60	4.13
June 16-30	5.00	4.25	4.63	3.75	3.00	3.49
1894.						
November 1-15	4.50	3.90	4.24	3.50	3.00	3.27
November 16-30	4.00	3.50	3.75	3.25	2.85	3.05
December 1-15	4.25	4.00	4.15	3.60	3.00	3.38
December 16-31	4.30	3.75	4.03	3.65	3.25	3.38
Jan. 1-15, 1895	4.50	4.00	4.26	4.00	3.50	3.59
January 16-31	4.80	4.40	4.56	4.00	3.50	3.89
February 1-15	5.65	4.65	5.05	4.70	3.85	4.23
February 16-28	5.50	5.20	5.38	4.50	4.25	4.36
March 1-15	5.60	5.20	5.43	5.00	4.35	4.32
March 16-31	6.00	5.60	5.82	5.00	4.75	4.89
April 1-15	6.10	5.75	5.89	5.00	4.50	4.85
April 16-30	5.85	5.35	5.55	5.05	4.50	4.68
May 1-15	5.95	5.60	5.72	5.00	4.30	4.57
May 16-31	6.35	5.40	5.99	5.10	4.50	4.83

The highest price of the year is from a cent and a half to two cents a pound above the lowest, but just when this highest price is coming cannot be foretold. Particular attention is called to the variation between the high and low prices. These are on the average half a cent a pound, that is, the market price is constantly fluctuating twenty-five cents a hundred each way from the average. These variations are due to the supply and demand, and are beyond the control of the feeder. In this lies the worst feature of all sheep-feeding, and it makes the profit always problematical until the sheep are actually sold. It takes five days to ship from Colorado and sell. When the sheep are loaded in Colorado, no one can tell within twenty-five cents each way as to what they will bring. The fifty cents difference in the price between a good market and a poor one often represents the whole profits of the winter and makes the difference between getting just market prices for the feed, or making in addition good wages for the work of feeding. No way has been devised for overcoming this difficulty, and it makes all sheep-feeding more or less a lottery.

The winter of 1891-92 was a time of high prices for all meat products and the prices received for sheep were such as to leave a large margin of profit, even though high prices had been paid for them in the fall and much waste allowed to occur in the feeding. The market the next year was nearly as good, and the feeders began in the fall of 1893 with the idea that their profits were an assured fact. Some feeders paid as high as two dollars a head for small lambs in the fall. The spring market proved to be from a dollar to a dollar and a half a hundred less than the previous winter. The careful buyers and feeders still made money, but some of the less careful and experienced lost heavily.

The average prices for 1894-95 have been about the same as for 1893-94; but, profiting by previous experience, the sheep were bought more carefully in the fall, fed with less waste, and almost every feeder made good profits, while some made very good.

In order more clearly to bring out the fluctuations in the market prices, the figures for the four years are gathered in the following tables:

LAMBS.

	HIGH.				LOW.				AVERAGE.				TOTAL.		
	1891	1892	1893	1894	1891	1892	1893	1894	1891	1892	1893	1894	HIGH.	LOW.	AV.
November 1-15	5 25	6.00	4.85	4.50	5.00	5.60	4.50	3.90	5.20	5.76	4.68	4.24	6.00	3.90	4.97
November 16-30	5.40	5.75	5.00	4.00	5.25	5.25	4.50	3.50	5.31	5.55	4.78	3.75	5.75	3.50	4.85
December 1-15	5.50	6.25	4.85	4.25	5.00	5.40	4.45	4.00	5 25	5.90	4.67	4.15	6.25	4.00	4.99
December 16-31	6.39	6.40	4.85	4.30	5.50	6.12	4.65	3.75	5.88	6.29	4.75	4.03	6.40	3.75	5.24
January 1-15	6.50	6.25	5.00	4.50	5.50	6.00	4.75	4.00	6.00	6.12	4.87	4.26	6.50	4.00	5.31
January 16-31	6.75	6.25	4.85	4.80	5.80	5.75	4.65	4.40	6.27	6.09	4.77	4.56	6.75	4.40	5.42
February 1-15	6.85	6.45	4.75	5.65	6.05	6.10	4.50	4.65	6.42	6.20	4.61	5.05	6.85	4.50	5.57
February 16-28	6.80	6.25	4.70	5.50	6.25	6.00	4.25	5.20	6.51	6.21	4.35	5.38	6.80	4.25	5.61
March 1-15	7.00	6.60	4 30	5.60	6.50	6.10	4.00	5.20	6.77	6.44	4.19	5.43	7.00	4.00	5.81
March 16-31	7.00	6.50	4.85	6.00	6.65	6.15	4.15	5.60	6.85	6.27	4.50	5.82	7.00	4.15	5.86
April 1-15	6.95	6.85	5.75	6.10	6.25	6.40	5.00	5.75	6.64	6.57	5.49	5.89	6.95	5.00	6.15
April 16-30	7.05	6.85	5.75	5.85	6.80	6.60	5.00	5.35	6.96	6.78	5.40	5.55	7.05	5.00	6.17
May 1-15	7.00	7.25	6.50	5.95	6.50	7.10	6.00	5.60	6.85	7.21	6.25	5.72	7.25	5.60	6.51
May 16-31	8.25	7.50	6.50	6.35	6.60	7.00	5.30	5.40	7.48	7.26	5.84	5.99	8.25	5.30	6.64
Average	6.62	6.51	5.11	5.24	5.97	6.11	4.69	4.74	6.31	6.33	4.94	4.99	6.77	4.38	5.65

SHEEP.

	HIGH.				LOW.				AVERAGE.				TOTAL.		
	1891	1892	1893	1894	1891	1892	1893	1894	1891	1892	1893	1894	HIGH.	LOW.	AV.
November 1-15	4.70	4.75	3.90	3.50	4.60	4.35	3.25	3.00	4.67	4.49	3.67	3.27	4.75	3.00	4.02
November 16-30	4.80	4.85	4.00	3.25	4.50	4.50	3.50	2.85	4.65	4.69	3.68	3.05	4.85	2.85	4.02
December 1-15	4.85	5.15	3.85	3.60	4.50	4.60	3.00	3.00	4.74	4.83	3.38	3.38	5.15	3.00	4.06
December 16-31	5.50	5.05	3.50	3.65	4.85	4.70	3.00	3.25	4.97	4.95	3.45	3.38	5.50	3.00	4.19
January 1-15	5.65	5.40	3.75	4.00	4.95	5.05	3.10	3.50	5.30	5.19	3.50	3.59	5.65	3.10	4.39
January 16-31	5.70	5.40	3.95	4.00	5.10	5.15	3.50	3.50	5.40	5.30	3.66	3.82	5.70	3.50	4.52
February 1-15	5.75	5.25	3.75	4.70	5.20	5.15	3.40	3.85	5.46	5.21	3.53	4.23	5.75	3.40	4.61
February 16-28	5.62	5.75	3.75	4.50	5.10	5.15	3.25	4.25	5.43	5.37	3.48	4.36	5.75	3.25	4.73
March 1-15	5.90	5.50	4.00	5.00	5.55	5.30	3.50	4.35	5.70	5.37	3.92	4.32	5.90	3.50	4.85
March 16-31	6.35	5.70	4.50	5.00	5.75	5.10	3.75	4.75	6.09	5.32	4.23	4.89	6.35	3.75	5.13
April 1-15	6.50	5.85	5.40	5.00	5.85	5.60	4.65	4.50	6.20	5.71	5.06	4.85	6.50	4.50	5.45
April 16-30	6.75	5.90	5.20	5.05	6.45	5.80	4.50	4.50	6.62	5.83	4.93	4.68	6.75	4.50	5.51
May 1-15	6.20	6.30	4.90	5.00	6.00	5.60	4.50	4.30	6.12	5.85	4.61	4.57	6.30	4.30	5.29
May 16-31	6.90	6.25	5.40	5.10	6.25	5.00	4.40	4.50	6.61	5.65	4.82	4.83	6.90	4.40	5.48
Average	5.80	5.50	4.27	4.38	5.33	5.07	3.66	3.87	5.57	5.27	3.99	4.08	5.84	3.57	4.73

A study of the tables will show that the top of the market for lambs has not been below five cents a pound during April and May for the last four years, while there has been some time in each year that it has been over six cents and the average of each year has been above five and a half cents. An average price of five cents will pay all expenses and return market prices for hay and grain, provided the lambs have been well bought in the fall and fed without waste. The prices show then that, if the future is to be judged by the past, a feeder who has used good judgment in his buying and feeding so as to have first-quality sheep, is sure of not losing anything on the April or May market, even if he happens to hit the poorest days. His chances are even for finding a market that will give him a fair profit and are good for striking a market that will prove a bonanza.

A noteworthy fact in regard to the prices for 1894-95 is the high price for March as compared with April and May. The same thing happened in 1891-92. This is just when the eastern sheep are diminishing in supply and before the western sheep are in prime condition. Though it would hardly be safe to feed for this market, yet it shows that it might possibly prove the most profitable of the year.

The prices show conclusively that the May market is the safest of all. Though the last half of the month is so little better than the first that most feeders prefer to begin shipping early in the month and close out their flocks during the latter half. The feeders on a small scale will find May 15 to 20 the safest market of the year.

What has been said of lambs applies in general to older sheep that can be held late in the season. But they fatten so much more quickly than lambs and have wool so much thicker that, in the general run, April had better be substituted for May as the best time for marketing. The time of marketing, therefore, will determine the kind of sheep to get, or, the sheep having been obtained, they will determine for themselves the time at which they should be marketed.

Of everything, except southern lambs, it can be said in general that the sheep should be crowded from the day they are put in the feeding pens and marketed as soon as fat. Southern lambs come here when they are only five or six months old and need to have considerable more growth of frame put on them before they are fattened.

All sheep except the southern lambs can be prepared for market in four months; old ewes and wethers in three months. The southern lambs require at least five months, and it has been found that, on the average, six months is more profitable.

It will be seen that, if a man wants to feed for the May market, which is considered the best market of the year, he has his choice between taking southern lambs in November or waiting until much later and then taking western lambs or old sheep. A bunch of 3,500 western lambs came to Fort Collins from the west in March that had beeh wintered on the range, and, with three months' feeding, were in good condition for the market. This is an exception; the range upon which they fed was extra good. Three lots of southern yearling wethers were brought up in March and crowded for the May market. But these are rare exceptions to the general rule that the May market is supplied by southern lambs that are in extra good condition from six months' feeding.

METHODS OF FEEDING.

In all sheep-feeding east of Colorado, hay is considered of value only as enabling the sheep to consume a large amount of grain and keep in health. A sixty-pound lamb requires just about one pound of digestible matter per day, and this is easily obtained from two pounds of grain which is almost always corn. For roughness to feed with this grain they usually use timothy hay, but good straw is considered about as good.

In Colorado sheep-feeding, hay has a much different use. It is so largely nitrogenous and so palatable that a large part of the growth and fattening comes from the hay.

In feeding southern lambs they are put on hay alone from one to three weeks and then grain feeding begins. In the feeding of sheep on a large scale, the grain is fed in a separate corral. The sheep are kept in bunches of about four hundred, their grain is put in feed troughs, the gates are opened, and they are allowed about ten minutes to eat their grain, then driven back and the next bunch brought in. By this method all the sheep have a chance to get some grain, and even the greediest sheep can not get very much.

The first grain feed is merely a sprinkling in the trough to get the sheep used to it. The principal skill in feeding sheep is in increasing the grain so gradually that the sheep eat it greedily all the time. Most feeders use pails and reckon feed by the number of bucketfuls fed per day. A bucketful of twenty pounds to four hundred sheep twice a day is one-tenth of a pound per day, and this is as much of an increase as it is considered safe to make at any one time, and it is customary to increase only one-half of this.

Lambs put in the pens in November will receive their first grain at the beginning of December and for the first week will get less than one-tenth of a pound per day per head, that is, the feeder will use a week in getting them up from nothing to one-tenth of a pound. The rest of the month to the first of January they will not go over one-fourth pound. Some hold through the whole month of January on one-fourth pound, while some gradually increase through the month to one-half pound.

This is all considered preparatory, and real grain feeding begins the first of February. Feeders vary in the speed with which they increase the grain; but by the first of March few will be feeding less than one pound, and the sheep are kept on full feed from then until they go to market. If nothing but wheat is fed, it is hard to get sheep to eat over a pound per day per head. By the addition of some other grain and by feeding three times per day, they can be brought up to one and a quarter pounds. This extra grain may be corn meal, cotton-seed meal, or linseed meal; in other words, any grain that has considerable oil which seems to help the digestion and enable the sheep to handle a larger amount of grain.

Most of the wheat fed near Fort Collins the past winter was unground. Considerable of this goes through undigested, and there is apparently no foundation for the claim made by the Nebraska feeders, that much of the nutriment has been taken out of this grain which passes whole. It is practically certain that no nourishment is received from it. It is probable that a very large amount of loss occurred in this vicinity last winter from this whole grain feeding, and that much of the trouble the feeders had from their first shipments of sheep not being fat was due to this cause.

It would be difficult to so say what portion of the wheat passes whole, but probably ten per cent. is a small estimate. When whole wheat was fed at the College Farm, the droppings appeared to have fully half as much wheat as the sheep ate.

There are men with portable mills who will grind wheat on the premises for three cents per hundred pounds, and the probabilities seem to be that the increased value is at least ten cents per hundred. It is a significant fact that the first bunch of sheep that went to the Chicago market last spring that had been fed on cracked wheat received a higher price than any other bunch, enough higher to pay for half the grain they had eaten.

The question of the comparative feeding value of wheat and corn for sheep is a long way from being decided. From 1891 to 1894 most of the grain fed to sheep in Colorado was corn, shipped in from Nebraska at about seventy-five cents per hundred. The partial failure of the corn crop of 1894 raised the price to over a cent a pound, while wheat could be bought for sixty-five cents to seventy-five cents per hundred pounds. Consequently, wheat was the principal grain fed from November 1894 to March 1895. Judged by its composition, wheat is well-adapted to making growth on an animal, and feeders were well satisfied with the gain in weight made by their sheep during the earlier part of the season. The first shipments showed that the sheep were not so fat as they seemed to be. They had made a growth in weight, but their flesh was soft and watery. They lacked the hard, solid kidney fat that had been a distinguishing feature of Colorado corn-fed sheep. The shrinkage of weight in shipping was nearly twice as much as in previous years on corn feeding.

So pronounced were these results of exclusive wheat feeding that, during April and May, many carloads of corn were bought, and some feeders claimed that they could afford to pay twenty-five dollars a ton for corn to finish off their sheep for market.

Several thousand old sheep were brought to Fort Collins and put on a heavy feed of wheat to fatten them rapidly for market. But, instead of fattening, the combination of wheat and alfalfa, both rich in bone and muscle-forming elements, started them growing again and delayed for some weeks their marketing.

The experiences of the past season have shown that, for lambs, it is probably best to feed wheat the first third of the winter, then half wheat and half corn for the next third, finishing off on clear corn. In feeding older sheep, corn is by far the best grain to use.

The hay fed to sheep in Colorado is all alfalfa. It is fed in racks that are best about fourteen feet wide. These racks are simply low fences enclosing a space fourteen feet wide and any length desired. The fences are made of three 8-inch boards running lengthwise of the racks, the bottom one resting on the ground; the others above with 8-inch spaces, making a fence foity inches high. The hay is pitched into the middle by the wagon load, and pushed up to the sides two or three times per day as fast as the sheep need it. There should be rack enough so that most of the sheep can eat at the same time; this will require about one foot per head for lambs and fifteen inches per head for older sheep.

The alfalfa in Colorado is all stacked, without cover, and consequently there is a large amount of poor hay on the top and bottom of the stacks. This is refused by the sheep, together with considerable of the coarser parts of the stalks. Practice varies greatly as to what is done with this refuse and as to how clean the sheep are required to eat the hay before fresh is given.

Southern lambs are rather dainty feeders and it is estimated that, with a fair quality of hay, one-fifth of that given them is not eaten. With older sheep, and especially with large western wethers, not more than half as much is refused. The best feeders clean out the refuse from four to six times a month. It makes the best of horse hay and is excellent to winter colts and range cattle. Under present methods much of it is wasted. Hundreds of tons are thrown out of racks into the spaces between and tramped over by the sheep until in some corrals this mixed layer of hay and manure becomes more than a foot thick. From ten to fifteen two-year-old steers can be wintered on the refuse from a thousand sheep, and it would be still better for all concerned if the hay was cleaned out so often as to furnish feed for twenty head. In counting the cost of feeding sheep, this refuse is not considered, and all the hay taken from the stacks is charged against the sheep.

Sheep do best with running water before them all the time. A large part of the feeding yards in Colorado are located on the banks of streams or near enough to rivers so that ditches can be run through the yards and the surplus water returned to the river. Those on high ground depend on windmills to pump the water into a tank from which it runs into the watering troughs. The troughs are furnished with float-valves that keep the water always at the same height. At night in cold weather the water is shut off by a valve below frost. A few feeders have done good work, though compelled to haul water several miles in tanks. During the coldest weather, sheep will drink only a quart of water per day a head, but in warm weather five to six quarts is an ordinary amount. It is probable that this fact exerts a large influence on the live weight of sheep at different periods of the year. The sheep on the College Farm gained rapidly during October on a moderate allowance of food. With the first real cold weather in November, they increased nearly half on the amount of food consumed, but the live weight decreased decidedly. Then there was a steady slow gain through the three winter months. When the first warm days of spring came, they made a sudden large gain in weight with no corresponding increase of food. After this the gain was again fairly constant, or at least, in accordance with the food eaten.

Opinions differs widely as to the amount of salt required by fattening sheep. The most common practice is to keep lumps of rock salt where the sheep can lick them. Under these conditions the sheep will scarcely eat two ounces of salt apiece. Some feeders supply the sheep with all the coarsely-ground salt they will eat, which is more than a pound per head. Others never give any salt at all The results seem to be equally good under each method. All the water of Colorado in winter is strongly alkaline and the theory of those who feed little salt is, that the water contains all the salt the sheep need. It is also a fact that alfalfa hay contains enormous quantities of salt.

Another undetermined point in the economy of sheep feeding is the matter of shearing. Southern lambs are so light of fleece that they never need shearing in the fall. But, if they are to be fed until the last of May, they get very fat and their thick fleece at that time makes them suffer from the heat. If they should happen to be shipped during a hot spell there would be danger of large death losses. If sheared six weeks before shipping, they will grow enough more rapidly to make up the weight of the wool, shrink less in shipping, and pack quite a number more in a car, lessening the freight charges per head. The cost of shearing is five cents per sheep, and the wool is about four pounds, worth thirty cents per head. When, however, these shorn sheep reach the Chicago market, they sell for less per pound, even as much as 35 cents per hundred, or about 30 cents per sheep. This is sufficient to take away all the profit of shearing. Therefore, but few southern lambs are shorn before shipment. The same is true of southern wethers and ewes.

With the western sheep the case is quite different. They are larger, the fleece is longer and grows earlier. They have to be sheared if they are to be fed late in the spring. It is probably best to shear them in the fall as soon as they are brought to the yards, so that the wool will start again before cold weather. They then grow more rapidly through the winter, and the wool in the spring will be almost as heavy as though they had never been sheared. This fall shearing applies only to good, well grown lambs. Wethers and ewes do not need shearing if they are to be marketed before April 15. If they are to be held until late in May, they had better be sheared in the spring rather than the fall.

DEATH LOSSES.

Colorado sheep are pre-eminently healthy. Losses from disease after the sheep are in the feeding yards are very infrequent. Moreover, the alfalfa hay is such an excellent fodder for producing both bone and muscle that the sheep, even in the last stages of fattening, are still healthy and strong. They stand shipment easily, and it is not uncommon for a train load of three thousand head to go through to Chicago without a single death. The shipping distance from New Mexico to Colorado is so short that not many head die while being brought in. Some train loads brought from Idaho and from southwestern New Mexico had a somewhat higher death loss. With the exception of one band that lost fifty head by an accident, the highest death loss that has come to light in Colorado the past season was about twenty-five head in a bunch of more than fifteen hundred. This is about one and a half per cent. The next highest is less than one per cent., and from that down to less than a fifth of one per cent. The average for the State is not far from a half of one per cent., or five head per thousand.

This is surprisingly small when compared with the death losses in Nebraska. Where corn is fed there with timothy hay, they finally work the sheep up to two and a half pounds per day per head. Such heavy corn feeding has a tendency to produce weakness and disease, especially impaction. Nebraska feeders calculate on a death loss of from two to five per cent., with an average of about three per cent. This would be three hundred sheep out of the ten thousand that are commonly gathered at a feeding ranch, or just about one thousand dollars worth of dead sheep.

SHIPPING.

As soon as enough of the sheep to make a few car loads get fat, shipping begins. From a third to a half in the bunch are picked out for the first shipments. The degree of fatness is the test; the size is secondary. The Chicago market pays just as much per pound for a small fat sheep as for a large one if both are equally fat. If ten or more car loads of sheep are shipped at the same time, the railroads will make up a special train and send the stock through on nearly passenger time. Enough sheep are now being fed in Colorado, so that by conference and mutual agreement train-load lots can always be shipped. One train of thirty-three cars, last winter, contained over six thousand sheep. The railroads allow one passenger free transportation one way for each carload. By shipping two cars in charge of one man, he gets free return transportation.

The sheep are usually loaded in the afternoon and start at once upon their journey. Twenty-four hours of fast travelling brings them to the vicinity of the Missouri river, where they are unloaded, fed, watered, and rested for one day. Another twenty-four hours' ride and they are near Chicago. They are not at once put on the market, but are unloaded a few miles out of Chicago and fed from one day to a week, according to their condition and the condition of the market. When it is desired to sell them they are loaded early in the morning, put in the pens at the Chicago stock yards, where they are so scared that they will neither eat nor drink and are weighed and sold as soon as possible. The shrinkage in weight from Colorado to Chicago is considerable, notwithstanding the two rests and feeds. In past years on exclusive corn feeding, five per cent. was considered a fair shrinkage. Some bunches have gone through with only a three per cent. shrink, while eight per cent. is not uncommon. The wheat-fed sheep of 1894-95 have showed some surprising shrinkages. One bunch of extra fine western lambs weighed at the cars 122 pounds per head after a drive of about a mile. In Chicago they weighed out only 104 pounds, a shrinkage of eighteen pounds per head, or over fourteen per cent. Early shipments of fat wethers and ewes showed nearly as great a shrink. Toward the close of the season as the sheep became fatter, the per cent. of shrink was somewhat less.

COST OF SHIPPING.

The freight rate from Colorado common points to Chicago is $95 per 30-foot car, with ten per cent. added for a 36-foot car. To this is added $15 for loading and unloading when feeding in transit. Two car loads in the fall will require three cars to take them to market in the spring, or two cars at $110 per car and one at $95. Three cents per day per head is charged for feed at each of the two feeding places on the road. A yard fee of five cents per head is exacted by the stock yards in Chicago, and the live-stock broker charges a commission of ten dollars per car for selling. To these items of cost are to be added the wages and hotel expenses of the man in charge for the twelve days occupied by the trip. Most of the men are willing to go for their bare expenses for the sake of the trip.

Sheep are always shipped in double-deck cars. The deck of a 36-foot car holds about ninety large western wethers or one hundred and twenty southern lambs. The expenses of shipping would be then for large sheep, for one thousand head:

Freight on four cars @ $119.50	$478.00
Freight on two cars @ $104.50	209.00
Feed two days @ 6 cents per head	60.00
Yardage at Chicago @ 5 cents per head	50.00
Commission on six cars	60.00
Expenses of three men @ $40	120.00
Total	$977.00

This is almost exactly a dollar a head.

On a bunch of fifteen hundred southern lambs, the account would stand:

Freight on four cars @ $119.50	$ 478.00
Freight on two cars @ $104.50	209.00
Feed two days @ 6 cents per head	90.00
Yardage at Chicago @ 5 cents per head	75.00
Commission on six cars	60.00
Expense of three men @ $40	120.00
Total	$1,032.00

This would be sixty-nine cents per head, and represents the least possible cost. It is common to estimate probable expenses for lambs at fifty cents per head in addition to the freight to the Missouri river on two-thirds of the cars and the traveling expenses of the owner. This is the same as about seventy-five cents per head.

EXPENSES OF FEEDING.

The expenses of feeding southern or Mexican lambs can be estimated with a great deal of certainty. The cost does not vary much from year to year and the cost of the various bunches in any given year will differ only a few cents. The fall of 1894 they cost $1.35 per head delivered at Fort Collins, with freight paid to the Missouri river. Alfalfa hay costs from $3.50 to $4 per ton in the stack. The buyer has to do the hauling from the stack to the feed racks. It is customary to add a dollar a ton if the seller does the hauling and also furnishes feeding yards, racks, etc. Wheat has cost on the average the past season $15 per ton, cotton-seed meal $19, oats and barley $21, and corn chop about $22.

The expense of caring for the sheep and giving them their feed will vary greatly with the size of the flock and the conveniences for feeding. Six hundred head is the smallest bunch that it is profitable to feed. One man and team will do all the work necessary for such a bunch and have enough spare time to do all the work needed through the winter on a farm large enough to raise the hay for this number of sheep. On a larger scale, three men and one team will haul the hay and do all the feeding for a bunch of four thousand head. Their wages would be not more than $150 per month or $900 for the six months' feeding period. This is less than twenty-five cents per head, while in bunches of fifteen hundred or less the average cost is not far from thirty-five cents per head.

How much hay will a sheep eat? The amount depends, principally, on the size of the sheep, but also upon the amount of grain fed. When fed on hay alone, the amount eaten is closely proportional to the size. If there is any difference, the larger sheep eat more per thousand pounds of live weight than the smaller. The general expectation among feeders is, that old wethers and ewes will eat about four pounds of hay a day in addition to their grain, while lambs will eat two and a half pounds. Careful tests were made at the College Farm last fall and it was found that during the mild weather in the fall, the large western wethers averaging 120 pounds live weight per head, ate 3.6 pounds of hay per day per head. Western lambs of 100 pounds weight, ate 2.3 pounds of hay, while southern lambs weighing 65 pounds ate only 1.3 pounds of hay per day. A few weeks later in cold weather, the wethers increased to 5.0 pounds of hay per day, the western lambs to 4.0, and the southern lambs to 2.2 pounds per day. At the end of the winter, when the sheep were eating a pound of grain and five pounds of sugar beets, apiece per day, the western wethers ate in addition 2.62 pounds of hay and the western lambs 3.0 pounds. By this time the wethers had grown to weigh 159 pounds and the lambs 137 pounds per head. The southern lambs, weighing 87 pounds each, ate six-tenths of a pound of grain, three pounds of sugar beets, and 1.8 pounds of hay. Reduced to digestible matter, all of these sheep were eating close to twenty pounds of digestible matter daily for each thousand pounds of live weight.

During the whole six months of feeding, the western wethers ate 512 pounds of hay in addition to 68 pounds of grain and 330 pounds of beets; the western lambs ate 529 pounds of hay, and the same amount of grain and beets. The southern lambs ate 296 pounds of hay, 58 pounds of grain, and 287 pounds of beets.

All these weights of hay represent the amount eaten, plus the very small amount wasted, but do not include the amount of refuse taken from the racks and fed to our horses and other stock. If this were added, it would bring the total for the southern lambs up to 350 pounds, while the ordinary rule is 200 tons of hay for 1,000 lambs, or 400 pounds per lamb.

The figures given above for western wethers and lambs are above the average per head, since these sheep were extra large. Probably 600 pounds per head, would be sufficient to include the hay eaten and wasted for sheep of average size.

The grain consumed is largely at the option of the feeder. The general attempt is to feed lightly until about the first of February, and after that induce the sheep to eat as much as possible. According as the feeding period is long or short and depending somewhat on the size of the sheep, the amount of grain will vary from 70 pounds per head to 150 pounds. The average is not far from 120 pounds. The tendency from year to year is to feed more and more largely of grain.

The account of feeding southern lambs would stand as follows:

Cost of lamb	$1.35
400 pounds hay @ $4 per ton	.80
120 pounds grain @ $15 per ton	.90
Labor of feeding	.35
Interest and death loss	.06
Freight and expenses to Chicago	.50
Total	$3.96

This $3.96 is a liberal allowance, and if the feeder gets this return he has received full market prices for his hay, grain, and time. All above this should be counted as clear profit.

Statistics have been gathered of the full feeding of over ten thousand southern lambs in Colorado the past season and the average feed has been 414 pounds of hay, 71 pounds wheat, 5 pounds cotton-seed meal, 6 pounds barley, 2 pounds oats, and 35 pounds corn; or a total of 119 pounds of grain. The highest amount of hay fed and wasted was 550 pounds per head and the man so reporting vows he will never again hire inexperienced men to feed for him. The lowest amount is 300 pounds of hay per head. The highest amount of grain fed is 146 pounds, and the lowest 97 pounds per head.

The average time of marketing was April 24th, average weight in Chicago 77 pounds, average price in Chicago $5.58 per 100 pounds, or $4.30 per head. This gives an average profit of 34 cents per head above all expense.

The feeders of Colorado have a peculiar way of never making any profit on their feeding transactions, but of taking out all expenses and counting the remainder as having been obtained for the hay. Figured in this way the sheep feeders netted $5.70 a ton for their alfalfa after paying for the labor of hauling and feeding it, or $7.45 per ton for the hay delivered at the racks.

Among so many feeders there would be, of course, a great variation in these net profits. The highest price received for any one carload was $6.35 per hundred pounds, and the lowest $5.00. The highest price for a whole bunch was $5.90 per hundred. The highest price per head for a whole bunch was $4.90, and the lowest $2.73. It would be difficult to figure any profit out of the latter while the former netted the fortunate feeder market prices for his hay and grain, all expenses, and $100 a month for his time. Or, it paid all expenses including the cost of feeding and netted him $9.45 per ton for his alfalfa.

It is a noteworthy fact that the original stock as put into the feeding yards in the fall was just about the same quality throughout. The difference in results is principally due to care and skill in feeding. The different results of feeding are also apparent in the live weight of the lambs when marketed in Chicago. In the fall the different bunches weighed 48 to 52 pounds per head. On the Chicago market the average was 77 pounds, with a variation of from 56 pounds to 83 pounds. The best feeders made more than twice as much gain in live weight as the poorer.

The average selling date is rather early. Prices rose to a point where the feeders could see a surety of profit and they wisely took advantage of it.

FEEDING WESTERN LAMBS.

The figures already given for southern lambs can serve as a basis for comparing the results on feeding the kinds of sheep. Several thousand western lambs were fed near Fort Collins last winter and the first impressions were quite favorable to them. If preparations for the feeding of 1895-96 had been made in February 1895, most of the feeders would have tried some western lambs.

The lambs fed here were from western Wyoming or Idaho and were graded with Shropshire and Cotswold blood. They were larger than the southern lambs when they were put in the feeding yards and they grew faster. They made a handsomer looking animal, and it seemed that they must give a fine profit. But, when the final test came in the Chicago markets, the buyers refused to pay as much for them as they were eager to give for the inferior looking southern lambs. The lower price of from fifty cents to a dollar per hundred pounds took away the expected profits and few western lambs will be fed in Colorado the coming season.

First-class western lambs in bunches weigh about seventy pounds per head at the feeding pens the first of November. They cost last fall two dollars per head here, or twenty-five cents more with freight paid to the Missouri river. They cost, then, a little over three cents per pound, live weight, as compared with the two and three-quarter cents per pound that the southern lambs cost.

Per head they eat more than the southern lambs, and per thousand pounds of live weight fully as much, if not more. In shipping, the freight per head is more and the freight per thousand pounds about the same as the southern lambs. On the market they bring less per pound and about the same per head as the southern lambs. Under these conditions, it can be seen that the chances for profit are slight

An average statement of receipts and expenditures for western lambs would be as follows:

Cost of lamb	$2.25
500 pounds hay @ $4 per ton	1.00
120 pounds grain @ $15 per ton	.90
Labor of feeding	.35
Interest and death loss	.06
Freight and expenses to Chicago	.60
	$5.16
Receipts, 96 pounds @ $5.25 per hundred	$5.04

The above showing is not very favorable to western lambs. A bunch might possibly be bought for less than the $2.25, but if so the chances would be that they would not be good enough to weigh out 96 pounds in Chicago. If cheap corn could be obtained to feed with the alfalfa, the time of feeding could be shortened to about four months and about fifty cents per head saved on the cost of the feed. One of the greatest objections to the western lambs is their aptitude for growth. If put on ripe timothy hay and clear corn chop, they might fatten without much growth, but on Colorado alfalfa and wheat they grow rapidly in frame and muscle, but are loath to lay on hard fat.

FEEDING OLDER SHEEP.

In general it can be said that old sheep cost more per head than lambs, and when put on the market sell for about the same. The only chance for profit comes from the shorter time required to get them fat. There seems to be a small profit to be made from yearling wethers if one could happen to get some good stock at a reasonable price, fatten it quickly with corn chop at $15 per ton, and find a good market in Chicago. Under these extra favorable conditions the account would stand as follows:

Cost of yearling wether	$2.25
450 pounds hay @ $4 per ton	.90
100 pounds grain @ $15 per ton	.75
Labor of feeding	.35
Interest and death loss	.06
Freight and expense to Chicago	1.00
	$5.31
Receipts, 130 pounds @ $4.50	$5.85
Profits per head	$ .54

The fattening of ewes has about the same business basis as of old wethers. They cost less, about a dollar and a half per head, and they sell for enough less fully to over-balance the less cost. Few feeders make a regular business of feeding ewes, but those who raise their own feeders have to fatten and get rid of their old ewes. Often in buying feeders a whole mixed bunch can be bought for about the same price as would be asked if the old ewes were sorted out. In these ways many thousand ewes are fed each year, but without much profit to the grower or feeder.

The question was often asked last winter, as to how much wheat was being fed in place of corn. The best statistics available show that the 117,000 sheep fed for the Chicago market ate about 136,000 bushels of wheat, 95,000 bushels of corn, and 840 tons of other grain.

With this there were consumed 27,560 tons of alfalfa hay. Few of the sheep fed for the Colorado home market received much grain and the same is true of those sold as feeders or shipped to Omaha. The above figures therefore represent, probably, four-fifths of all the grain fed to sheep in Colorado and probably about half of the hay fed. No attempt has been made to ascertain how much wheat was fed to steers, but it was of course a very large amount.

SHEEP STATISTICS.

Much care has been taken to get the facts concerning the sheep fed in Colorado the past season. It is believed that the following list is practically complete for the sheep that were shipped to the Chicago market. It does not include any sheep fed for the home market, sold to feeders, or shipped to Omaha.

NAME.	ADDRESS.	SOUTHERN and MEXICAN. Lambs.	Wethers.	Ewes.	COLORADO. Lambs.	Wethers.	Ewes.	WESTERN. Lambs.	Wethers.	Ewes.
J. C. Beers,	Fort Collins	800								
S. Underwood,	" "	717								
Alex Barry,	" "	611								
J. L. Hice,	" "	800								
Q Schlang,	" "	1300								
C. F. Blunk,	" "	1100								
A. B. Rugh & Co.,	" "									
Jerry Beach	" "	899						1471		29
J. Z. Smith,	" "	620								
H. W. Brownell,	" "	845								
Chas. Trimble,	" "	1200								
E. H. Bushnell,	" "	600	650							
Beach & Fowles	" "	1300	450			200				
Mr. Gilmore,	" "	900								
Chas Johnson,	" "									
Miller & Trimble,	" "	2644						600	1400	
Mr. Ormsby	" "									
F. J. Schroeder,	" "	1200							7000	
August Koeper,	" "	1000								
W. H. Humphrey,	" "	600								
A. H. Hice,	" "	450								
Parker & Windham,	" "	250	110	200						
Mr. Hoard	" "		2000							
Stockwell & Matthews,	" "	3000	5000	200						
P. Anderson & Co.,	" "									
At J. A. Brown's	" "		1009	67		52		775	800	
At Mr. Williams's,	" "							608		
At S. Garrett's,	" "							2000	1500	
At N. C. Alford's,	" "								2080	
At F. J. Murray's,	" "								4000	
At Moore Bros'.,	" "								4000	
At Jesse Harris',	" "								2000	
At Dwinell Bros'.,	" "							2000		
J. E. Law,	New Windsor.				935		630		2000	
E. Boettcher,	" "									
W. E. Mayhood & Co.,	" "	1175			113				3500	
Bennett Bros.,	Timnath		571			579				
W. B. Aiken,	"				1500					
Taylor & Stiles,	Loveland	480			20					
Alex Spear,	"	1000								
W. Griep,	Berthoud				600					
A. A. Knott,	"				1534	439	405			
John Welty,	"				600					
W. E Doyle & Co.,	Rocky Ford								6000	
A. Forder	" "				1000					
T. S. Orcutt,	" "				1000		1000			
One Feeder,	" "				2000					
Huling & Norward,	Las Animas			500	1500					
Mr. Dostal,	" "				1500		500			
Sargent & Webber,	" "				500		500			
L. Baldwin & Co.,	Lamar	5000	4000	1000						
E. F. Swift,	Ordway								15000	

Southern and Mexican.	Lambs	28,491	
	Wethers	13,790	
	Lambs	1,967	
			44,248
Colorado.	Lambs	12,802	
	Wethers	1,270	
	Ewes	3,035	
			17,107
Western.	Lambs	7,454	
	Wethers	49,280	
	Ewes	29	
			56,763
Total.	Lambs	48,747	
	Wethers	64,340	
	Ewes	5,031	

Grand Total........................118,118

FEEDING EXPERIMENTS ON THE COLLEGE FARM.

HISTORY.

The following experiments were undertaken with a view of obtaining some accurate figures in regard to the feeding of sheep in Colorado and more particularly to ascertain the relative chance for profits in feeding southern and western sheep.

The several bunches of sheep were secured in the fall and held on alfalfa hay until all preparations for the tests were completed. A test was made of the relative amounts of food eaten by the different sheep when on the same rations. Then on December 13, they were divided into four lots for the testing of four different feeds, namely, corn, wheat, sugar beets, and sugar beets and wheat, each being fed with alfalfa hay. The feeding test proper closed March 20, when all lots were again put on the same rations to determine their relative capacity for food. The western sheep were sold April 11, while the southern sheep were kept a month longer and used in a test of shrinkage in shipping as between corn and wheat for the grain feed.

The animals used were as follows: Twenty yearling wethers, obtained from L. P. Southworth, Cotswold and Shropshire blood topped on the original Merino. They were selected for size and vigor from a large bunch, and were very heavy sheep. They were raised in southern Idaho.

Seventeen wether lambs and three ewe lambs of the same source and general breeding as the yearling wethers. These were selected from a flock of 2,500, and represented the western lamb in its best possible form. They weighed nearly a hundred pounds apiece, though only five months old.

Twelve yearling wethers from New Mexico were obtained from C. R. Bullard. They were probably late lambs of the year before, and weighed but little more than the spring lambs.

Eight wether lambs were also obtained from C. R. Bullard and twenty wether lambs from Jerry Beach. All were from New Mexico and all selected from large bunches, so as to be heavier sheep than the average though not much better feeders than are commonly obtained. Since the New Mexican sheep were low in quality the fall of 1894, it is probable that these tops represent about an average grade of an average year, although ten pounds heavier in weight.

The tests were thus made with eighty sheep: twenty western yearlings, twenty western lambs, twelve southern yearlings, and twenty-eight southern lambs.

FEEDING.

As all of the feeding in Colorado has been done on a large scale, with almost no weights of either sheep or feed, and as no records have been made of amount eaten as separated from that wasted, it has been deemed best to print the full records of the feeding. The sheep were fed in racks fourteen by sixteen feet square, with tight board bottoms. These were filled with a weighed quantity of hay, about four hundred pounds to the rack. As the sheep ate the hay around the sides of the rack, new hay was pushed out from the middle and the coarse butts they refused drawn out of their way. Fresh loads of hay were added from time to time. The sheep were tagged and weighed individually each two weeks, at which time the refuse was all cleaned out of the racks aud weighed, giving by subtraction the amount of hay actually eaten. In the amount credited as eaten is included the small quantity that was thrown out of the racks by the sheep and trampled under foot. By keeping the ground clear around the racks, this was reduced to a minimum and probably does not represent over five per cent. of the total amount actually eaten. Thus the sheep always had the best of hay before them, and the amounts of hay they are credited with eating represent the maximum amounts that sheep will really eat. That these amounts are less than those commonly given for sheep, show how large a proportion of the hay put in the feeding racks is ordinarily wasted.

The grain and beets were fed in separate racks twice a day, and were usually all eaten in about fifteen minutes.

Feeding began October 24, 1894, and for the next twenty-eight days nothing was given but alfalfa hay. On November 13, the twenty western lambs were sheared, yielding four and one-fifth pounds of wool per head. The first snow storm of the season came November 15, with a high wind and a temperature of one below zero. The newly sheared lambs suffered severely with the cold, but ate so much that they rapidly made up the loss of the weight of their fleece.

FEEDING RECORD OCTOBER 24 TO NOVEMBER 19.

	Weight Oct. 24. lbs.	Weight Nov. 19. lbs.	Hay eaten per head per day. lbs.	Hay eaten per day per 1000 lbs live weight. lbs.	Digestible dry matter per day, per 1000 lbs live weight. lbs.
Western yearlings,	118	128	3.6	30	15.0
Western lambs,	101	103*	2.3	23	11.5
Mexican yearlings,	73	75	2.8	38	19.0
Mexican lambs,	63	66	1.3	20	10.0
Average,	89	93	2.5	28	13.9

*To this would be added the four pounds of wool, so that the western lambs really gained six pounds during the four weeks.

It will be noticed that in both cases the older sheep ate more than the lambs, both per head and per thousand pounds of live weight.

From November 20 to December 13, the feed remained alfalfa alone. The sheep ate considerably more, due probably to the increased cold weather. From December 1 to 13, was steadily cold, freezing hard every night and not thawing in the shade in the day time. During these three weeks the sheep lost weight, and on December 13 weighed just about the same as when they came in October. It is probable that this loss of weight was merely a shrinkage of the water in the sheep's system, not a loss of real flesh—a preparation by the sheep for cold weather. During these weeks they decreased in the amount of water drunk, and for the rest of the winter they drank very sparingly.

FEEDING RECORD NOVEMBER 19 TO DECEMBER 13.

	Weight Nov. 19. lbs.	Weight Dec. 13. lbs.	Hay eaten per head per day. lbs.	Hay eaten per day per 1000 lbs live weight. lbs.	Digestible dry matter per day per 1000 lbs live weight. lbs.
Western yearlings,	128	121	5.0	42	21.0
Western lambs,	103	99	4.0	40	20.0
Mexican yearlings,	75	75	3.6	49	24.5
Mexican lambs,	66	61	2.2	35	17.5
	93	89	3.7	41	21.0

In this heavy increase of food the different lots retain the same relative places they did the month previous on lighter feed. The Mexican yearlings still eat the most for their weight, and this relation continues throughout the whole winter's feeding. They also make the least gain in return for their food.

CHANGE OF FEED.

On December 13, they were divided into four groups of twenty each and put in four separate pens. Each pen had a small shed for shelter from the wind and snow, but, as it was always open, it was not much protection from the cold. Nor did they seem to mind the cold in the least, although it was an unusually severe winter. All feeding was done in the open air. Each group consisted of five western yearlings, five western lambs, three Mexican yearlings, and seven Mexican lambs. Care was taken to have the groups as nearly even as possible, and the extremes of variation from the average were less than half a pound in live weight per head.

Pen No. 1, received 1-2 pound cracked wheat and 3 to 5 pounds of beets per day per head, with all the alfalfa hay they wanted.

Pen No. 2, 1-2 pound cracked wheat and alfalfa hay.

Pen No. 3, 1-2 pound cracked corn and alfalfa hay.

Pen No. 4, 3 to 5 pounds beets and alfalfa hay.

FEEDING RECORD DECEMBER 13 TO 26.

PER DAY PER HEAD.

	Hay. lbs.	Wheat. lbs.	Corn. lbs.	Beets. lbs.	Total Digestible dry matter. lbs.	Gain per pen. lbs.
Pen No. 1,	3.5	0.5		2.9	2.59	121
Pen No. 2,	3.8	0.5			2.28	76
Pen No. 3,	3.3		0.5		2.02	69
Pen No. 4,	3.8			3.2	2.41	108
Average,	3.6	0.25	0.125	1.5	2.32	93

GAINS IN LIVE WEIGHT DECEMBER 13 TO 26.

	Pen 1.	Pen 2.	Pen 3.	Pen 4.	Total.
Western yearlings,	56	39	29	49	
Western lambs,	31	17	19	33	
Mexican yearlings,	9	11	6	13	
Mexican lambs,	25	9	15	13	
Total,	121	76	69	108	

The gains agree very closely with the food eaten. The sheep that eat the most, gain the fastest.

The same rations were continued unchanged to February 7. Some variations were shown in the amount of hay eaten with the other feeds as given below:

RECORD OF HAY EATEN DECEMBER 13 TO FEBRUARY 7.

Date.	Pen 1.	Pen 2.	Pen 3.	Pen 4.	Average.
December 13 to December 26,	3.5	3.8	3.3	3.8	3.6
December 26 to January 8,	3.2	3.3	3.4	3.6	3.4
January 8 to January 23,	2.2	3.1	3.0	1.7	2.5
January 23 to February 7,	2.6	3.5	2.8	3.0	3.0
Average,	2.9	3.4	3.1	3.0	3.1
Total Digestible,	2.4	2.1	2.0	2.2	2.2

The pen that has both grain and beets eats less hay than any of the others, but the total amount of food per day per head is largest in this pen. As a natural consequence, they gain most in live weight as shown in the following table:

GAINS IN LIVE WEIGHT DECEMBER 13 TO FEBRUARY 7.

Date.	Pen 1.	Pen 2.	Pen 3.	Pen 4.	Total.
December 13 to December 26,	121	76	69	108	374
December 26 to January 8,	15	30	31	30	106
January 8 to January 23,	145	154	144	150	593
January 23 to February 7,	75	38	38	43	194
Total,	356	298	282	331	1267

On February 7, the feed was increased. At first the pens Nos. 2 and 3 that were getting one-half pound per head per day were increased to three-fourths of a pound and the others remained unchanged. This resulted in the grain pens gaining 63 pounds more in the next two weeks than the root pens. At the same time they ate more hay than when on half a pound of grain per day.

For the next four weeks, the sheep were stuffed all they could eat. Pen No. 1 had half a pound of grain and six pounds of beets; pens Nos. 2 and 3, one pound of grain, and pen No. 4, from six to seven pounds of beets. The weather was so much warmer that they ate much less total food. Thus the grain and roots were a larger proportion of their food than at any other time. They did not gain quite so fast as in the two weeks previous, but they still made a rapid growth.

RECORD OF HAY FEEDING FEBRUARY 7 TO MARCH 20.

Date.	Pen 1.	Pen 2.	Pen 3.	Pen 4.	Average.
February 7 to February 19,	3.2	3.8	3.4	2.6	3.2
February 19 to March 20,	1.6	2.2	2.1	1.2	1.6
Average,	2.1	2.7	2.5	1.7	2.2

TOTAL DIGESTIBLE.

February 7 to February 19,	2.6	2.4	2.3	2.1	2.3
February 19 to March 20,	2.0	1.8	1.8	1.6	1.8
Average,	2.2	2.0	2.0	1.8	2.0

GAINS PER PEN.

February 7 to February 19,	111	148	119	95	485
February 19 to March 20,	194	194	174	181	743
Total,	305	342	293	276	1228

This completed the experiment proper, and on March 20, the sheep were separated, each kind by itself and all fed alike to get the relative amounts of food eaten by each. To complete the record, the further feeding will be given before discussing the results.

On March 20, all the sheep were fed on cracked wheat, beets, and alfalfa hay, the feeding continuing to April 10, when the western lambs and yearlings were sold.

FEEDING RECORD MARCH 20 TO APRIL 10.

	Per head per day. Hay.	Wheat.	Beets.	Total Digestible.	Total digestible per day per 1000 lbs live weight.	Gain in weight per head.
Western yearlings,	2.62	1.00	5.00	3.00	18.4	9.4
Western lambs,	3.00	1.00	5.00	3.13	21.8	12.1
Mexican yearlings,	2.00	0.75	3.00	2.08	21.0	5.0
Mexican lambs,	1.80	0.58	3.00	1.83	20.3	4.4
Average,	2.33	0.83	4.00	2.51	20.4	7.7

The appetites seem to have undergone a change during the winter. The western lambs eat the most per head and per weight, even exceeding the Mexican yearlings that in the fall were far the largest eaters. The western yearlings have fallen to the rear, both in food eaten and in gain in weight. They reached the limit of their rapid growth some weeks before. In fact, old sheep naturally fatten more quickly than lambs, and to be most profitable should be sold as soon as they are ready for market.

The gains in live weight follow closely the amount of food eaten for each class of sheep, i. e., western lambs eat and gain more than western yearlings, while Mexican yearlings eat and gain more than Mexican lambs.

The western lambs and yearlings were sold April 10. It would probably have been better, commercially, to have sold the Mexican sheep at the same time; but they were kept to make a further experiment of the relative value of wheat and corn as foods to "finish off" sheep for market. The lambs were evenly divided: one-half fed cracked wheat and the other half cracked corn, each without beets.

The weather was very disagreeable and the sheep which were already quite fat did not eat much nor make much gain. On May 7, they were shipped to Chicago, to Swift & Co. With these, as with the western sheep consigned to the same firm, the slaughtering of the two lots was done separately, and full data furnished us of dressed weight, tallow, etc., so that we have the complete records of these four bunches of sheep from the time they left the range until they were hung up in Swift & Company's refrigerators.

WHAT SHEEP IS THE MOST PROFITABLE TO FEED?

This question is more frequently asked than any other. The figures of these feeding tests furnish a good basis for a satisfactory answer to this question.

The conditions of the test all the way through favored the large western sheep. They were better specimens of their class than the southern sheep. They were bought on little more advantageous terms and, being larger, when fed in the same pens with the southern sheep, they had the better chance at the best of the feed.

If under these conditions the southern sheep have showed themselves the more profitable, and if this result is also obtained by other feeders with large bunches, it can safely be concluded that the Colorado feeders had better turn their attention to the southern sheep.

The western lambs cost $2.77 per 100 pounds live weight plus the freight from Soda Springs to Chicago, which was 94 cents per head.

The labor of feeding was, of course, the same for each bunch, while owing to the smaller number that can go in a car, the incidental expenses per head of shipping are about one-fifth higher for the large western than for the small southern sheep.

The full account of the western lambs is as follows:

WESTERN LAMBS.

First cost, 95 pounds @ $2.77 cwt.		$2.63
Freight to Chicago		.94
Incidental expenses of shipping		.41
Labor of feeding		.35
Cost of feed		2.23
Total expense		$6.56
Sold in Chicago, 135 lbs @ $5.25 cwt.	$7.09	
Net receipts from wool,	.18	
		$7.27
Net profit per head		$ .71

WESTERN YEARLINGS.

First cost, 119 pounds @ $2.75 cwt.	$3.27
Freight to Chicago	1.00
Incidental expenses of shipping	.44
Labor of feeding	.35
Cost of feed	2.39
Total expense	$7.45
Sold in Chicago, 153 pounds @ $4.75 cwt.	7.27
Net loss per head	$ .18

MEXICAN YEARLINGS.

First cost, 69 pounds @ $2.82 cwt.	$1.95
Freight to Chicago and expenses	.50
Labor of feeding	.35
Cost of feed	2.24
Total expense	$5.04
Sold in Chicago, 95 pounds @ $5.25 cwt.	4.99
Net loss per head	$ .05

MEXICAN LAMBS.

First cost, 60 pounds @ $2.82 cwt.	$1.69
Freight to Chicago and expenses	.50
Labor of feeding	.35
Cost of feed,	1.90
Total expense	$4.44
Sold in Chicago, 91 pounds @ $5.85 cwt.	5.32
Net profit per head	$.88

The *Mexican lambs* have made the most profit, whether figured per head or per dollar invested or per ton of hay fed. But it should be noted that in the items of cost of feed given above in estimating the total expenses of the sheep, hay has been figured at $4 per ton, wheat and corn at $15, and beets at $4; so that when as in the case of the Mexican yearlings, the debtor and creditor sides balance, the feeder has still marketed his crops on his farm at full value and has also received full pay for his labor. As a farmer doing his own feeding, he has put in a profitable winter. As an outside party, buying all his supplies and hiring the work done, he has lost money.

RETURN FOR ALFALFA.

A common way in Colorado is to figure the returns as so much per ton for the alfalfa fed, and make no account of the labor.

The western yearling ate 612 pounds of hay per head, the western lambs 529, Mexican yearlings 509, and the Mexican lambs 359 pounds of hay. Making no account of the labor, the western yearlings have returned $4.57 per ton for the alfalfa eaten; the western lambs $8; the Mexican yearlings $5.22; and the Mexican lambs $10.94. These figures are not far from the proportions in which returns have been received by other feeders on a larger scale. The above figures are the averages for all the kinds of feed given. Some foods proved more profitable than others. The Mexican lambs that were fed on alfalfa and cracked wheat did the best, financially, and returned $12.34 per ton for the alfalfa they ate.

COST OF GROWTH.

Another method of estimating the comparative value of the different kinds of sheep is by relation to the amount of food required to make a pound of growth and the growth they will make per month. This is not so exact as the former method, because this growth has not the same commercial value. A pound of Mexican lamb is worth more than an equal quantity of western yearling. During the ninety-eight days from December 13 to March 20, when all the bunches were on the same feed, the record stands as follows:

FEED AND GAINS DECEMBER 13 TO MARCH 20.

	Weight. Dec. 13.	Weight Mch 20.	Gain in Weight.	Total Digestible matter eaten.	Digestible matter eaten for one pound of growth.	Value of food eaten.	Value of food eaten for one lb. of growth.
Western yearlings,	121	158	37	242	6.5	$1.49	4.2c.
Western lambs,	99	137	38	228	6.0	1.43	3.8
Mexican yearlings,	74	95	21	194	9.2	1.30	6.2
Mexican lambs,	61	87	26	156	6.0	1.14	4.4

It would seem at first thought that if the western lambs and the Mexican lambs each ate the same amount of food for a pound of growth, the cost of the growth should be the same. They both ate the same amount of the expensive grain and beets, but the Mexicans ate so much less of the cheap hay that it raises the average cost per pound of their feed.

VALUE OF A POUND OF GROWTH.

During the whole winter the western yearlings gained 49 pounds per head at a cost for care and feed of 5.6 cents per pound. The western lambs gained 54 pounds at a cost af 4.8 cents per pound; the Mexican yearlings 32 pounds at 8.1 cents; and the Mexican lambs 37 pounds at a cost of 6.1 cents per pound. On the average it cost 6.1 cents to put a pound of growth on a sheep and they averaged growing 43 pounds per head during the winter. They gave a net profit of 34 cents per head, which would add 8 cents to the value of each pound of growth, or about 7 cents per pound as its market value. In other words, if a man furnished the sheep and paid seven cents a pound for each pound of growth, he would come out just about even on the transaction—that is, on a mixed bunch of western and Mexican sheeep. On western sheep alone he would lose money, and on Mexican alone he would be the gainer by the transaction.

WHAT IS THE BEST FEED FOR SHEEP?

No one experiment would be sufficient to offer a complete answer to this question, but some light is thrown on it by the records of this test.

Four combinations of feed were used: wheat and alfalfa, corn and alfalfa, beets and alfalfa, wheat, beets, and alfalfa.

It is necessary to consider the results both from the side of growth, which made the fastest growth, and from the money standpoint, which made the cheapest growth. The test lasted ninety-eight days, and the separate feeding records have already been given. They are summarized below:

FEEDING RECORD DECEMBER 13 TO MARCH 20.

	Hay.	Wheat.	Corn.	Beets.	Hay per day per head.	Total digestible per day per head.
Pen 1,	5009	980		8150	2.55	2.32
Pen 2,	6139	1315			3.13	2.05
Pen 3,	5682		1315		2.90	1.92
Pen 4,	4728			9792	2.41	2.03
Total,	21558	2295	1315	17942	2.75	2.08

The average feed per sheep for the 98 days was 270 pounds of alfalfa, 46 pounds of grain, and 224 pounds of beets, at a cost per head of $1.34. The average gain was 31 pouuds, at a food cost of 4.3 cents per pound of gain in live weight.

The palatability of the food as evidenced by the amount eaten, seems to be the governing factor in regard to the rapidity of growth. The larger the amount eaten, the more the gain. This is shown in the following table:

GAIN IN WEIGHT AND COST OF GAIN PER POUND.

Feed.	Total digestible.	Gain in Live Weight.	Pounds digestible to one lb. of gain.	Cost of food.	Cost of gain per pound.
Wheat and Beets,	4541	661	6.9	$33.71	5.1c.
Wheat,	4020	640	6.3	21.86	3.4
Corn,	3802	575	6.6	22.42	3.9
Beets,	3970	607	6.5	29.14	4.8
Average,	4083	614	6.6	26.78	4.3

The gains in live weight do not differ much, scarcely enough to be detected by the eye. The extremes differ about 15 per cent., but even this difference might change loss to profit. The sheep that ate the most gained the most without exception; but it does not follow that those that grew the fastest required the least food to make a pound of growth or made the cheapest growth. There is but little difference in the amount of food required for each pound of growth. The ones that grew the fastest, ate the most for each pound of growth, and the ones that grew the slowest required the next largest amount.

The governing factor in the cost of the growth is the amount of beets eaten. The beets were valued at $4 per ton, the same as alfalfa. This is much too high if the relative feeding values of the two are to be taken in to account, but it is closely correct if the cost of production is made the basis of comparison.

Under Colorado conditions at the present time, it costs just about as much to grow a ton of beets as a ton of alfalfa, and if there was an assured market for an unlimited quantity of each at $4 per ton, there would still be more alfalfa grown than sugar beets. The same result is obtained if purchase price is considered. In Colorado, a man can buy all the alfalfa he wants for four dollars per ton, or even three dollars and a half, but he could not buy sugar beets for less, nor could he hire them raised at any less figure than he could secure alfalfa under the same conditions. It costs about two dollars per ton to raise each of them, and the difference between that and the selling price is no more than a fair profit for the grower.

In all the figuring on the beets of these tests, it is necessary to bear in mind that these were below the average in quality. A hard rain came the first week in September, when the beets needed dry weather to ripen them, and kept the ground wet and the beets growing until harvest time. This made watery beets with a very low percentage of sugar.

On the average of the season, it took between four and one-half and five pounds of beets to contain as much digestible feeding material as one pound of the wheat or corn. It is one of the most interesting features of the test to note how the judgment of the sheep as to their feeding value compared with this estimate based on the chemical analysis.

Two comparisons can be made: previous to February 7, when moderate feeds of both grain and beets were given, and after that date when the sheep were crowded to their full capacity. A third comparison can also be made by taking the figures for the whole time.

Up to February 7, all the pens had been getting all the hay they would eat, and pen No. 1, 1-2 pound wheat and 4 pounds of beets; pen No. 2, 1-2 pound of wheat, pen No. 3, 1-2 pound of corn, and pen No. 4, 5 pounds of beets. Pen No. 1 gained 356 pounds, pen No. 2, 298, pen No. 3, 280, and pen No. 4, 331. Thus the pen with the heaviest feed, i. e., pen No. 1, gained the most, beets alone next, wheat next, and corn last. The average of the wheat and corn is 289 pounds gain. Therefore the addition of the four pounds of beets in pen No. 1 to the 1-2 pound of grain had made an extra gain of 67 pounds over the grain alone, or of 58 pounds over the wheat alone. But pen No. 1 also ate some hay less than pens Nos. 2 and 3 that had grain alone. Thus there are 477 pounds of hay less and 3,970 pounds of beets more to be offset by 67 pounds of gain in live weight. Counting the gain in live weight worth seven cents per pound, and hay at $4 per ton, leaves $2.60 per ton for the beets.

The beets alone in pen No. 4, gave 42 pounds more growth than the average of the grain pens with 378 pounds less of hay. That is, 4,852 pounds beets gave 42 pounds more growth than 508 pounds of grain and 378 pounds of hay. Or, if gain in weight is worth 7 cents and hay $4, 4852 pounds of beets are worth $3.70 more than 508 pounds of grain. At $15 per ton for grain, the beets would be worth $3.10 per ton, or 4.8 pounds of beets are worth as much as one pound of grain.

A comparison can be made between pens 1 and 4. Pen No. 1 ate 508 pounds more of grain and pen No. 4, 882 pounds more of beets, 100 pounds more of hay, and gained 25 pounds less. With hay and beets at $4 per ton each, leaves $14.60 per ton for the extra grain.

The results for moderate feeding, therefore, are that beets alone as compared with grain alone give $3.10 per ton for the beets. The addition of beets to the grain ration yields only $2.60 per ton for the beets, and the addition of grain to the beet rations gives $14.60 per ton for the grain.

As between corn and wheat during this part of the test, there is but little difference. The wheat makes 18 pounds of growth at an expense of 325 pounds more of hay.

Put on the basis of digestible matter, the record stands as follows:

	Digestible matter eaten.	Gain.	Pounds of digestible matter to one pound of gain.
Pen 1,	2689	356	7.5
Pen 2,	2374	298	7.9
Pen 3,	2212	280	7.9
Pen 4,	2500	331	7.5

This shows the substantial equivalence in nutritive value of the digestible material of the several rations.

Full feeding commenced February 7th, and the gain in live weight correspondingly increased. The grain was increased two weeks earlier than the beets and during this time the grain pens gained much more rapidly than the others, but after the beets were also increased the gains were not much different.

RECORD FEBRUARY 7 TO MARCH 20.

	Hay.	Wheat.	Corn.	Beets.	Gain.
Pen 1,	1940	420		4180	305
Pen 2,	2230	755			342
Pen 3,	2098		755		295
Pen 4,	1360			4940	276

Figured in the same way as the last, the beets return $1.76 per ton compared with the grain, i. e., pen No. 4 as compared with the average of pens Nos. 2 and 3. They give only 85 cents per ton when added to the grain, and the grain gives $11.40 per ton when added to the beets. If these comparisons are made with the pen that had wheat alone, they are still less favorable to the beets.

For the last four weeks when both grain and beets were at full feed, the record stands as follows:

RECORD FEBRUARY 19 TO MARCH 20.

	Hay.	Wheat.	Corn.	Beets.	Gain.
Pen 1,	918	290		3140	194
Pen 2,	1252	560			194
Pen 3,	1216		560		174
Pen 4,	700			3640	181

The same methods give for these four weeks, beets as worth $2.77 per ton when compared with grain both alone; as worth $2.17 per ton when added to the grain, and the grain as worth $10.10 per ton when added to the beets.

The results show that, as compared with grain, beets are better adapted to light feeding than heavy; that when the amount of grain fed per day rises above one-half pound per head, or the amount of beets above four pounds per day per head, the return for the beets is too small to pay for raising them.

In every case, beets alone have given a less growth than beets and grain, and, on the basis of the comparative market values assumed in these tests, there has been a larger return for the beets when fed alone than when in combination. It is probable, however, that the better and plumper condition of the sheep fed on both grain and beets would have made them still enough better to offset the apparent advantage of the beets alone.

The tests seem to show that if beets are to be fed, not more than three pounds per day per head should be given, and, in addition, the sheep should be given a grain feed gradually increasing, the same as would be done if no beets were fed.

COMPARATIVE VALUE OF WHEAT AND CORN.

From first to last the pen receiving wheat made a little more rapid growth than the corresponding one that received corn. They ate the same amount of grain and considerable more hay, but they gained enough faster so that they required less digestible matter for each pound of growth and produced the growth at less cost per pound. The wheat pen ate 6,139 pounds of hay, and 1,315 pounds of wheat to make a growth of 640 pounds, at a cost of 3.4 cents per pound; while the corn pen ate 5,682 pounds of hay with 1,315 pounds of corn and made a growth of 575 pounds, at a cost of 3.9 cents per pound. The result is, therefore, 15 per cent. in favor of the wheat over the corn.

Had the experiment stopped here, the evidence would seem to be strongly in favor of wheat, but on March 20, all the sheep were put on to a mixed ration of grain and beets, and so fed for three weeks. Those that had corn immediately began to grow faster than those that had previously been on wheat. At the end of the three weeks, the two bunches were just even as the result of 119 days of feeding. In fact, the total record shows a little more in favor of corn than wheat, since there was the same growth made on a little less hay.

On April 10th the western sheep were sold. The Mexican sheep were then equally divided, and for the next four weeks one-half were fed corn and hay, the other half wheat and hay. The amounts of grain fed were equal, 21 1-2 pounds per head, while those on corn ate in all two pounds more of hay per head than those on wheat. The weather was hot and the gains small, but the corn-fed sheep gained one pound more per head. Both bunches were then shipped together to Chicago, were killed by Swift & Company, and dressed in the same manner. The corn-fed shrank in shipping just the one pound extra that they had gained in feeding, and both lots dressed out within half a pound of each other, or 53.5 per cent. of their live weight.

Thus it would be difficult to get two lots of sheep on the same feed to agree any closer from the range in the fall to the Chicago refrigerators than these two lots did fed one on wheat and the other on an equal amount of corn.

SHRINKAGE IN SHIPPING AND DRESSING.

The western lambs shrank 14 pounds, or 9.4 per cent. in live weight from Fort Collins to Chicago, and the western wethers 15 pounds or 9.0 per cent. The corn-fed Mexican sheep shrank 7 per cent., and the wheat-fed 6 per cent. The western lambs dressed 56.9 per cent. of their live weight, or 51.6 per cent. of their Fort Collins weight. The western wethers dressed 55.2 per cent. of their live weight, or 50 per cent. of their Fort Collins weight.

The Mexican sheep dressed 53.5 per cent. of their live weight and 49.2 per cent. of their Fort Collins weight.

These figures show that all the sheep were very fat.

The western lambs yielded 12.3 pounds of tallow, or 16 per cent. of their dressed weight; the western wethers 12.8 pounds, or 15 per cent., while the Mexican sheep gave 7.8 pounds, or 12 per cent. of their dressed weight.

EFFECT OF SIZE ON GROWTH.

The question arose at the time the College sheep were bought, as to whether we gained by picking the larger sheep. The results show that there was a decided advantage in taking the heavier sheep. Dividing each of the four bunches into two equal parts, one containing the sheep that weighed more than the average when bought, and the other half less, it is found that in every case the ones that were the heavier at the start more than held their own, growing faster than the lighter ones, as shown in the table below:

	Western Yearlings.	Western Lambs.	Mexican Yearlings.	Mexican Lambs.
Weight of heavier half when feeding ended,	179	162	107	101
Weight of heavier half when feeding began,	128	105	78	63
Weight of lighter half when feeding ended,	158	136	95	92
Weight of lighter half when feeding began,	115	93	71	56
Gain in weight of heavier half during feeding,	51	57	29	38
Gain in weight of lighter half during feeding,	43	43	24	36
Heavier half gained more than lighter half,	8	14	5	2
Final weight of heavier half exceeded final weight of lighter half,	21	26	12	9

Even granting that the heavier sheep eat some more than the lighter, and that they sell for no more per pound, there is still a larger profit in them from the larger growth and the greater number of pounds of original weight, which is sold for two to three cents per pound more than it cost.

EFFECT OF TEMPERATURE OF FOOD AND GROWTH.

It has long been known that animals eat more in cold weather than in warm, and the following table is presented, not as showing any new facts, but as containing more data bearing on the subject:

	Average Live Weight.	Per head per day. Hay.	Grain.	Roots.	Total Digestible material.	Total Diges-tible per 1000 lbs. per day.	Av'ge Temper-ature.	Gain in live weight per head per day.
Oct. 24--Nov. 5,	86	1.9			0.92	10.6	45.6	.15
Nov. 5--Nov. 19,	88	2.5			1.23	14.0	40.1	.10
Nov. 20--Dec 13,	86	3.3			1.63	18.9	34.1	.09
Dec. 13--Dec. 26,	90	3.8	0.40	1.50	2.44	27.1	29.8	.36
Dec. 26--Jan. 8,	92	3.4	0.40	1.75	2.27	24.6	14.2	.10
Jan. 8--Jan. 23,	97	2.5	0.37	2.25	1.89	19.5	30.5	.49
Jan. 23--Feb. 7,	102	3.0	0.37	2.25	2.14	21.0	16.7	.14
Feb. 7--Feb. 19,	106	3.2	0.50	2.25	2.34	22.1	9.9	.46
Feb. 19--March 20,	114	1.6	0.67	3.20	1.82	16.0	31.7	.33
March 20--April 10,	122	2.3	0.84	4.00	2.45	20.0	44.7	.37
April 10--May 7,	97	2.3		0.80	1.75	18.0	52.9	.15
Average,	98	2.8	0.39	1.56	1.95	19.8	31.8	.23

It will be seen that sheep eat more when the temperature falls, and drop off again as soon as the weather moderates. Special attention is called to the further fact that sheep do not necessarily grow more slowly in cold weather than in warm. They seem to eat so much more in cold weather that they have a fair surplus in the system for growth. During the severest cold of the winter, about the middle of February, the sheep appeared in fine spirits and made nearly the most rapid growth of the season.

The apparent exceptions to the rule of the feed varying with the temperature, found during December 13 to 26, and March 20 to April 10, are due to changes of feed to fodders that the sheep specially liked, and they filled themselves up so that they had less appetite during the following period.

The State Agricultural College.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN No. 33.

Seepage or Return Waters from Irrigation.

Approved by the Station Council.
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

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SEEPAGE OR RETURN WATERS FROM IRRIGATION.

BY L. G. CARPENTER.

For convenience of reference, the principal paragraphs are numbered:

§ 1. In countries where irrigation is practiced, it is often the case that, though streams may be drained dry by the diversion of the waters into canals, not far below the stream will again be of considerable size, and this without the inflow of visible tributaries.

§ 2. This may become of considerable economic importance, as it already has in the valleys whose measurements are here reported. In the valley of the Poudre, the seepage water is worth, at prices at which sales have already been made, from $300,000 to $500,000 at the least, and the waters of the Platte from two to three million dollars. It is of corresponding importance in the valleys of Clear Creek, St. Vrain, and others. Of such importance already, it promises, if the deductions of the bulletin are correct, to be of still greater importance in the future and in the development of the State. Certainly it is true that the value of water will steadily increase.

The experience of all irrigation countries shows that their prosperity is largely bound up in the water question—in the certainty of water, in the security of their rights, and the freedom from abuse. They have found themselves often bound by customs and laws, now become fixed, formed as the practice developed gradually. We are in danger of such here, mostly from lack of knowledge of the conditions. This bulletin is a contribution toward a better knowledge of one condition of water supply, which has already given rise to much vexatious litigation, to some harmful divisions, and to some unrest among those affected one way or another.

§ 3. The increase which is found in such rivers is attributed to the inflow from innumerable springs fed and supplied by the water which has been applied in irrigation upon the higher lands. In irrigation, more water is applied than the crop uses. Of that applied, some is used by the crop and stored in its tissues; more is transpired in the process of growth; some is evaporated from the soil; a portion is usually lost by surface run-off; a certain amount passes down into the ground and disappears. This varies in amount and depends upon various conditions. Usually concurrent observations show that this water passes directly downwards, with little or no lateral movement except capillary imbibition, until reaching an impervious stratum, when, filling the interstices, it gradually rises in the subsoil, and passes laterally with a slow movement due to the slope of the water surface which is thus formed. When the passage takes place through the interstices of the soil the movement is very slow, much slower than is ordinarily supposed by those first encountering the subject. It is faster as the material is coarser. Where there are perceptible channels, the movement may be relatively rapid.

§ 4. One of the first effects noted in irrigation where the soil is pervious, is in the filling of the subsoil. The first evidence is found in the gradual rising of the water in the wells which may have been sunk. Throughout the United States where irrigation is practiced, the evidence is ample, for as the application has been made within a single generation, the changes which have ensued from the application of water are within the memory of hosts of living observers. In many places in the Poudre valley, where it was originally forty or fifty feet to water, water now stands from ten to twenty feet from the surface, the subsoil having been filled to a depth of twenty to forty feet.

There is sometimes a lowering during some seasons of the year, due to the lateral passage of the water. The lateral passage has had the effect in some places of filling in the ground until in some places the water shows on the surface, water-logging or seeping the ground, rendering it unfit for cultivation and capable of growing only sedges, cat-tails, and other water-loving plants. Sometimes on the evaporation of the water, a deposit of alkali is left, rendering the land unfit for cultivation without draining. These effects are found underneath the lines of ditches, so that many companies insert clauses in their contracts for water or for right-of-way freeing the company from liability for damage of such nature. In other cases where contracts do not prevent, it has given rise to suits for damage from such cause.

The water usually first appears near the canal, and progressively further away year by year.

§ 5. The phenomenon has been but little studied. The reason has doubtless been that in most countries irrigation is of such age that there is no record with which to compare the condition now and before irrigation, and the changes due to the construction of canals have been lost in the centuries which have elapsed. There is, however, land in Lombardy which is manifestly seeped and water-logged, and has every appearance of being due to irrigation. Pavia Canal, between Milan and Pavia, built in the early part of this century, has damaged much land. There is loss from the canals themselves, as well as from the water which is applied to the soil.

Wherever the conditions before the construction of canals are within the range of memory, the fact has been observed to a greater or less extent.

Year by year the effect is found farther and farther away from the canal, or from the irrigated locality, as the case may be. In course of time, the waters which are percolating through the subsoil reach the thalweg or the depression of a "draw," or a river, and increase the waters passing therein.

It, therefore, happens that the depressions or draws, which in Colorado are usually dry before irrigation is practiced, contain living streams after irrigation has been carried on for some time. While the Poudre river varies during the year from a maximum of 3,000 to 5,000 cubic feet per second to a minimum of 50 to 100 cubic feet per second, or may vary by forty to eighty times the minimun flow, and other streams correspondingly, these seepage waters will not often vary twice their minimum flow. In consequence the water rights in the seepage channels are usually considered more valuable than those in the river waters.

The particular places at which the waters come to the surface will generally be determined by the nearness of the underlying rock. Frequently the water shows in a particular locality, so that there is a localized gathering area. There may be several on some of the channels, so that different seepage ditches may be supplied.

§ 6. The present measures which are reported, include measurements made on the Cache a la Poudre river and on the South Platte, in Colorado. Most of the measurements have been made on the former, and have been for the object of determining the amount of the increase in the stream; the relation between the increase and the amount of water applied; between the increase and the area irrigated; and to collect data which should give the means of studying these facts and other phenomena of the return of the waters. The measures on the Platte have been for the same purpose and in connection with the office of the State Engineer of Colorado. To a greater degree, the measures on the Platte were taken because of the light they might show on certain inter-state questions which have, or may arise, and on some points that could not be decided from the Poudre alone.

The present and future importance of the inflow was under estimated. In the course of the measures, the facts determined have led to much wider and more useful application than was anticipated during their progress.

METHODS OF GAGING.

§ 7. The points at which gagings were made are scattered over a distance of 200 miles by the river, without following its meanderings. The distance to be traveled by road is much in excess of this; and the distance is made longer for the reason that the highway does not follow the river, and at many points the headgates and places of gaging are not easily accessible. Some roads cross fields and, until an intimate acquaintance is gained with the river and the special by-ways, time is lost in passing from one point to another.

The first measurement on the Poudre was usually made at the gaging station in the Canon, about 12 miles from the College, at the point indicated on the map [page 16]. On the way the ditches on one side of the river would be examined and the in-takes measured. Where the water exceeded more than a few inches in depth in the smaller channels, or where there was sufficient to measure by the current meter, the meter was used to determine the velocity and thus determine the amount entering the canal. In cases where the canal was small and the in-take at the time of gaging was little, surface floats were often used, and the mean velocity determined in this manner. While not overly accurate, the results obtained can usually be depended upon to within a few per cent., and the absolute error where used is too small to make any appreciable effect in the general result.

In gaging the river at the regular gaging station, which is at a point in the Canon above the headgates of all the principal canals, a tape is stretched across the river between points on the masonry side walls and the depth of the water at each one-foot or two-foot interval measured throughout the entire width, which is very nearly 100 feet. Then observations were taken with the current meter, usually at two-foot intervals, sometimes at less, across the stream. As most of these gagings were made at a time of low water in the spring, or low water in the fall, the meter has been held by hand and the gager has waded the stream. At other points on the river where gagings were made the method has been essentially the same, although the cross-sections have not been as favorable as at the gaging station. It is not thought, however, that any material error has crept in from these sources. In the notes on the measurements some individual sources of error are noted.

DESCRIPTION OF THE POUDRE VALLEY, IN WHICH THE MEASUREMENTS WERE TAKEN.

§ 8. The measurements have been made on the Cache a la Poudre river and also on the South Platte. The "Poudre," as it is called, is the river which drains the valley in which the State Agricultural College is located, and is, therefore, the most easy of access for the purpose of this and similar investigations. It has the additional advantage of being one of the largest irrigation streams in the State, and one which has been the best used for irrigation purposes, and where irrigation has been carried on as completely and successfully as in any part of the United States. There is in addition as large a body of land irrigated in one tract as anywhere in the United States. The phenomena observed are, therefore, found under conditions of irrigation on a large scale. They are of great economic importance to this valley, and may be expected to hold true of other valleys under similar conditions, and where irrigation has been practiced as long as it has here.

The map in the inset [page 16] is intended to give an understanding of the conditions which may affect the return waters in this valley. The gaging station is indicated near the left of the map, below the junction of the north Poudre with the main stream. The only canal above this point which needs consideration is the North Poudre canal, shown on the map, irrigating some 4,000 acres, principally in the valley of the Box Elder.

The main trend of the valley is to the southeast. Near the stream the land is low, the bottom land varying in width from one-half to two miles. These bottoms have been occupied in times past by the bed of the stream, which is subject to shifting at times of high water. With the decrease of floods, and with the use of wate for irrigation, the changes are less.

As we pass out of the first bottoms, we reach successively two or three terraces, or mesas, which are generally sandier and stretch back for varying distances. On the north side of the stream the watershed extends many miles, and the streams here indicated as Dry creek, Box Elder creek, Lone Tree creek, and several smaller channels, are simply ravines or depressions which at times after storms are filled with water and may become at such periods raging torrents. Ordinarily their beds are sharply marked and have a clear tributary country; they are entirely dry, giving almost no indication whatever of water. After their channels cross the lines of the canals and enter the irrigated country, these streams begin to carry running water.

The lines of the canals, which follow approximately contour lines, indicate by their bends the general character of the country and the slope. On the north side of the river the land, as a whole, is more uniform than on the south side. Nearly all the irrigation is, therefore, confined to the north side of the river; the exception being in the region near Fort Collins, and a little space near Greeley. Between the two there is a rougher and more broken country on the south side of the stream, not easily reached by canals from the Poudre.

On the south side, the divide which separates the Poudre from the Big Thompson is but a few miles from the main river, and as we reach range sixty-eight, the location of the divide is indicated closely by the ditch which takes from the stream to the south. Some of the waste of this canal passes into the Poudre river. To the west, the drainage on the south side, even the mountain drainage, does not flow into the Poudre to any great extent, the lateral valleys being nearly all tributary to the stream to the south.

The foothills are near the western portion of range sixty-nine, following a line a little east of south. The first ranges, generally known as hogbacks, are formed of gray sandstone, and very shortly afterward the granite is met with, forming the foothills of the main Rockies. The sandstone appears in ridges, and even on the plains for miles the same general appearance may be seen in the buried ridges which traverse the country from north to south, and made evident on the map by the intermediate valleys, in which flow streams like Dry creek, Box Elder creek, etc., approximately parallel for a long distance and separated by pronounced ridges. These ridges sometimes form natural basins, which have been largely used for storage purposes. As the amount of water there stored affects, to some extent, the amount of return waters, the principal reservoirs in use are indicated on the map.

§ 9. As the length of time that irrigation has been practiced, together with the distance of the land from the river, is an important element in the amount of seepage, a fuller description of the valley is needed with reference to its irrigation. The crops grown in the valley are principally the cereals, alfalfa, and potatoes. Potatoes have been extensively grown only during the last few years, and the greater part of this crop has been grown near the lower end of the valley. The upper end of the valley is confined almost exclusively to alfalfa and grain, with some market gardens. The distribution of the crops affects the application of the water, both in amount and in time of application. The grains receive water early in the season, and rarely any after July 1. Alfalfa receives from one to three irrigations, commonly two, one often in May. Two will be given, then, and if late water be sufficient, a third in August, after the second cutting; this is by flooding. For potatoes, the ground may be irrigated before plowing. If not, then irrigation will usually be commenced in July or early in August, and is practically over by the end of the first week in September, the active period being confined to five or six weeks. With the crops thus grown, irrigation extends from May to September, with minor quantities applied to orchards and gardens both earlier and later. More water is applied in June than in any other month. Until the development of storage capacity by the construction of reservoirs, the amount of water applied in August was necessarily limited by the stage of the river. Since then, more is applied, and this being for potatoes, is largely applied to the section composing the east half of the valley.

§ 10. Of the canals shown on the north side of the river, the Cache a la Poudre No. 2 is the oldest of the large canals, being one of the original Greeley colony canals. The land irrigated under the Cache a la Poudre No. 2 has been almost fully occupied for a number of years. Some of the land near the upper end has become too wet to need water, and the stock representing the water hitherto applied to this land has been sold and the water is now largely applied to land lower down the canal, and largely drains into the Lone Tree creek, which empties into the Platte just below the mouth of the Poudre. The Larimer & Weld comes next in point of time of construction, dating from 1879–81. It is the largest of the ditches, having an appropriation of 720 cubic feet per second, and a capacity still greater for a portion of its length. The amount of land brought under irrigation from this canal has largely increased during the past few years. The Larimer County canal has been still more recently constructed, and waters the country still farther from the river to the extent of something like 16,000 or 20,000 acres. Owing to the later appropriation of this canal, and the low stage of water in the river for some years, this canal has not been able to apply as much water compared with its land as the others mentioned, until within the last few years. Recently, by the development of their system of storage reservoirs, combined with the construction of a canal bringing water from the watershed of the Laramie river, this canal has been able in 1894 and 1895 to secure an amount of water more nearly comparable with the others.

On the south side of the river the canals are mostly small, and have irrigated essentially the same land and the same amount for a number of years.

The other canals of the river have not changed to any great extent in the amount or the distribution of the land irrigated, for eight or ten years. It will be shown later that there is reason to suppose that the water passes through the ground at a very slow rate. Hence the amount of the land irrigated and the time when brought under cultivation will make some difference with the return waters. It seems probable that the seepage due to much of the land under the Larimer & Weld canal, and from the Larimer County, as well as all from the North Poudre canal, has not yet reached the river.

The point where the weir is placed at the canon is in a granite formation inside the foothills. Within a short distance, the Poudre passes out of the granite and cuts across the upturned edges of sandstones of the Jurassic and Cretaceous periods, and its course from this point until it reaches the Platte is across the slightly upturned edges of the strata, which are mostly shale and some sandstone. In some places these form marked ridges across the country, extending slightly northwest. Their effect will be noticed in the map in the case of the drainage on the north side of the Poudre, where many of these small streams extend to the north for a long distance. The canals show the contours approximately as far up as these go.

CHARACTER OF THE STREAM.

§ 11. The character of the stream is essentially that of all our mountain streams, as its source of water supply is in the snows of the mountains. It is low in the spring, increasing from April to the middle of June, when it reaches its highest stage; then decreasing, reaching its low stage again in September. It remains low during the winter. Its maximum discharge may vary from 3,000 to 5,000 cubic feet per second. Its average winter flow is from 50 to 100 cubic feet per second. Its average flow is shown in the following table, the averages being made from records of from three to twelve years for the different months:

TABLE I.

January	110 cubic feet per second.
February	83 " " " "
March	70 " " " "
April	237 " " " "
May	1,245 " " " "
June	2,017 " " " "
July	1,018 " " " "
August	362 " " " "
September	173 " " " "
October	136 " " " "
November	81 " " " "
December	74 " " " "

CONDITIONS AFFECTING ACCURACY.

§ 12. The stream itself is subject to fluctuations, which, however, are more noticeable at times of high water during the summer than at low water, or at the times at which measurements were made. When the snow is melting rapidly the effect of the daily heat is to increase the quantity of snow melted and thus increase the height of water in the river. This makes a very perceptible daily tide, the hour at which it reaches the gaging station varying according to the stage of the river and the distance from which the water comes. When the water is low, the daily rise is later than when the water is high. With high water the greatest height occurs at from 4 to 6 o'clock in the morning; with a low stage of the river it may not be until toward evening. After the principal snow fields are melted the effect of this daily tide is small, so as scarcely to be perceptible upon the self-registering instruments which are located at the gaging station. At the dates at which gagings have been made for the purpose of this investigation, the tide has been very small, the greatest in August, 1894, and has been neglected. Even if not, inasmuch as the greater portion of the river is taken into the canals before many miles, the quantity of return waters found by the measurements would not be affected thereby. It is of small importance, as the greater quantity of the return waters has been found to be near the lower end of the river.

Errors in gaging might introduce some errors in the results, but the relative values should remain the same. The meters, however, have been rated in still water, and the constants determined often enough to indicate that the constants have been nearly the same. The meter usually used has been the "Lallie Meter," made in Denver, Colo. Sometimes a meter made by Messrs. Buff & Berger, of Boston, Mass., has been used.

The omission occasionally of some of the ditches drawing water from the stream would induce an error, but it is not believed that such an error has been committed.

If a portion of the returns by the various creeks and sloughs were waste water instead of seepage water, the quantity found would be reduced correspondingly. The amount found in these streams is here given in parenthesis (though not counted), and the effect can be easily seen.

Without having determined the actual origin of the water in every case, it is believed that in no case is any of the water derived from above the ditches.

§ 13. The diagram, Fig. 1, shows graphically the amount of return waters as found in the different measurements. The horizontal distances, or abscissæ, give the distances in miles from the gaging station. The vertical distances, or ordinates, indicate the amount of return waters in cubic feet per second. The vertical lines are drawn at the principal points of measurement. The distances have been measured, not along the curves of the river, but on the map, taking generally a straight course across the bottoms, because it is thought that the amount of inflow will not be increased by the curves of the river, but rather will depend upon the straight course of the river, other things being equal. The different lines indicate the different measurements. It is evident that there is a general agreement between them. There are some marked exceptions, which it is difficult to entirely account for. The small amount of inflow in the first ten miles is noticeable in the eighth and ninth measurements, while in all previous ones it had been considerably greater. A decrease between the seventeenth and twentieth miles is noticed twice, and once between the seventeenth and thirty-second mile. Notwithstanding the minor discrepencies, there is a general agreement, especially during the last portion. It may be seen that the total inflow does not vary much.

Several of the measurements were not carried beyond the Ogilvy ditch, which is several miles from the north of the river, and, therefore, the values found are less than had they been continued to the mouth.

§ 14. Table II. shows the rainfall in connection with the gaging, so as to give the means of judging as to the effect of the rainfall of the previous and the current year upon the amount of inflow. The headings of the columns sufficiently indicate the quantities given. Thus, column 3 gives the amount of rain which fell during the calendar year up to the first of the current month of gaging, and the fifth column is the amount of precipitation during the month and previous to the time of gaging. There does not seem to be any particular connection between the wet and dry seasons and the amount of return waters.

With a high river, the amount of water applied is more than when the river is low, because in the latter case there is stinting of water and much land does not secure enough for the needs of the crops, far less than enough to satisfy the owners; hence, we may

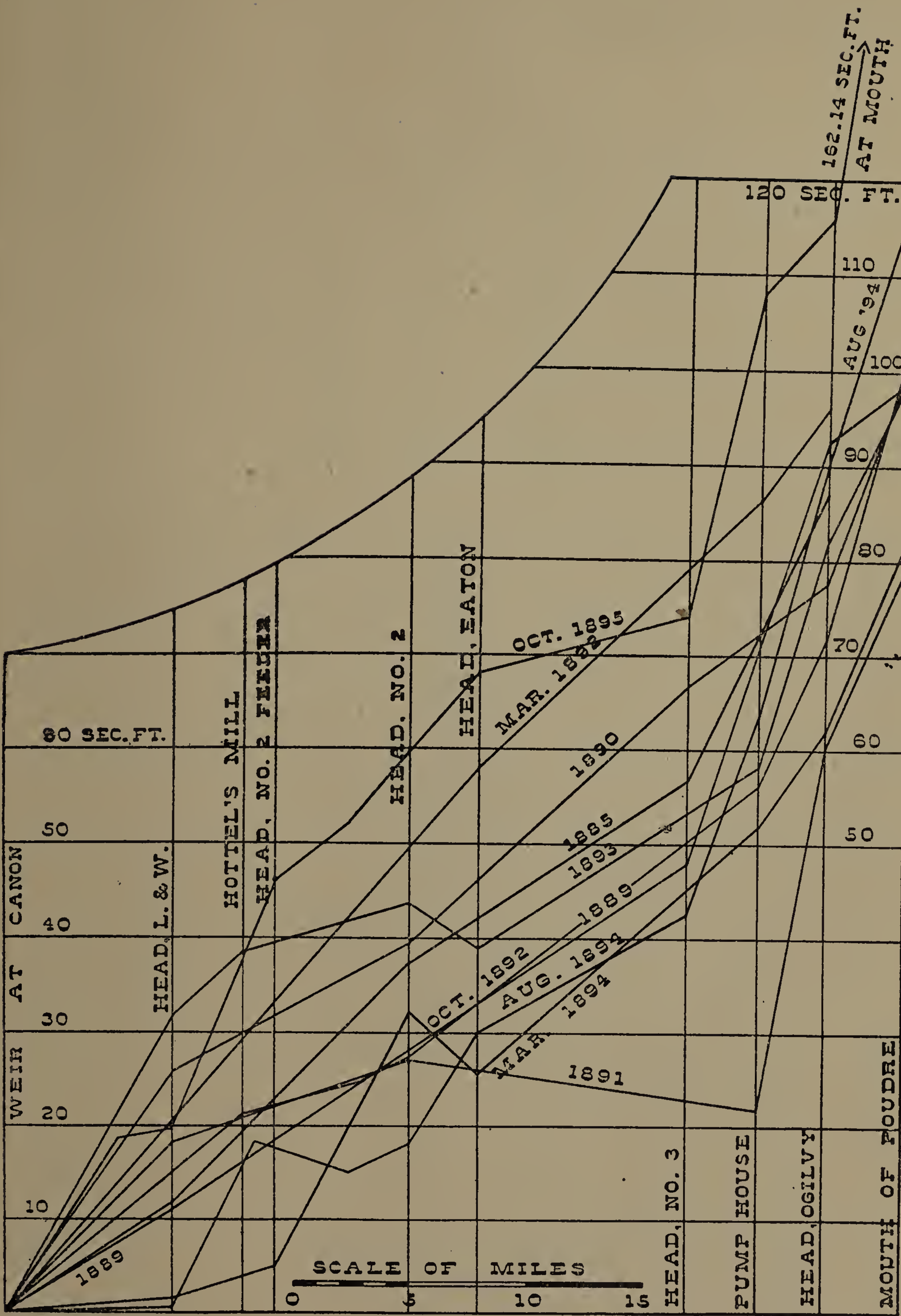


Fig. 1.—Seepage Increase of the Cache a la Poudre River.

expect that the high years of the river will tend to increase the amount of water that is applied, and likewise the amount of water that returns in the form of seepage.

TABLE II.

YEAR.	Rainfall of Previous Calendar Year.	Rainfall to Time of Gaging, first of Month.	Rain During Current Month.	Rain Immediately Before Gaging.	Rain During Gaging.
1884	15.07	....	....	....	....
1885	15.95	....	....	....	....
1889	9.79	10.88	3.16	0.34	.09
1890	14.48	12.42	0.70	0.70-week before gaging	....
1891	13.58	14.43	0.20	0.19-3 weeks " "	0
1892, March	15.69	1.89	1.52	0.83 week " "	0
1892, October	15.69	13.94	0.93	None	0
1893	15.45	6.28	0.16	None	0
1894, March	7.11	0.85	0.67	None	0
1894, August	7.11	9.17	1.53	.08	0
1894, October	....	11.46	T.	None	0
1895	12.36	16.60	1.06	None	0

In the measurement of August, 1894, irrigation was still being carried on quite extensively, especially for potatoes, the most of which are raised toward the lower end of the valley. At this measurement, it is noticed that the total increase is greater than at any previous one, amounting to 118 cubic feet per second. This would seem to show either that a considerable portion of the water returns in a comparatively short time to the river, or that there is some waste which returns directly. During the past few years, there has been an active increase in the use of seepage water for irrigation by the construction of drainage ditches, which in some cases extend back a number of miles. The effect of this is in most cases to cause the water to be applied to the ground nearer the river than where it is cut, and thus the water is developed and hastened in its journey to the river. In some cases the ditches are constructed and deliver the water directly to the river, so that the water returns sooner than it otherwise would. We should expect in consequence a greater development of the inflow during the period immediately succeeding irrigation, and less during the spring following.

NOTES ON THE MEASUREMENTS.

§ 15. The first measurement of the river was made by Mr. E. S. Nettleton, when State Engineer, in 1885, with the aid of Hon. B. S. LaGrange, then Water Commissioner of this district. The measurement was made in October, 1885.

This was at a time when most use of water for irrigation had ceased. A special attempt was made to get all ditches to shut their headgates for the period of the measurement, which had been done very generally by the ditches, so that the amount entering them was only the leakage that passed the gates. No account was made of the water entering the stream by the small channels, which is given in the later measurements. The assumption was made in this, as in several subsequent measurements, that this water was all seepage water, as, in fact, the investigations of later years have seemed to show.

The second measurement was made in October, 1889, under the direction of Mr. E. S. Nettleton, then Supervising Engineer for the U. S. Geological Survey, and Mr. J. S. Greene, State Engineer.

The inflow determined by this measurement was 99 cubic feet per second in the distance from the gauging station to the mouth of the Poudre. This is a little greater distance than measurement No. 1.

Measurement No. 3, was made in October, 1890, by Mr. L. R. Hope and Mr. E. C. Hawkins, representing J. P. Maxwell, State Engineer, and Col. Nettleton, of the U. S. Department of Agriculture. The total amount of inflow is very nearly the same as in the second measurement.

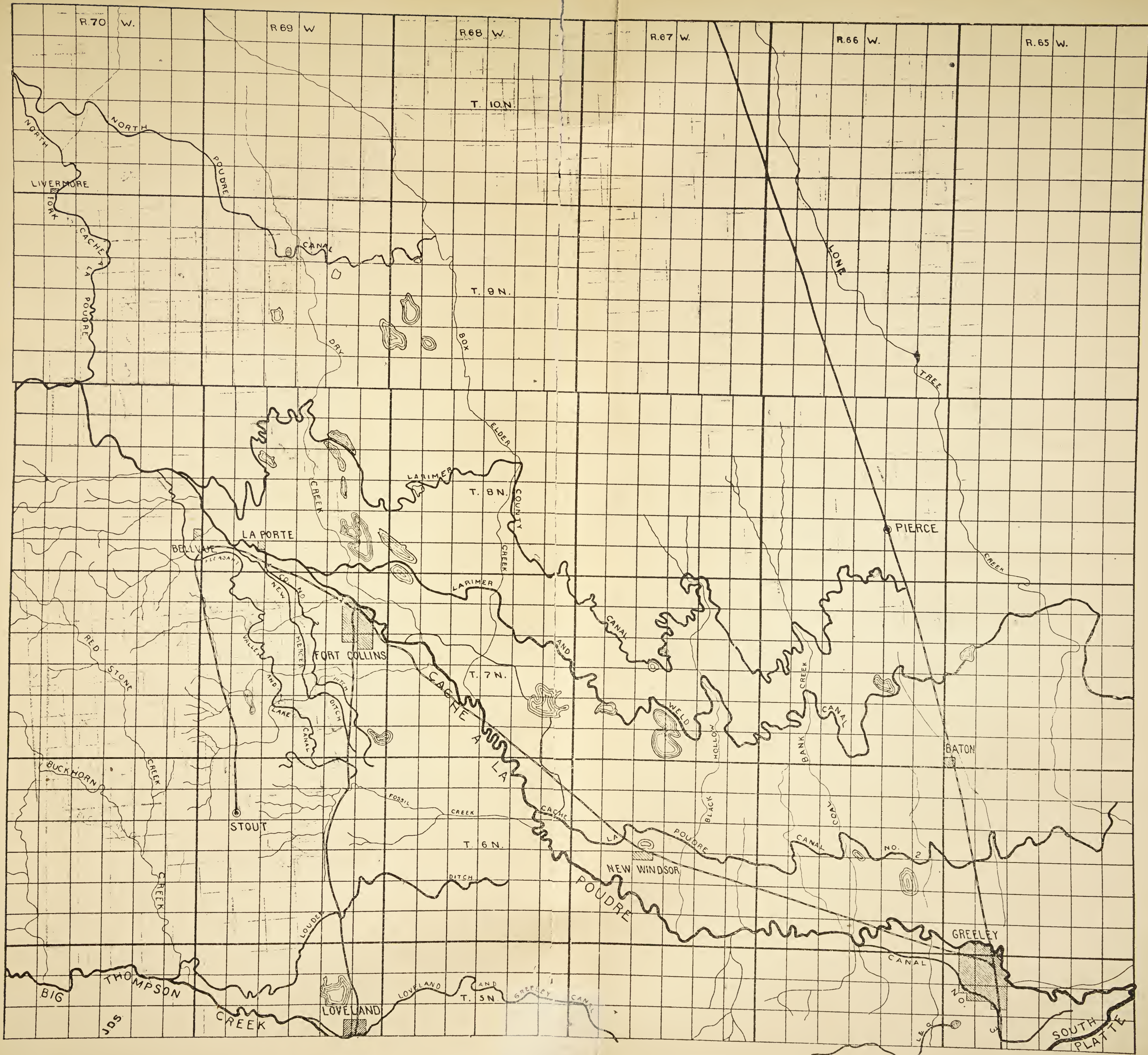
The fourth measurement, made in the latter part of October, 1891, was made by this Section in co-operation with the State Engineer's measurements of the Platte river, with which the Section also co-operated. During the first day Mr. Trimble assisted and then joined Mr. Hope at Greeley, helping him take the measurement of October 29th, from Greeley to the mouth of the Poudre, and thence going down the Platte, assisting in making these measurements. In this and the subsequent measurements which have been made by this Section, each measurement has shown some features which it has been desirable to avoid, but which it has not been possible to do. In order not to interfere with the use of water for irrigation, in this and the subsequent measurements no attempt was made to regulate the ditches themselves. The time, however, was chosen so that the use of water in any ditch was nearly constant during the few days devoted to the gaging, and the irregularity, if any, is so small as not to affect the results derived from the measurements. There is one measurement, however, to which an exception may be made. This is No. 6, of 1892, during which time the river was constantly affected because of the trading of water between the Larimer & Weld canal and a mill at Fort Collins. Each had some claims to the water, but not to the full amount, hence it became mutually convenient to the two parties to alternate the water, so that the mill used the water during the day and the canal took the water at night for storage. This, therefore, caused fluctuations in the streams at points below the Larimer & Weld headgate, and hence caused some of the discrepancies which are evident in this measurement. Thus, on October 6th, at three o'clock p. m., the river below Strauss's bridge had fifty-four second feet, while the next morning, at 11 o'clock a. m., it had but twenty-one. This is due to the water entering the canal during the night, and the day water in use by the mill has not yet reached this point. It is not thought that this fluctuation materially affects the indicated inflow at lower points on the river at that date.

The measurements made up to this time indicated that the inflow was approximately the same. Inasmuch as the measurements had been made at only one period of the year, it seemed desirable to know whether or not the amount of return waters was the same at other seasons of the year; hence, beginning with the measurement of 1892, gagings have been made during the spring, when the conditions were favorable, as well as in the fall.

The fifth measurement was made in March, 1892, at a time before the canals had used much water for irrigation, but still when most of them were drawing some water, either for domestic purposes or for irrigating fruit and garden lands. All streams or ditches which contained water were measured and are indicated in this table, as in subsequent ones. In case the streams were bringing water to the river which seemed to be derived from seepage water, thus finding a way to the stream, the amount of the gaging is inclosed in parenthesis, and is not counted in the summation, as it is considered only another way of the water returning to the stream. The source of these waters has not at every gaging been investigated, but, in several cases, and at different times, we have traced these sloughs and creeks to their crossing with the outermost ditches, finding in every case that there is not a stream above the ditch. In some instances the quantity here given may include some waste waters. In general, the amount is insignificant, although in the measurements of August, 1894, there may be some to be thus considered.

In some cases the out-takes of ditches are inclosed in parenthesis. These are cases where the water returned almost immediately to the river. Frequently the measurement was made, and the fact of the water returning was discovered afterwards as we passed down the stream.

In several measurements, as in 1895, it was not possible to complete the gagings without intermission. In these cases the increase was found for each section. In several cases wherever seepage water had been collected in a lateral channel or drainage ditch and was found running into the river, it was measured and noted as a matter of record, and is found inclosed in single parentheses. Where this was caught in another channel, and did not reach the river, it is inclosed in two sets of parentheses. The water is thus found coming from the Big Thompson creek.



MAP OF THE CACHE A LA POUDRE VALLEY.

GAGINGS OF THE CACHE A LA POUDRE RIVER.

(In cubic feet per second.)

MEASUREMENT No. 1—Made by E. S. Nettleton, October 12–15, 1885.

Place of Measurement.	Out-take.	Remainder.	River	Gain.	No. of Miles.	Gain per Mile.
River at Gaging Station	.....	....	127.609	....	....	....
Pleasant Valley & Lake canal	1.75	....	....	....	....	....
Larimer County canal	0.58	....	....	....	....	....
Jackson ditch	0.266	....	....	....	....	....
Little Cache la Poudre ditch	1.00	....	....	....	....	....
Larimer County No. 2 canal	0.534	....	....	....	....	....
New Mercer canal	0.228	....	....	....	....	....
Fort Collins canal	1.14	....	....	....	....	....
Sum	5.498	122.111	....	....	....	....
River. 2½ miles above Fort Collins	......	....	133.973	11.862	7.25	1.64
Larimer & Weld canal	1.731	....	....	....	....	....
Pioneer ditch	2.60	....	....	....	....	....
Ames ditch	0.69	....	....	....	....	....
Lake canal	1.248	....	....	....	....	....
Cache la Poudre No. 2	3.216	....	....	....	....	....
Sum	9.485	124.488	....	....	....	....
River at the dam below No. 2	......	....	149.985	25.497	10.10	2.52
The Whitney ditch	1.583	....	....	....	....	....
Greeley No. 3 canal	5.870	....	....	....	....	....
Sum	7.453	142.532	....	....	....	....
River. ¼ mile below No. 3	......	122.908	161.863	19.331	12.25	1.58
Ogilvy ditch	38.955	....	....	....	....	....
River, ⅓ mile below Ogilvy ditch	....	....	153.117	30.209	5.6	5.39
Totals	......	....	....	86.90	35.0	2.48

MEASUREMENT No. 2—Made by L. R. Hope and E. C. Hawkins, under direction of E. S. Nettleton, October 14–17, 1889.

Place of Measurement.	Out-take.	Remainder.	River	Gain.	No. of Miles.	Gain per Mile.
River at Gaging Station	......	....	68.723	....	....	....
Pleasant Valley & Lake canal	14.781	....	....	....	....	....
Larimer County canal	.818	....	....	....	....	..
Jackson ditch	5.288	....	....	....	....	....
Little Cache la Poudre ditch	6.968	....	....	....	....	....
Taylor and Gill	2.577	....	....	....	...	....
Larimer County No. 2 canal	12.425	....	....	....	....	....
Fort Collins Water Works	.875	....	... .	....	....	....
Arthur Irrigating Co. canal	.650	....	....	....	....	....
Larimer & Weld canal	3.040	....	....	....	....	....
Sum	47.422	21.301	....	....	....	..
River, below L. & W. dam	......	....	32.571	11.270	7.25	1.55
Pioneer ditch	1.746	....	... .	....	....	....
Josh Ames ditch	1.378	....	....	....	....	....
The Lake canal	1.500	....	....	....	....	....
The Arthur canal	1.497	....	....	....	....	....
Box Elder ditch	6.555	.. .	....	....	....	....
Cache a Poudre Canal No. 2	55.184	....	....	....	....	....
Sum	67.860	-35.289	....	....	....	....
River, below No. 2 dam	......	....	1.500	36.789	10.10	3.64
Whitney ditch	2.285	....	....	....	....	....
Eaton ditch	.300	....	....	....	....	....
Greeley Canal No. 3	9.835	....	....	....	....	....
Ogilvy ditch	30.098	....	....	....	....	....
Sum	42.518	-41.018	....	....	....	....
River, below Ogilvy dam	......	....	3.480	44.498	17.50	2.54
River, near mouth	......	....	9.887	6.407	3.75	17.09
Totals	157.800	....	....	98.964	38.60	2.56

GAGINGS OF THE CACHE A LA POUDRE RIVER.

(In cubic feet per second.)

MEASUREMENT No. 3—Made by L. R. Hope and E. C. Hawkins, October 16–18, 1890.

Place of Measurement.	Out-take.	In-flow.	Remainder.	River.	Gain.	No. of Miles.	Gain per Mile.
River, at Gaging Station	......	....	....	80.776	....	....	....
Canon ditch	.975	....	....	....	....	....	....
Larimer County canal	2.849	....	....	....	....	....	....
Jackson ditch	4.125	....	....	....	....	....	....
Little Cache la Poudre canal	4.016	....	....	....	....	....	....
Taylor and Gill ditch	.700	....	....	....	....	....	....
Fort Collins Water Works	.383	....	....	....	....	....	....
Larimer & Weld canal	16.401	....	....	....	....	....	....
Sum	29.449	....	51.327	....	....	....	....
River, below Larimer & Weld dam	......	....	....	77.117	25.79	7.25	3.56
Riddle ditch	.106	....	....	....	....	....	....
Josh Ames ditch	1.000	....	....	....	....	....	....
The Lake canal	1.040	....	....	....	....	....	....
Coy ditch	.973	....	....	....	....	....	....
Box Elder ditch	5.730	....	....	....	....	....	....
Cache la Poudre Canal No. 2	79.867	....	....	....	....	....	....
Sum	88.716	....	-11.599	....	....	....	....
River, below No. 2 canal	......	....	....	2.060	13.66	10.10	1.35
River, above Greeley (Pump House)	.....	....	....	19.308	17.25	15.0	1.15
River, at Ogilvy ditch	......	....	....	40.180	20.87	2.00	10.43
Ogilvy ditch	36.675	....	....	....	....	....	....
River, near mouth	......	....	....	32.729	23.22	4.(?)	5.80
Totals	......	....	....	.....	100.79	38.35	2.63

MEASUREMENT No. 4—Made by L. G. Carpenter and R. E. Trimble, October 28, and by L. G. Carpenter and J. D. Stannard, October 29–30, 1891.

Place of Measurement.	Out-take.	In-flow.	Remainder.	River.	Gain.	No. of Miles.	Gain per Mile.
River at Gaging Station	......	....	....	97.58	....	....	....
Canon ditch	.03	....	....	......	....	....	....
Pleasant Valley & Lake canal	6.99	....	....	......	....	....	....
Jackson ditch	0	....	....	......	....	....	....
Little Cache la Poudre ditch	5.21	....	....	......	....	....	....
Taylor and Gill ditch	2.16	....	....	......	....	....	....
Larimer County canal	1.00	....	....	......	....	....	....
New Mercer canal	0	....	....	......	....	....	....
Fort Collins Water Works	0.30	....	....	......	....	....	....
Larimer County No. 2 canal	.64	....	....	......	....	....	....
Arthur ditch	1.82	....	....	......	....	....	....
Larimer & Weld canal	43.30	....	....	......	....	....	....
Sum	61.45	....	36.13	......	....	....	....
River, below L. & W. canal	......	....	....	54.39	18.26	7.25	2.52
Pioneer ditch	0.0	....	....	......	....	....	....
Josh Ames ditch	.50	....	....	......	....	....	....
The Lake canal	.24	....	....	......	....	....	....
Coy ditch	1.60	....	....	......	....	....	....
Box Elder ditch	3.78	....	....	......	....	....	....
Cache la Poudre No. 2 canal	.50	....	....	......	....	....	....
Sum	6.62	....	47.77	......	....	....	....
River, at head of No. 2	......	....	....	56.48	8.71	10.10	0.86
Whitney ditch	0.0	....	....	......	....	....	....
Eaton ditch	1.42	....	....	......	....	....	....
Jones ditch	(8.126)	....	....	......	....	....	....
Greeley No. 3 canal	32.24	....	....	......	....	....	....
Boyd and Freeman ditch	2.42	....	....	......	....	....	....
Sum	36.08	0	11.69				
River, near Pump House	......	....	....	15.3	—5.1	15.0	....
Poudre below Greeley	......	....	....	53.56	38.26	2.1	2.24
Ogilvy ditch	18.12	....	....	......	....	....	....
Waste	......	5.88	....	......	....	....	....
River, near mouth	......	....	....	60.72	19.40	4.25	4.56
Totals	......	....	....	.....	84.63	38.7	2.19

River at Gaging Station Nov. 3. 107.61 cu. ft.

GAGINGS OF THE CACHE A LA POUDRE RIVER.

(In cubic feet per second.)

MEASUREMENT No. 5—Made by L. G. Carpenter and J. D. Stannard, March 10, and by L. G. Carpenter and F. DeVotie, March 11–12, 1892.

Time.	Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
	MARCH 10.						
....	River at Gaging Station	......	....	65.02	....	....	....
....	Lew Stone creek	......	0.50	......	....	....	....
....	Canon ditch	0	....	......	....	....	....
....	Pleasant Valley canal	4.38	....	......	....	....	....
....	Jackson ditch	2.07	....	......	....	....	....
....	Little Cache la Poudre ditch	1.08	....	......	....	....	....
....	Taylor and Gill ditch	0.59	....	......	....	....	....
....	Fort Collins Water Works	0.22	....	......	....	....	....
....	Larimer County ditch	0	....	......	....	....	....
....	Larimer County No. 2	10.10	....	......	....	....	....
....	New Mercer	0.28	....	.....	....	....	....
	MARCH 11.						
....	Larimer & Weld canal	0.72	....	......	....	....	....
....	Pioneer ditch	0	....	......	....	....	....
....	Lake canal	0	....	......	....	....	....
....	Coy ditch	(2.47)	....	......	....	....	....
....	Dry Creek ditch	......	(1.25)	......	....	....	....
....	Ames slough	......	(7.00)	......	....	....	....
....	Cooper slough	......	(2.43)	......	....	....	....
....	Box Elder creek	......	(2.16)	......	....	....	....
....	Spring creek	......	(6.04)	......	....	....	....
....	Box Elder ditch	0.75	....	......	....	....	....
....	Fossil creek	......	(2.72)	......	....	....	....
....	Near Whitney ditch	......	(0.81)	......	....	....	....
	MARCH 12.						
....	Eaton ditch	0.10	....	......	....	....	....
....	Whitney ditch	0	....	......	....	....	....
	Sum	20.29	0.50	......	....	....	....
....	River, near Eaton ditch	......	....	102.54	57.31	20.35	2.82
....	Near Fulton bridge	......	1.15	......	....	....	....
....	Inflow above Briggs	......	(2.25)	......	....	....	....
....	Inflow near Whitney ditch	......	....	......	....	....	....
....	Jones ditch	0	....	......	....	....	....
....	Inflow opposite Jones'	......	(1.35)	......	....	....	....
....	Inflow near Fletcher ditch	......	(0.75)	......	....	....	....
....	Greeley canal No 3	0	....	......	....	....	....
....	Inflow	......	(0.90)	......	....	....	....
	Sum	......	1.15	......	....	....	....
....	River near Pump house		....	132.75	29.06	12.0	2.42
....	Ogilvy ditch	1.00	....	......	....	....	....
....	River below Ogilvy ditch	......	....	141.49	9.74	2.50	3.89
	Totals	......	....	......	96.11	34.85	2.76

MEASUREMENT No 6—Made by R. E. Trimble and J. D. Stannard, October 5–8, 1892.

	OCTOBER 5.						
1 p. m.	River at Gaging Station	......	....	62.92	....	....	....
....	Canon ditch	.03	....	......	....	....	....
....	Jackson ditch	4.51	....	......	....	....	....
....	Little Cache la Poudre ditch	.18	....	......	....	....	....
....	Taylor and Gill ditch (est.)	6.25	....	......	....	....	....
....	Larimer County ditch	0	....	......	....	....	....
....	New Mercer canal	.35	....	......	....	....	....
....	Fort Collins Water Works	.28	....	......	....	....	....
....	Larimer County No. 2 canal	.36	....	......	....	....	....
	Sum	11.96	....	......	....	....	....
....	River 100 yards above L. & W. canal	......	....	66.33	15.37	7.25	2.12
5:30	Larimer & Weld canal	58.86	....	......	....	....	....

GAGINGS OF THE CACHE A LA POUDRE RIVER.

(In cubic feet per second.)

Measurement No. 6 –(Continued).

Time.	Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
....	River below L. & W. canal	......	....	5.95	....	....	....
	October 6.						
....	Pioneer ditch, near Inverness farm	.01	....	......	....	....	....
....	Josh Ames ditch	.89	....	......	....	....	....
....	The Lake canal	2.00	....	......	....	....	....
....	Coy ditch	(.74)	....	......	....	....	....
	Sum	2.90	....	......	....	....	....
Noon.	River, below Lindell Mills	......	....	52.56	*.60	3.00	....
....	Dry ditch	......	(.95)	......	....	....	....
....	Ames slough	......	(2.56)	......	....	....	....
....	Cooper slough	......	(2.63)	......	....	....	....
....	Box Elder creek	......	(2.90)	......	....	....	....
....	Spring creek	......	(1.25)	......	....	....	....
....	Box Elder ditch	2.14	....	......	....	....	....
	Sum	2.14	....	......	....	....	....
3 p. m.	River, below Strauss bridge	......	....	53.93	3.51	4.75	0.74
	October 7.						
11 a. m.	River below Strauss bridge	......	....	21.03	....	....	....
....	Inflow below Strauss bridge	......	(.02)	......	....	....	....
....	Cache la Poudre No. 2 canal	1.93	....	......	....	....	....
	Sum	1.93	....	......	....	....	....
Noon.	River, below No. 2 canal	......	....	21.65	2.52	2.40	1.05
....	Fossil creek	......	(1.33)	......	....	....	....
....	Whitney ditch	2.72	....	......	....	....	....
2 p. m.	River, below Eaton ditch	......	....	24.90	5.97	3 00	1.99
....	Jones ditch	.15	....	......	....	....	....
....	Greeley No. 3	32.20	....	......	....	....	....
	Sum	32.35	....	......	....	....	....
	October 8.						
9 a. m.	River, near Greeley Pump house	......	....	14.36	21.81	12.00	1.82
....	Ogilvy ditch	29.14	....	......	....	....	....
....	River, below Ogilvy dam	......	....	2.53	17.31	2.50	6.92
3 p. m	River at mouth	......	....	31.69	29.16	3.75	7.78
	Totals	......	....	......	101.65	38.65	2.47

* Estimated.

Measurement No. 7—Made by R. E. Trimble and R. Q. Tenney, November 9–11, 1893.

	November 9.						
....	River at Gaging Station	......	....	52.47	....	....	....
....	Canon ditch	0.48	....	......	....	....	....
....	Pleasant Valley canal	4.69	....	......	....	....	....
....	Larimer County ditch	0	....	......	....	....	....
....	Jackson ditch	4 83	....	......	....	....	....
....	Little Cache la Poudre ditch	0.23	....	......	....	....	....
....	Taylor and Gill ditch	1.41	....	......	....	....	....
....	New Mercer ditch	0	....	......	....	....	....
....	Fort Collins Water Works (est.)	.60	....	......	....	....	....
....	Larimer County No. 2 canal	1.87	....	......	....	....	....
....	Arthur Irrigating canal	0	....	......	....	....	....
	November 10.						
....	Larimer & Weld canal	(0.54)	....	......	....	....	....
....	River below L. & W. canal	......	....	69.61	31.25	7.25	4.31
....	Pioneer ditch	0.45	....	......	....	....	....
....	Josh Ames ditch	1.39	....	......	....	....	....
....	Lake canal	0	....	......	....	....	....
....	Coy ditch	2.00	....	......	....	....	....

GAGINGS OF THE CACHE A LA POUDRE RIVER.

(In cubic feet per second.)

MEASUREMENT No. 7—(Continued).

Time.	Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
....	River below Hottel Mill			72.48	6.71	3.25	2.61
....	No. 2 Feeder	6.80					
....	Spring creek		(0.68)				
....	Ames slough		(5.00)				
....	Cooper slough		(1.50)				
....	Box Elder creek		(3.70)				
....	Box Elder ditch	1.04					
....	Cache la Poudre Irr'g Canal No. 2	60.03					
	NOVEMBER 11.						
....	River below No. 2			9.84	5.23	6.90	0.76
....	Fossil creek		(1.35)				
....	Whitney ditch	0.08					
....	Eaton ditch	0.					
....	River below Eaton ditch			4.95	—4.81	3.00	—1.60
....	Jones ditch	0.19					
....	Greeley No. 3 canal	0					
....	Boyd and Freeman ditch	3.65					
....	River north of Pump house			20.32	19.21	12 00	1.60
....	Ogilvy ditch	0.65					
....	River below Ogilvy dam			43.26	23.59	2.50	9.44
....	River at the mouth			60.76	17.50	3.25	5.38
	Totals				98.68	38.15	2.59

MEASUREMENT No. 8—Made by R. E. Trimble and R. Q. Tenney, March 13–15, 1894.

Time.	Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
	MARCH 13.						
....	River at Gaging Station			99.21		C	
....	Canon ditch	0.03					
....	Pleasant Valley & Lake canal	(4.70) 12.60					
....	Larimer County canal	0.25					
....	Jackson ditch	6.17					
....	New Mercer canal	0					
....	Fort Collins Water Works	0.60					
....	Little Cache la Poudre canal	0.53					
....	Taylor and Gill ditch	5.22					
....	Chamberlain ditch	(2.00)					
....	Larimer County No. 2 canal	0.57					
....	Arthur Irrigating canal	0					
....	Larimer and Weld canal	25.30					
....	Riddle ditch	0.33					
....	River below L & W. canal			49.18	1.57	7.25	0.22
	MARCH 14.						
....	Pioneer ditch						
....	Ames ditch	1.28					
....	Lake canal	0.16					
....	Coy ditch	0					
....	No. 2 Feeder	49.70					
....	River below No 2 Feeder			1.49	3.45	4.45	0.78
....	Spring creek		(2.78)				
....	Ames slough		(0.22)				
....	Cooper slough		(1.21)				
....	Box Elder ditch	0.11					
....	Box Elder creek		(0.24)				
....	No. 2 Feeder, north of Timnath	(23.90)					
	MARCH 15.						
....	Cache la Poudre No. 2 canal	1.43					
....	River below No. 2			27.17	27.22	5.65	4.82
....	Fossil creek		(0.19)				
....	Eaton ditch	.08					
....	River below Eaton ditch			20.44	—6.65	3.00	—2.22
....	Jones ditch	0					
....	Greeley No. 3 canal	0.12					
....	Boyd and Freeman ditch	0.12					

GAGINGS OF THE CACHE A LA POUDRE RIVER.

(In cubic feet per second.)

MEASUREMENT No. 8—(Continued).

Time.	Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
....	River near Pump house...	......	....	46.46	26.26	12.00	2.19
....	Greeley drain sewer...............	(1.47)	....	......	....	....	....
....	Ogilvy ditch......................	0	....	......	....	....	....
....	River below Ogilvy dam............	......	....	56.51	10.05	2.50	4.02
....	River at mouth, ¼ mile above.......	......	....	76.93	20.42	3.25	6.28
....	Totals.....	......	....	......	82.32	38.10	....

MEASUREMENT No. 9—Made by R. E. Trimble and John D. Bloomfield, August 20–23, 1894.

Time.	Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
	AUGUST 20.						
12:35	River at Gaging Station...........	......	....	268.07	....	....	....
2:45	Canon ditch......................	0.80	....	......	....	....	....
11:30	Pleasant Valley & Lake canal..	23.63	....	......	....	....	....
3:15	Larimer County ditch............	31.39	....	......	....	....	....
4:15	Jackson ditch....................	11.17	....	......	....	....	....
10:40	New Mercer canal..	3.42	....	......	....	....	....
....	Fort Collins Water Works.........	0.60	....	......	....	....	....
4:40	Little Cache la Poudre canal.....	7.87	....	......	....	....	....
4:50	Taylor and Gill ditch............	4.46	....	......	....	....	....
....	Chamberlain ditch...............	4.53	....	......	....	....	....
....	Larimer County No. 2 canal......	0	....	......	....	....	....
....	Arthur Irrigating canal...........	0	....	......	....	....	....
5:40	Larimer & Weld canal..........	27.80	....	......	....	....	....
6:15	River below L. & W. canal......	......	....	153.17	0.77	7.25	0.11
	AUGUST 21.						
9:20	Pioneer ditch......................	0.16	....	......	....	....	....
9:50	Ames ditch........................	2.56	....	......	....	....	....
10:10	Lake canal.........................	0.13	....	......	....	....	....
10:20	Coy ditch....................	16.30	....	......	....	....	....
11:10	River at Coy's farm...............	......	....	(151.61)	17.59	3.50	5.26
11:55	Coy ditch waste	......	0.82	......	....	....	....
12:00	Coy slough	......	(1.70)	......	....	....	....
2:45	Horner supply	6.39	....	......	....	....	....
3:15	Chaffee ditch.....................	2.77	....	......	....	....	....
3:40 }	Pioneer waste	......	} 9.51	......	....	....	....
	Horner supply waste..............	......		......	....	....	....
9:15	Spring creek (Aug. 22)........	......	(5.56)	......	....	....	....
4:00	Ames slough.........	......	(0.90)	......	....	....	....
4:30	Emigh drain ditch	(3.00)	....	......	....	....	....
9:50	Cuthbertson (Aug. 22)............	......	(0.51)	......	....	....	....
....	Cooper slough (into Emigh drain)	......	(0.50)	......	....	....	....
4:45	Box Elder creek..................	......	(2.52)	......	....	....	....
10:15	Box Elder ditch (Aug. 22)	7.93	....	......	....	....	....
5:40	River at Strauss bridge.............	......	....	141.52	—3.33	4.20	—0.79
	AUGUST 22.						
11:05	River at Strauss bridge..............	......	....	139.61	....	....	....
12:35	Cache la Poudre No. 2 canal......	74.27	....	......	....	....	....
1:35	River below No. 2.........	......	....	68.46	3.12	2.40	1.30
2:45	Fossil creek.......................	......	(4.58)	......	....	....	....
3:30	Whitney ditch	19.98	....	......	....	....	....
3:35	Eaton ditch........................	10.90	....	......	....	....	....
4:00	River below Eaton ditch............	......	....	49.44	11.86	3.00	3.95
6:40	Jones ditch.............	5.28	....	......	....	....	....
	AUGUST 23.						
10:50	Greeley No. 3 canal......	56.55	....	......	....	....	....
10:25	River below No. 3.....	......	....	0.29	12.68	9.	1.41
12:10	Boyd and Freeman ditch..........	3.30	....	......	....	....	....
2:30	River near Pump house.............	......	....	18.13	21.14	3.00	7.05
3:15	Greeley drain sewer	(3.51)	....	......	....	....	....
3:50	Ogilvy ditch.......................	38.39	....	......	....	....	....
4:15	Camp Bros. river supply........	1.17	....	......	....	....	....
4:45	Camp Bros. Slough supply......	(2.16)	....	......	....	....	....
4:25	River below C. Bros, river supply	......	....	4.93	26.36	3.00	.79
6:00	River ½ mile above mouth.........	......	....	32.90	27.97	2.75	.17
	Totals	......	....	......	118.16	38.10	3.10

GAGINGS OF THE CACHE A LA POUDRE RIVER.

(In cubic feet per second.)

MEASUREMENT NO. 10—Made October 9-14, 1895.

Time.	Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
	NOVEMBER 9.						
....	River at Gaging Station............	......	....	66.47	....	....	....
....	Canon canal........................	.10	....	......	....	....	....
....	Pleasant Valley & Lake canal..	21.23	....	......	....	....	....
....	Inflow from Canon canal.........	......	.13	......	....	....	....
....	Larimer County canal....	0	....	......	....	....	....
....	Jackson ditch......................	0	....	......	....	....	....
....	River 150 yards above Mercer ditch	......	....	63.53	18.75	5.50	3.41
....	New Mercer ditch..................	0	....	......	....	....	....
....	Little Cache la Poudre ditch.....	6.67	....	......	....	....	....
....	Taylor and Gill ditch.............	4.55	....	......	....	....	....
....	Chamberlin ditch..................	......	....	......	....	....	....
....	Larimer County No. 2 canal......	.50	....	......	....	....	....
....	Fort Collins Water Works (est.).	.75	....	......	....	....	....
....	Inflow waste from T. & Gill ditch	......	3.63	......	....	....	....
....	Inflow waste from T. & Gill ditch	......	.93	......	....	....	....
....	Arthur ditch.......................	2.88	....	......	....	....	....
....	River above Larimer & Weld.....	......	....	54.10	1.46	1.75	.81
	OCTOBER 10.						
....	River below Larimer & Weld....	......	....	0.55	....	....	....
....	Pioneer ditch......................	0.28	....	......	....	....	....
....	Seepage ditch	.....	(0.50)	......	....	....	....
....	Ames ditch.........................	0.21	....	......	....	....	....
....	Lake canal.........................	3.06	....	......	....	....	....
....	City sewer.........................	......	....	......	....	....	....
....	College sewer......................	......	....	......	....	....	....
....	Coy ditch..........................	.01	....	......	....	....	....
....	No 2 Res. supply canal...........	.18	....	......	....	....	....
....	River below No. 2 Res. Supply canal	......	....	26.44	26.63	4.4	6.05
....	Dry creek..........................	......	(1.71)	......	....	....	....
....	Ames slough........................	......	(0.96)	......	....	....	....
....	Emigh drain........................	......	((3.68))	......	....	....	....
....	Cooper slough...............	......	((0.53))	......	....	....	....
....	Box Elder creek....................	......	(3.76)	......	....	....	....
....	Spring creek.......................	......	(6.12)	......	....	....	....
....	Box Elder ditch....................	0	....	......	....	....	....
....	Seepage ditch from Spring creek.	......	((0.63))	......	....	....	....
....	Side Hill ditch from Spring creek	......	((2.53))	......	....	....	....
....	Ditch from Cooper slough.........	......	((1.15))	......	....	....	....
....	River at Strauss bridge............	......	....	32.53	6.09	4.2	1.45
	OCTOBER 14.						
....	River at Strauss bridge.	......	....	26.24	....	....	....
....	Cache la Poudre No. 2 canal......	.02	....	......	....	....	....
....	River below Cache la P. No. 2 canal	......	....	33.73	7.51	2.4	3.13
....	Fossil creek........................	......	(7.63)	......	....	....	....
....	Whitney ditch......................	5.72	....	......	....	....	....
....	Eaton canal........................	8.09	....	......	....	....	....
....	River below Eaton canal............	......	....	26.91	6.99	3.0	2.33
....	Seepage ditch.............	......	(1.34)	......	....	....	....
....	Jones ditch........................	1.39	....	......	....	....	....
....	Greeley No. 3 ditch (Oct. 15)......	13.10	....	......	....	....	....
....	River below Greeley No. 3 ditch....	......	....	19.77	7.35	9.0	.82
	OCTOBER 15.						
....	Greeley No. 3......................	.61	....	......	....	....	....
....	River below Greeley No. 3 ditch....	......	....	32.26	....	....	....
....	Waste into No. 3..................	......	((1.86))	......	....	....	....
....	Waste into No. 3...	......	((0.56))	......	....	....	....
....	Boyd and Freeman ditch..........	2.77	....	......	....	....	....
....	River at Pump house................	......	....	62.73	33.85	3.0	11.28
....	Mill Power canal..................	(4.05)	(5.40)	......	....	....	....
....	Ogilvy ditch.......................	0	....	......	....	....	....
....	River below Ogilvy dam............	......	....	70.47	7.74	2.5	3.10
....	Camp ditch.........................	0	....	......	....	....	....
....	River ½ mile above mouth..	......	....	116.84	46.37	3.25	5.05

TABLE III.

SUMMARY OF THE PRECEDING TABLES, SHOWING GAIN IN SEEPAGE OF CACHE A LA POUDRE RIVER.

(In cubic feet per second.)

	1885.	1889.	1890.	1891.	Mar. 1892.	Oct. 1892.	1893.	Mar. 1894.	Aug. 1894.	1895.
Canon to Larimer & Weld canal..	11.9	11.3	25.8	18.3	......	15.4	31.3	1.6	0.8	19.61
Larimer & Weld to No. 2 canal...	25.5	36.8	13.7	8.7	......	12.0	11.9	30.67	17.4	13.6
No. 2 canal to Ogilvy ditch........	49.5	44.5	38.1	38.3	......	45.1	38.0	29.8	72.0	55.9
Ogilvy ditch to Month of Poudre.	......	6.4	23.2	19.4	......	29.2	17.5	20.4	28.0	46.4
Total Gain	86.9	99.0	100.8	84.6	96.1	101.6	98.7	82.3	118.2	164.4

DESCRIPTION OF THE PLATTE.

§ 16. The portion of the Platte river which was subjected to measurement consisted of that portion below the junction of the Poudre river with the Platte, to the State line between Colorado and Nebraska, at the point where the Platte enters the western extension of Nebraska. The country traversed by the Platte has still the main characteristics of that nearer the mountains. From the junction with the Cache a la Poudre, the Platte leaves the general northerly course which it has traveled since leaving the foothills above Denver, bends abruptly eastward and crosses the ridges which run approximately parallel to the mountains. The effect of these ridges in guiding the drainage of the plains is shown by the long lateral channels. On the south these extend nearly parallel to the Platte for 90 miles, extending to the divide between the Platte and Arkansas rivers, east of Colorado Springs. For a portion of the distance, the Box Elder is within a short distance of the Platte, but, confined by these ridges, it does not meet the Platte until the latter cuts through these ridges. These are drainage channels rather than tributaries, for, except in times of freshets or storms, they do not contain water. Near the heads they are living streams. The last drainage channel from the south of any consequence enters the Platte east of Fort Morgan; for the rest of the distance the drainage of the country on the south side is collected by branches of the Republican river.

§ 17. On the north the Platte takes the drainage of the country as far north as Wyoming. The three principal lines of drainage—Lone Tree, Crow, and Lodge Pole creeks—each head near Cheyenne, the first two entering the Platte near Greeley, the last passing nearly eastward for 150 miles, forming the line followed by the main line of the Union Pacific Railway between Julesburg and Cheyenne, and enters the Platte 150 miles farther east, just above Julesburg.

None of these, nor any of the other channels to which the name creek is applied, can be spoken of as tributaries. It is rare

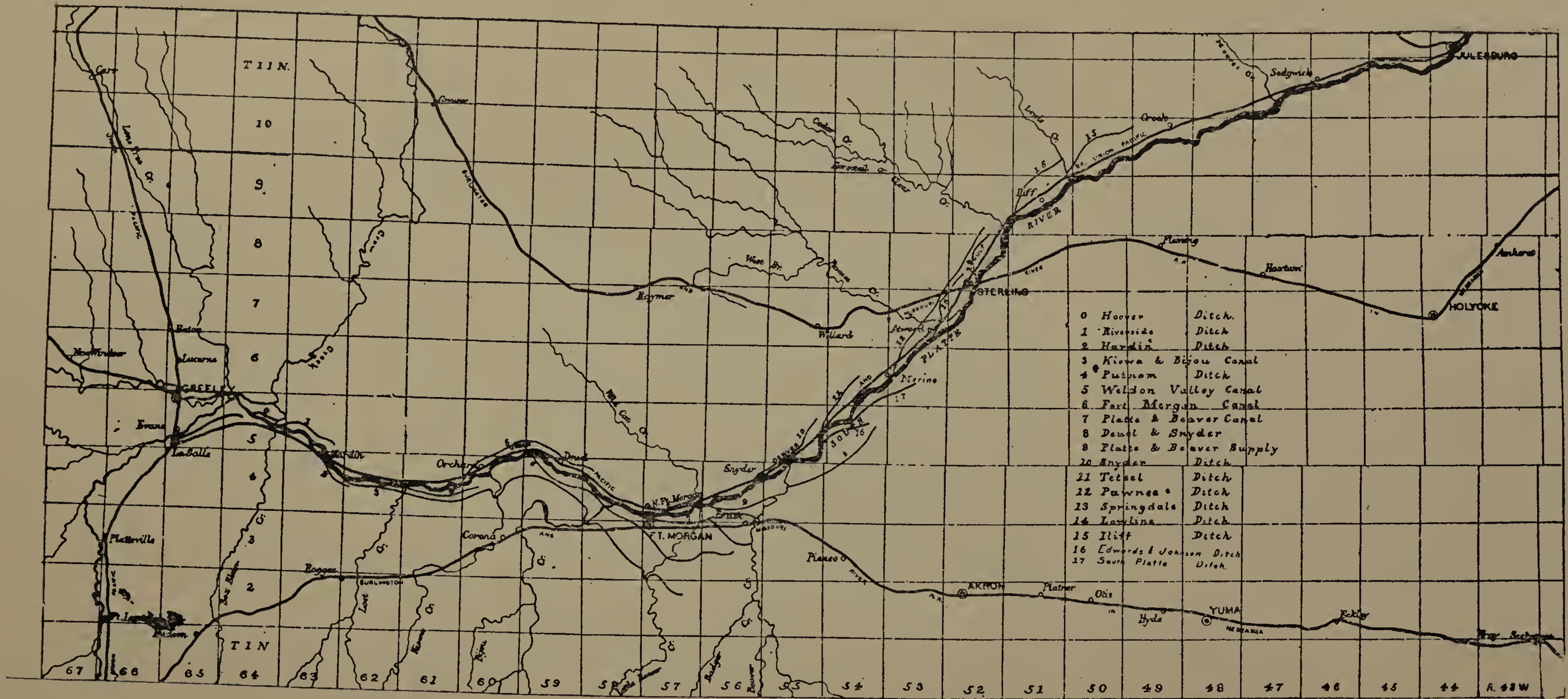


FIG. 3--Map of the South Platte Valley.

that any water reaches the Platte through their channels, the only times being after heavy rains or sudden and violent storms on the higher grounds on either side. In these cases, the plains shed water as a roof, and the channels bring down violent floods, dangerous, it may be, to travelers. The area drained by these channels is great. As in most cases, the channels are confined by ridges of rock, it was thought that there might be some indication of underground increase from these streams, even if no visible surface inflow. Accordingly in 1894 it was tested by measuring the river above and below the points where the creeks debouch into the bottoms, with results given later.

For a portion of the lower course of the stream, it is lined on one or both sides by a strip of sand hills and dunes, molded and blown by the wind, back of which is a country free from sand.

§ 18. The bed of the stream is a bed of sand, of varying fineness—in some places and at some times quicksand—and shifting with the current, which changes from one side to the other. For some miles below the mouth of the Poudre, the stream is in one channel. It is then gradually broken up by sandbars and by small islands into smaller channels, increasing in number. At the State line there were sixteen channels where we measured in 1895. These channels are constantly shifting by bars forming or washing away in the rapid current, so that they change their importance and frequently their position. The general location of the bed seems to be fairly stable. The river requires bridges some 600 to 1,000 feet in length. The slope of the bed of the river averages about eight feet per mile between the mouth of the river and Julesburg, being greater at the upper portion and less at the lower end. When there is much water this fall is sufficient to give the current great velocity, constantly carrying along the sand, depositing, removing and shifting it.

§ 19. The principal ditches along the course of the river are shown on the map (Fig. 3). It will be noted that the area limited by the outermost ditch under irrigation does not cover a wide strip. Many of the ditches are small, some used to irrigate only the bottom lands. Others, like the Fort Morgan, the Weldon Valley, the Platte and Beaver, and Pawnee Canal systems, irrigate considerable areas of excellent land and are almost the only ones passing out of the bottoms.

If the water reaches the river from the land irrigated, it may be expected to drain into the river following the lines of surface drainage, though remaining unseen. It cannot cross the ridges between the channels. As a rule, wherever the facts are known, the ridges are of rock which is higher than the bottoms of the channels. With the system of ditches, there is then some possibility of separating the drainage of extensive areas of irrigated land from land which receives little or no irrigation.

COMPLICATING CONDITIONS.

§ 20. The bed is almost invariably of sand of unknown depth. In a few places the rock of the ridges cut through by the river shows at the surface. If there is any flow in the sand, it may be expected to be forced to the surface at such places and increase the volume of the stream. Such a place is just above the Bijou creek, above Fort Morgan. And again below the Hardin ditch and above the Corona ditch the bluffs on the south side of the river are prominent, and show evidence of rock outcropping across the river. The sand is porous and has the capacity to hold much water. The results which may be met with in the natural inflow are masked by the effects due to the varying distance to the rock. These may sometimes be more than sufficient to counterbalance the increase from the inflow. This may explain the unusual gains noticed in several places and the losses which are found in certain stretches, even where an area of irrigated land is tributary to that section. The most marked case is at the mouth of Bijou creek. In the measurement of 1894, which was made above and below the Bijou, a gain was looked for in the few miles between the two measurements. The Bijou drains some 1,400 square miles. Besides, there was some water evident on the south side seeping into the river. Nevertheless, a loss was found in 1894, and in 1895 on making another test the gain was so slight that it may be called a loss. In both cases the Platte & Beaver canal was measured several miles from its head, and the loss for the few miles if considered may make a slight gain. But with all allowance possible for this, the gain is slight, or an actual loss which the measurements show. Moreover, at the last point of measurement, there are practically no bottom lands.

§ 21. The methods of irrigation on the lower Platte are somewhat different from those on the Cache a la Poudre, and this may account for the difference in the relative magnitude of the result. The Poudre being a mountain stream, fed almost solely by melting snow, is low in the autumn and late summer. On the Platte the summer flow is small, being reduced both by the usage above and by the avidity of the sands and atmosphere. In the fall, however, the seepage from all the streams nearer the mountains—Clear creek, Boulder creek, St. Vrain, Big Thompson, and Cache a la Poudre—pour the seepage from these channels and the greater part of the flow received from the mountains into the Platte. As a consequence the Platte is higher in the fall and winter. This gives the settlers along the Platte opportunity to irrigate extensively in the fall, and as late as the ditches can well carry water; they thus each year irrigate their lands. At the time of measurement they were irrigating extensively. It will be noticed in the tables, as in 1895, that the canals are running nearly, if not quite full, though late in the season. This in itself increases the rapidity of flow from the lower ends of the small tubes extending to the river, and is one reason why the increase of water is more than in the case of the Poudre in proportion to the same area irrigated. The use of water at this time when vegetation is not active, also permits the use of water in greater quantities without damage. We have no measures which determine the amount actually used, but from observation and the conditions, it seems probable that water is used in greater quantities than in the Poudre valley.

§ 22. Fig. 4 shows graphically the results of the gagings below the mouth of the Poudre. The distances between the points of measurement are in proportion to the distance between the lines. The amount of gain is indicated by the distance the line is above the base. Hence the steeper the line in any section, the faster is the gain in that section. If the line descends, as it does in some places, it indicates a loss.

§ 23. The tables show the measurements in detail, and give the results of each. The dates and the observers are also given. The distances given are different from the distances given in the report of the State Engineer, but are believed to be here correct. In some cases the distance between the same points in different years is apparently not the same, the reason being that the place out of gaging was not quite the same.

In gaging the Platte, the trouble to find accommodations caused considerable interference with the best prosecution of the work. Often after the last gaging of the day a drive of some miles would be necessary, and the river would be taken up at another point the next morning. This did not allow a check on any change the river may have undergone during the night. In 1895 a tent and camp wagon was taken as far as Sterling, and the party camped where night overtook them.

The height of the river was observed both night and morning. It was proved that the change was exceedingly small, amounting, usually, to an increase of about one-fourth inch during the night and a corresponding decrease during the day. A loose block of wood placed at the edge of the water the second night out from Greeley was undisturbed a week later and still just at the edge of the water, indicating a very steady condition of the stream.

The ditches were not disturbed. Where streams are not mentioned in some of the measurements, it is because they were found to be dry.

In 1895 several small ditches near Julesburg were found to be drawing water. Their existence had never been reported to the Water Commissioner, so that they had not been looked for in 1894.

The measurement of March, 1892, was interfered with by snow, which prevented carrying the gaging beyond Fort Morgan.

In 1895 where any of the quantities are enclosed in parentheses, they are not to be taken in the summation. In the case of inflow it was known to be seepage, or in case of out-take it returned immediately to the river.

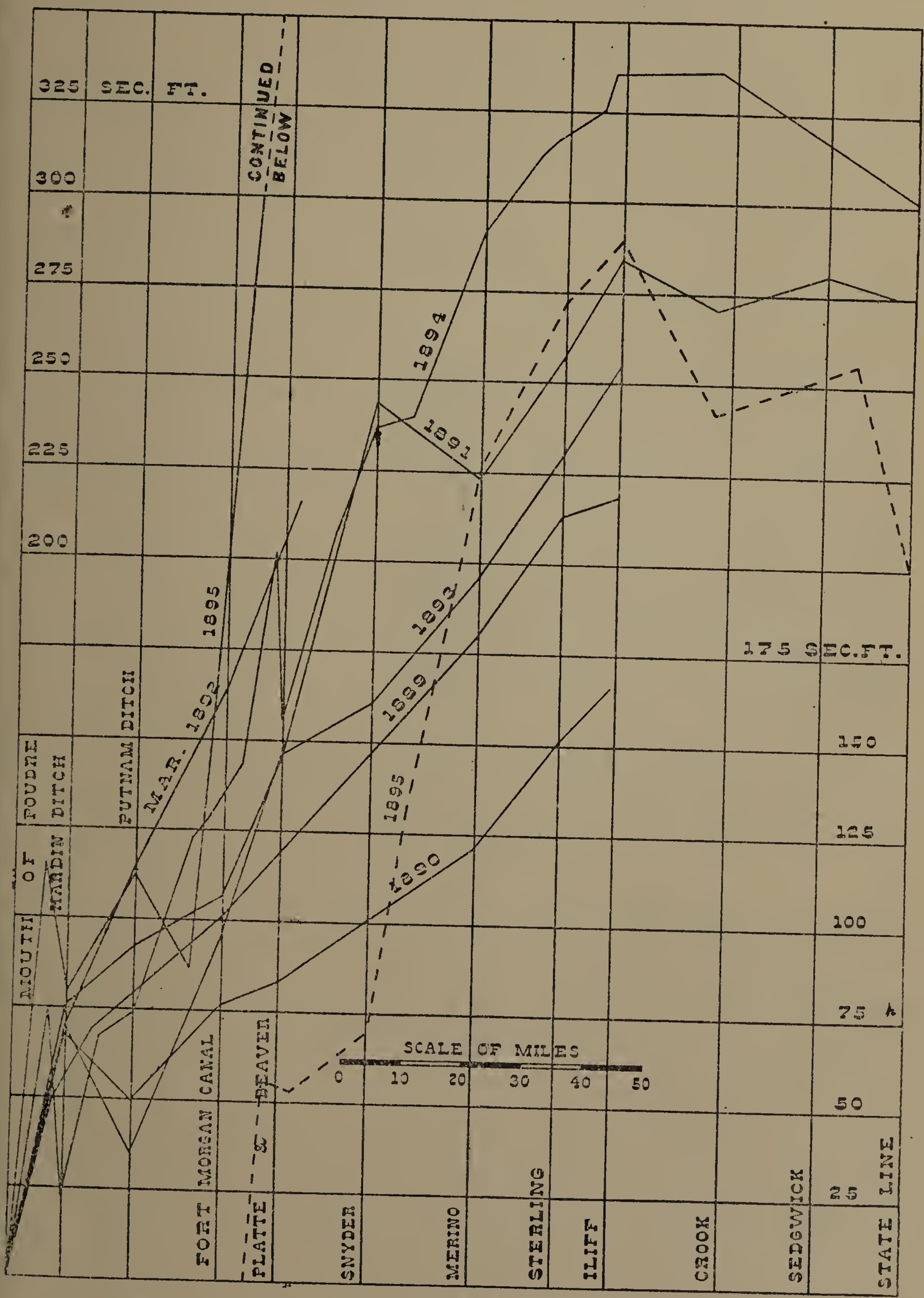


FIG. 4.—Seepage Increase of the South Platte River.

GAGINGS OF THE SOUTH PLATTE RIVER.

(In cubic feet per second.)

Measurement No. 1—Made by L. R. Hope and E. C. Hawkins, October, 1889.

Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
River at head of Latham ditch	......	....	45.718	....	....	....
Cache a la Poudre river	......	14.830	......	....	....	....
River at Hoover ditch	......	....	120.136	*49.000	6.30	9.46
Hardin ditch	1.005	....	......	....	....	....
River, at head of K. and B. ditch	......	....	139.641	20.51	7.20	2.85
Small ditch (no name)	2.00	....	......	....	....	....
Putnam ditch	30.905	....	......	....	....	....
River at ——	......	....	105.769	....	....	....
Fort Morgan canal	131.932	....	......	....	....	....
River below Fort Morgan canal	......	....	3.625	30.755	19.0	1.62
Bijou creek	......	3.575	......	....	....	....
River at Deuel	......	....	8.310	1.11	12.0	0.09
Deuel and Snyder ditch	3.567	....	......	....	....	....
Platte & Beaver canal	25.023	....	......	....	....	....
Lower Beaver ditch	17.487	....	......	....	....	....
Beaver creek	......	7.000	......	....	....	....
Smith ditch	8.447	....	......	....	....	....
Tetsel ditch	2.340	....	......	....	....	....
South Platte ditch	24.106	....	......	....	....	....
Pawnee ditch	4.367	....	......	....	....	....
River at Merino	......	....	8.481	78.508	30.75	2.55
Schneider ditch	12.609	....	......	....	....	....
Springdale ditch	3.583	....	......	....	....	....
Sterling ditch No. 1	10.076	....	......	....	....	....
Low-line ditch	1.796	....	......	....	....	....
Smith and Henderson ditch	6.833	....	......	....	....	....
River at Sterling	......	....	6.378	32.794	13.75	2.39
Sterling ditch No. 2	1.946	....	......	....	....	....
Arnette ditch	8.871	....	......	....	....	....
River near Iliff	......	....	......	4.439	9.25	0.48
Total	......	....	......	217.116	....	....

* Estimated portion seepage from mouth of Poudre river to Hoover ditch.

Measurement No. 2—Made by L. R. Hope and E. C. Hawkins, October, 1890.

Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
River above Cache a la Poudre river	......	....	98.458	....	....	....
Cache la Poudre river	......	32.729	......	....	....	....
Box Elder creek	......	23.524	......	....	....	....
Hardin ditch	10.279	....	......	....	....	....
River below Hardin ditch	......	....	213.174	68.742	8.0	8.59
Bijou canal	21.424	....	......	....	....	....
Winkle ditch	2.220	....	......	....	....	....
Putnam ditch	6.581	....	......	....	....	....
River below Putnam ditch	......	....	164.881	-18.775	12.25	—1.53
Weldon Valley ditch	31.674	....	......	....	....	....
River 4 miles below Orchard	......	....	156.403	23.196	12.25	1.89
Fort Morgan canal	114.262	....	......	....	....	....
River below Fort Morgan canal	......	....	45.931	3.79	1.5	2.53
Small gulch (no name)	......	7.421	......	....	....	....
Bijou creek (waste from Ft. M. canal)	......	2.028	......	....	....	....
Platte & Beaver canal	36.674	....	......	....	....	....
River below P. & B. canal	......	....	25.215	6.509	11.0	0.59
Platte & Beaver Supply ditch	24.155	....	......	....	....	....
Smith ditch	5.199	....	......	....	....	....

GAGINGS OF THE SOUTH PLATTE RIVER.

(In cubic feet per second.)

Measurement No. 2—(Continued).

Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
River at Snyder	......	....	12.950	17.089	13.75	1.24
Tetsel ditch	4.250	....	......	....	....	....
South Platte ditch	17.661	....	......	....	....	....
Pawnee ditch	3.881	....	......	....	....	....
River ¼ mile above Merino	......	....	8.444	21.286	18.0	1.18
Schneider ditch	5.063	....	......	....	....	....
Springdale ditch	18.500	....	......	....	....	....
Smith and Henderson ditch	2.640	....	......	....	....	....
River at Sterling	......	....	11.933	29.692	13.75	2.16
Sterling No. 2 ditch	3.827	....	......	....	....	....
Arnette ditch	11.448	....	......	....	....	....
Midline ditch	7.054	....	......	....	....	....
River below Midline ditch	......	....	3.647	14.043	8.0	1.76
Totals	......	....	......	165.57	98.50	....

Measurement No. 3—Made by L. R. Hope and R. E. Trimble, October, 1891.

River above the Cache a la Poudre river	......	....	114.60	....	....	....
Cache a la Poudre river	......	61.11	......	....	....	....
Hoover ditch	6.40	....	......	....	....	....
Hardin ditch	1.51	....	......	....	....	....
River below Hardin ditch	......	....	244.33	75.53	8.0	9.44
Kiowa & Bijou canal	38.86	....	......	....	....	....
Putnam ditch	10.39	....	......	....	....	....
River below Putnam ditch	......	....	211.69	16.61	12.25	1.36
Weldon Valley ditch	20.93	....	......	....	....	....
Fort Morgan canal	99.35	....	......	....	....	....
River below Fort Morgan canal	......	....	106.69	15.28	13.75	1.11
Deuel & Snyder ditch	7.81	....	......	....	....	....
Platte & Beaver ditch	2.33	....	......	....	....	....
River, below Platte & Beaver ditch	......	....	134.81	38.26	11.0	3.48
Platte & Beaver Supply ditch	46.21	....	......	....	....	....
River at Snyder	......	....	186.79	98.19	13.75	7.14
Smith ditch	1.36	....	......	....	....	....
Edwards ditch	18.27	....	......	....	....	....
South Platte ditch	35.51	....	......	....	....	....
Pawnee ditch	64.70	....	......	....	....	....
River, above Merino	......	....	46.68	-20.27	18.0	-1.13
Schneider ditch	3.46	....	......	....	....	....
Springdale ditch	9.85	....	......	....	....	....
River at Sterling	......	....	66.73	33.36	13.75	2.43
Smith and Henderson ditch	6.74	....	......	....	....	....
Low-line ditch	2.12	....	......	....	....	....
Iliff & Platte Valley ditch	33.22	....	......	....	....	....
River, at Iliff	......	....	52.72	28.07	9.25	3.03
River, 2 miles above Crook	......	....	39.65	-13.07	16.50	-0.79
River, below Sedgwick	......	....	47.70	8.05	21.50	0.37
River, at Julesburg	......	....	42.96	-4.74	11.50	-0.41
Totals	......	....	......	275.27	149.25	....

GAGINGS OF THE SOUTH PLATTE RIVER.

(In cubic feet per second.)

Measurement No. 4—Made by L. R. Hope, March, 1892.

Time.	Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
....	River, above Cache a la Poudre river	......	....	473.09	....	....	....
....	Cache a la Poudre river...........	......	145.56	......	....	....	....
....	River, below Hardin ½ mile........	......	....	687.73	69.08	8.5	8.13
....	Kiowa & Bijou canal...............	0.50	....	......	....	....	....
....	River, 2¼ miles below Putnam ditch	......	....	732.59	45.36	14.25	3.18
....	River, below Fort Morgan canal....	......	....	762.07	29.48	11.25	2.62
....	River, opposite Fort Morgan.......	......	....	834.72	72.65	13.5	5.38
.	Totals......	......	....	......	216.57	47.50	....

Measurement No. 5—Made October 30–November 10, 1893.

Time.	Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
....	River, above the Cache a la Poudre.	......	....	124.16	....	....	....
....	Cache a la Poudre river......	......	64.11	......	....	....	....
....	River, below Hardin ditch..........	......	....	257.30	69.03	8.0	8.63
....	Choat's ditch......................	4.05	....	......	....	....	....
....	River, above Putnam ditch.........	......	....	219.52	-33.73	12.25	-2.75
....	Putnam ditch.....................	12.28	....	......	....	....	....
....	Weldon Valley ditch..............	30.70	....	......	....	....	....
....	Fort Morgan canal................	132.08	....	......	....	....	....
....	River, below Fort Morgan canal....	......	....	105.29	60.83	13.75	4.42
....	Deuel & Snyder ditch............	4.11	....	......	....	....	....
....	River, below P. & B. canal..........	......	....	151.49	50.31	11.0	4.57
....	Platte & Beaver Supply canal.....	114.12	....	......	....	....	....
....	Gill ditch.........................	0.94	....	......	....	....	....
....	River at Snyder.....................	......	....	51.46	15.03	13.75	1.09
....	Smith ditch..........................	8.49	....	......	....	....	....
....	Edwards ditch.....................	10.20	....	......	....	....	....
....	Tetsel ditch.......................	6.94	....	......	....	....	....
....	South Platte ditch................	44.12	....	......	....	....	....
....	Pawnee ditch......................	11.80	....	......	....	....	....
....	River, at Merino....................	......	....	4.63	34.72	17.75	1.96
....	Schneider ditch...................	16.55	....	......	....	....	....
....	Springdale ditch..................	8.51	....	......	....	....	....
....	River, at Sterling....................	......	....	13.33	33.76	14.0	2.41
....	Smith and Henderson ditch......	11.49	....	......	....	....	....
....	Low-line ditch	6.19	....	......	....	....	....
....	Iliff & Platte Valley ditch.........	14.77	....	......	....	....	....
....	River above Iliff.....................	......	....	5.72	24.84	9.25	2.69
	Totals......	......	....	......	254.79	99.75	....

Measurement No. 6—Made by P. J. Preston and R. E. Trimble, October 16–24, 1894.

Time.	Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
	October 16.						
2 p. m.	River, below Cache a la Poudre river	......	....	308.68	....	....	....
3:15	Lone Tree creek....................	......	3.01	......	....	....	....
3:50	River, below Lone Tree creek......	......	....	323.85	12.16	1.50	8.11
	October 17.						
8:30	River, below L. T. creek, same place	......	....	345.60	....	....	....
10:30	Sterling Seepage ditch............	6.60	....	......	....	....	....
11:15	Hoover ditch......................	11.84	....	......	....	....	....
12:30	River, below Hoover ditch..........	......	....	389.90	62.74	3.50	17.93
2:45	Hoover ditch (waste)..............	......	0.61	......	....	....	....
2:35	Box Elder creek....................	......	10.19	......	....	....	....
4:15	River, above Hardin ditch..........	......	....	349.65	-51.05	3.00	-17.02

GAGINGS OF THE SOUTH PLATTE RIVER.

(In cubic feet per second.)

MEASUREMENT No. 6—(Continued.)

Time.	Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
	OCTOBER 18.						
7:45	River, above H'r'n ditch, same place	......	....	343.29	....	....	....
9:20	Hardin ditch	5.36	....	......	....	....	....
10:30	Illinois ditch	2.58	....	......	....	....	....
11:50	River, at head of Corona ditch	......	....	378.89	43.54	7.00	6.22
3:20	River, above Putnam ditch	......	....	385.87	6.98	5.25	1.33
2:45	Putnam ditch	27.90	....	......	....	....	....
	OCTOBER 19.						
8:25	Weldon Valley ditch	36.98	....	......	....	....	....
10 a. m.	River, above Kiowa creek	......	....	369.81	48.82	8.50	5.74
12:20	River, below Kiowa creek	......	....	375.07	5.26	1.75	3.01
2:15	Fort Morgan canal	170.30	....	......	....	....	....
2.55	River 3½ miles below Fort M. canal	......	....	219.00	14.23	7.0	2.03
	OCTOBER 20.						
9:15	River, above Bijou creek	......	....	278.45	59.45	5.75	10.34
11:55	Deuel & Snyder ditch	3.65	....	......	....	....	....
2:35	Platte & Beaver canal	77.28	....	......	....	....	....
12:05	River, below Bijou creek	......	....	152.09	-45.43	1.75	-25.96
3:50	Platte & Beaver Supply canal	71.90	....	......	....	....	....
4:05	River, below P. & B. Supply canal	......	....	131.54	51.35	8.00	6.42
	OCTOBER 21.						
9:10	Parson ditch	4.95	....	......	....	....	....
10:05	Smith ditch	9.06	....	......	....	....	....
10:15	River, at Snyder	......	....	142.37	24.84	5.75	4.32
1:30	River, below Big Beaver creek	......	....	149.63	7.26	5.75	1.26
5 p. m.	South Platte ditch	60.01	....	......	....	....	....
	OCTOBER 22.						
8:25	Pawnee ditch	99.55	....	......	....	....	....
9:20	River, at Merino	......	....	41.48	51.41	12.25	4.20
10:50	Schneider ditch	20.33	....	......	....	....	....
11:40	Springdale ditch	22.66	....	......	....	....	....
1:20	River, above Pawnee creek	......	....	20.80	22.31	9.00	2.48
3 p. m.	River, below Pawnee creek	......	....	24.32	3.52	1.75	2.01
4:20	Henderson and Smith ditch	2.08	....	......	....	....	....
	OCTOBER 23.						
9:45	River, above Cedar creek	......	....	30.36	8.12	10.00	0.81
11:30	Iliff & Platte Valley ditch	4.14	....	......	....	....	....
10:35	River, below Cedar creek	......	....	35.93	9.71	1.50	6.47
3:50	River, 2½ miles above Crook	......	....	36.07	0.14	17.25	0.01
	OCTOBER 24.						
8:20	River, at State line	......	....	1.90	-34.17	36.00	-0.95
	Totals	......	....	......	301.19	152.25	....

MEASUREMENT No. 7—Made by L. G. Carpenter and P. J. Preston to Sterling, and by P. J. Preston and R. E. Trimble from Sterling to Julesburg, October, 1895.

Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
OCTOBER 21.						
Cache a la Poudre river	......	123.02	......	....	....	....
River below the Poudre	......	....	826.55	....	....	....
Lone Tree creek	......	5.24	.....	....	....	....
OCTOBER 22.						
Hoover ditch	6.07	....	......	....	....	....
River below Hoover ditch	......	....	939.95	114.23	3.50	33.0
Hoover ditch	......	4.47	......	....	....	....
Sterling Seepage ditch	......	(3.86)	......	....	....	....
Box Elder	......	0	......	....	....	....
Illinois ditch	0	....	......	....	....	....
River above Hardin ditch	......	....	909.15	-35.27	4.50	-8
Hardin ditch	6.74	....	......	....	....	....
OCTOBER 23.						
Corona ditch	10.00	....	......	....	....	....

GAGINGS OF THE SOUTH PLATTE RIVER.

(In cubic feet per second.)

MEASUREMENT No. 7—(Continued).

Place of Measurement.	Out-take.	In-flow.	River.	Gain.	No. of Miles.	Gain per Mile.
River above Putnam ditch	......	....	935.36	42.95	12 25	3.5
Lost creek	......	0	......	....	....	....
Putnam ditch	14.38	....	......	....	....	....
Kiowa creek	......	0	......	....	....	....
Weldon Valley ditch	86.85	....	......	....	....	....
OCTOBER 24.						
River at Orchard	......	....	940.73	106.60	8.25	12.92
Seepage ditch	......	(4.10)	......	....	....	....
Fort Morgan canal	208.28	....	......	....	....	....
River, at Shaffer's ford	......	....	778.37	45.92	9	5.10
OCTOBER 25.						
River, above the Bijou	......	....	861.85	83.48	5.75	14.50
Bijou creek	......	(4.84)	......	....	....	....
OCTOBER 26.						
Platte & Beaver canal	100.39	....	......	....	....	....
Deuel & Snyder ditch	14.70	....	......	....	....	....
River, at Fort Morgan	......	....	745.21	—3.97	4.25	—0.93
Pyott ditch	15.58	....	......	....	....	....
Platte & Beaver supply	55.72	....	......	....	....	....
Smith ditch	2.88	....	......	....	....	....
River, at Snyder	......	....	685.85	14.82	11	1.35
OCTOBER 27.						
River, 5 miles below Snyder	......	....	751.23	65.38	5	13.08
Tetsel ditch	.90	....	......	....	....	....
Johnson and Edwards ditch	18.06	....	......	....	....	....
South Platte ditch	4.80	....	......	....	....	....
Pawnee ditch	129.00	....	......	....	....	....
OCTOBER 28.						
River, at Merino	......	....	691.63	93.16	13	7.17
Schnieder ditch	14.60	....	......	....	....	....
Springdale ditch	38.59	....	......	....	....	...
Sterling No 1 ditch	10.63	....	......	....	....	....
Smith and Henderson ditch	2.97	....	......	....	....	....
OCTOBER 29.						
River, at Sterling bridge	......	....	671.64	46.80	13.75	3.40
Iliff ditch	0	....	......	....	....	....
River, at Iliff	......	....	688.63	16.99	9.25	1.84
OCTOBER 30.						
Powell and Dillon ditch	3.04	....	......	....	....	....
McPhee and Mullins ditch	10.42	....	......	....	....	....
River, at Crook	......	....	626.12	-48.05	19.00	—2.53
NOVEMBER 1.						
Henry Fuller ditch	3.07	....	......	....	....	....
South Side Res. Co. ditch	2.37	....	......	....	....	....
Tom Little ditch	(2.19)	....	......	....	....	....
River, at Pole creek	......	....	633.23	14.75	24	.61
OCTOBER 31.						
River, at State line	......	....	585.60	-47.63	9.50	—5.01
Total	......	....	......	....	152.25	....

TABLE IV.

SUMMARY OF PRECEDING TABLES, SHOWING GAIN IN SEEPAGE OF SOUTH PLATTE RIVER.

(In cubic feet per second.)

	No. of Miles.	Oct. 1889.	Oct. 1890.	Oct. 1891.	Mar. 1892.	Oct. 1893.	Oct. 1894.	Oct. 1895.	Ave.
Mouth of Poudre to Hardin ditch	8	49.0	68.7	75.5	69.1	69.0	23.9	79.0	62.0
Hardin ditch to Putnam ditch.........	12	....	-18.8	16.6	45.4	-33.7	50.5	43.0	17.2
Putnam ditch to Fort Morgan canal....	14	51.3	27.0	15.3	29.5	°60.8	°68.3	°152.5	57.8
Fort Morgan canal to P. & B. canal ...	11	....	6.5	38.3	*72.7	50.3	65.4	....	46.6
P. & B. canal to Snyder.................	14	....	17.1	98.2	....	15.0	24.8	94.3	49.9
Snyder to Merino........................	18	79.6	21.3	-20.3	....	34.7	58.7	158.5	55.4
Merino to Sterling......................	14	32.8	29.7	33.4	...	33.8	†25.8	46.8	33.7
Sterling to Iliff	9	4.4	14.0	28.1	....	24.8	17.8	17.0	17.7
Iliff to Crook...........................	17	....	....	-13.1	....	....	0.1	-48.1	-20.3
Crook to State line	36	....	....	3.3	....	....	-34.2	-32.9	-21.3
Totals......	151	217.1	165.5	275.3	216.7	254.7	301.1	510.1	298.7
Average per mile........................	..	2.2	1.7	1.8	1.6	2.6	2.0	3.4	2.0

*Opposite Fort Morgan. °Schaefer's Ford. † Below Pawnee.

§ 24. We also include the results of the measurements on the Upper Platte, from the canon, 22 miles above Denver, to the mouth of the Cache a la Poudre, a total distance of 74 miles. The measurements were usually made continuous with those of the Lower Platte, though here given separate. In 1895 they were made after the Lower Platte was completed. These measurements were made under direction of the various State Engineers, with the exception of the first, which was made under direction of Col. E. S. Nettleton in connection with the U. S. Irrigation Survey.

TABLE V.

SEEPAGE INCREASE OF THE UPPER SOUTH PLATTE FROM CANON.

(In cubic feet per second.)

	Distance in Miles from Canon.	Oct. 18. 1889	Oct. 14, 1890.	Oct. 23, 1891.	Mar. 7, 1892.	Oct. 30–Nov. 1893.	Oct. 29–Nov. 4, 1894.	Nov. 1895.	Average.
To head of City ditch................	6	....	8.95	27.6	26.0	18.4	49.2	19.4	24.9
" Littleton	12	59.30	18.9	83.2	73.9	50.1	84.6	80.4	64.3
" Denver	22	64.1	70.8	105.0	137.4	94.9	221.6	198.2	127.4
" Fulton ditch	28½	....	110.4	146.5	149.4	138.8	256.0	179.0	163.3
" Brighton	35½	91.6	115.8	184.8	124.5	164.6	306.0	214.1	171.6
" Elwood and Wheeler ditch.......	44½	133.6	191.3	228.3	145.7	220.4	342.6	272.0	219.1
" Platteville......................	51½	147.9	...	236.5	189.9	230.6	371.0	336.8	252.1
" above St. Vrain..................	56½	....	172.7	242.9	....	....	....	....	(207.8)
" Union ditch	60½	161.4	....	....	....	264.5	426.6	357.5	302.5
" Latham............................	68	211.5	192.8	308.8	202.7	291.7	478.4	381.1	295.3
" Cache a la Poudre river...........	74	260.*	232.1	335.7	226.0	329.9	501.8	438.3	332.0

*Interpolated.

The sums given in this table will be found to differ from those given in the reports of the State Engineer. In many cases the seepage collects in side channels, and runs to the river. Where there is good reason to know that it is seepage, it seems better to include this as a part of the seepage inflow of the river. The examination of numerous channels has shown that in almost all cases they are dry above the lines of the ditches. In some cases waste from irrigation and from ditches, not seepage, also reaches these channels. As a rule, along the line of the Platte, there is little wasted, especially at the time of this measurement. To eliminate the waste, the inflow from the same channel was compared in the various years, and in cases where unusually large, the excess is counted as waste. The inclusion of these lateral inflows causes an increase of the amount by about twenty feet on the average to the mouth of the Poudre.

RELATION TO AREA IRRIGATED.

§ 25. If the water returned comes from the water applied in irrigation there should be a relation between the amount of water applied and the amount returning to the river as seepage. There should also be a relation between the area irrigated and the amount of return. There are so many interfering conditions, that we cannot expect to find the relation a very close one, even had we the means to know the total area, or the total amount of water applied, with accuracy. A portion of the water applied raises the water table or the height of the water in the soil. The land newly irrigated gives no material return for several years, as most of the excess of water applied fills the subsoil. If the land is some distance from the river the element of time also enters. In the case of the Poudre river, there have been many seepage ditches constructed for the purpose of taking the seepage water before it reaches the river, and again applying it to the land. In the aggregate they use a considerable number of second-feet. The increase as shown in the tables should be increased by the amount thus used. The relation between the seepage and the area irrigated will be obscured by these and other causes. The return for any one year is not from the water applied in that or in any other one year. It is rather the result of the applications of several different years at different distances. Hence, while the amount varies from year to year, the variation from one year to another is less necessary to take into account as the strip irrigated becomes of greater width. In the case of the Poudre valley and also in the Platte, the area under irrigation has steadily increased since the first measures were made. The total amount irrigated in the Poudre valley may be considered as between 120,000 and 135,000 acres. The latter sum was used in bulletin No. 22, on the "Duty of Water."

Table VI. gives the data regarding the principal ditches in the valley, and is given in full to show the character of the land devoted to agriculture. In this table, column 3 includes the total amount of land supplied with water rights under the canals. The waste and pasture land includes much that is not irrigated, and some that is. Hence the difference, given in column 11, is really less than the area irrigated, if the figures are otherwise correct. The area shown by this table as irrigated in 1894, exceeded 116,000 acres. In the previous year it was less. The increase amounted to several thousand acres per annum, principally under the outer ditches, and at the lower end of these canals. The drainage from a portion of this area does not enter the Poudre, but instead it enters the Platte directly, and through the Lone Tree and Crow creek valleys. This seepage has amounted to probably not less than from twelve to twenty second-feet during the past few years, but is included in the seepage of the Platte and cannot be separated. But, considering that all this area is tributary to the Poudre, we have from 116,000 acres a return of 104½ cubic feet per second on the average, or one cubic foot per second from each 1,100 acres irrigated. The seepage known to be caught and stored in reservoirs is more than enough to make the return one cubic foot per second for less than 1,000 acres. In 1895 it amounted to one cubic foot per second to every 700 acres. In the case of the Platte, one cubic foot per second returns from still fewer acres.

TABLE VI.

Reference Number.	Name of Canal.	Total Acres.	Pasture and Waste Land.	Acres Alfalfa.	Grass.	Other Crops.	Wheat, Oats and Barley. No. of Bushels.	Corn, No. of Bushels.	Potatoes, No. Sacks.	Total Acres, Less Waste and Pastures.	Amount of Water Applied, 1894. Acre-feet.
(1)	(Col. 2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	N. Poudre canal	9.074	7.081	843	795	2.430	63,626	3,775	5,687	1.993	18,306
2	Box Elder canal	1,280	1,000	50	....	100	1,200	25	200	280	.....
3	Canon	497	197	160	5	90	427	300	500	300	.....
4	Larimer Co.	27,844	11,131	4,010	....	12,847	120,838	4,075	113,795	16,713	27,830
5	Jackson ditch......	3,160	991	1,131	223	453	5,246	....	350	2,169	7,984
6	Small ditches, n. side	2,054	453	786	145	886	4,542	100	2,770	2,101	....
7	Larimer & Weld.....	59,507	15,123	7 428	878	32,182	390,601	6.702	554,303	44.384	77,225
8	Pleasant Valley & L.	8,221	3,110	1,750	470	2.234	19.746	1,972	3,655	5,111	17,387
9	New Mercer	4,256	1,867	1,664	174	1,020	48,015	2,032	13,448	2,389	11,110
10	Larimer Co. No. 2..	8,623	985	2,751	61	2,680	56,191	280	10.389	7,638	18,545
11	Fort Collins.........	1,179	374	492	45	387	1,944	65	860	805	.....
12	Box Elder	1.735	1,028	270	144	351	3.178	95	3.184	707	.....
13	Watrous, W. and S..	120	75	20	....	25	......	....	600	45	.....
14	Ames, P. and C. d's.	1,468	1,303	409	295	646	17,036	1.755	11,070	165	.....
15	Lake	6.242	2,076	1,007	156	1.762	36.698	3,855	23,280	4,166	11,262
16	Cache a la P. No.2..	33,173	11,128	5.032	704	15,065	236.689	3,670	602.485	22.045	70,610
17	Whitney	2,080	683	358	55	652	10.461	100	17,500	1,397	.....
18	Eaton and Jones....	360	149	75	119	135	1,900	250	2,240	211	.....
19	No. 3	1,275	480	147	103	517	3,015	....	14,652	795	.....
20	Boyd and Freeman..	900	158	90	350	300	3,150	300	7,000	742	.....
21	Ogilvy	3,800	1,728	720	....	1,357	20,755	....	29,660	2,072	.....
	Totals	176,848	61,120	29,193	4,722	76,119	1,045,258	29,351	1,417,628	116,228	260,259

§ 26. The foregoing table shows the distribution of the irrigated land, and of the water applied in the valley, according to the canals. The record is taken from the figures obtained by Water Commissioner Tenney in 1894, and include the first complete data for the entire valley. The data gives nearly the relative quantities, and is far better than other records available. Some of the figures will be referred to later.

§ 27. On the Lower Platte the extent of the irrigated area is not so well known as on the Poudre. This portion of the valley includes two districts—Water District No. 1, from the mouth of the Poudre to the east line of Morgan county, just below the head of the Tetsel ditch, and No. 64, from that point to the State line. In the report of the Commissioner for district No. 1, for 1890, the total amount irrigated is given as less than 11,000 acress. In 1892 it is given as 43,730 acres. This latter is probably excessive. The amount is reported in 1895 as practically the same, distributed among the ditches as follows:

	Acres.
The Hardin ditch	525
The Hoover and Illinois ditches	720
The Putnam ditch	1,875
The Weldon Valley	6,250
The Fort Morgan	12,600
The Platte & Beaver	14,080
The Platte & Beaver Supply	9,500
Deuel & Snyder	1,000

In district 64, through the courtesy of Mr. Patterson, the Water Commissioner for that district, we are given the following approximations:

	Acres.
South Platte ditch	3,500
The Pawnee	4,700
Schneider	2,600
Sterling Irrigation Co.	4,400
Henderson and Smith	1,275
Sterling No. 2	1,800
Low Line	1,900
Springdale	3,200
Powell and Dillon	930
Iliff & Platte Valley	5,000
Small ditches	6,000
Or a total of	35,000

This makes a total acreage for the valley of about 75,000 to 80,000 acres. With an average inflow of 340 cubic feet per second from the mouth of the Poudre river to Iliff, this is an inflow of one cubic foot per second from 220 to 240 acres irrigated. This is far more than in the case of the Cache a la Poudre. It is to be noticed that in the case of the Platte, a relatively large proportion of the irrigation is given to the bottom lands, which are used for hay. The principal exceptions are in the vicinity of Fort Morgan and Sterling. The river overflows the bottoms many years, and did so in 1893, 1894 and 1895, and soaks them with water sometimes for a considerable period. More water is applied in the bottom irrigation than in the uplands. The practice of fall irrigation is very extensively followed. The river then having sufficient water, all the lands with few exceptions are soaked. We do not have measurements to show how much water is thus applied, but from what I observed, and from the conditions, the watering seems to be relatively a very profuse one. This land receives more water than an equal area on the Poudre, and is, as a whole, much closer to the river. These conditions tend to give a more profuse and a speedier return to the Platte.

On the Upper Platte, the conditions have not been under observation, and the areas are not well known. The seepage of fully half a million acres drains into this portion of the Platte and the tributaries which flow into it. In the cases of the latter, the construction of numerous seepage ditches have interfered with the natural flow of the water, so that the amount which reaches the river is much less than the total amount of seepage. A portion of the land irrigated from these lateral streams drains directly into the Platte. This is especially the case with Clear creek. According to the reports of the Superintendent of Irrigation of this division to the State Engineer, there have been, using round numbers, 58,000 acres irrigated in district No. 2, including the Platte from Denver to the mouth of the Poudre; 39,500 in district 8, which includes the Platte from Denver to the canon. This is a total of 98,000 acres irrigated directly from the Platte. In addition to this there are about 45,400 acres draining into the Platte which are irrigated from Bear creek, Clear creek, St. Vrain and Big Thompson, making a total of 143,000 acres lying along the Platte and tributary thereto. This sum is rather above than below the truth. Comparing with the total inflow, we have an average return of 332 cubic feet per second from 143,000 acres, or one cubic foot per second from 430 acres.

During the first four measurements the average return was 264 second-feet, and during the last three, 423 second-feet. The latter is at the rate of one second-foot for each 238 acres. It is certain that many acres of the land in this valley returns but little water to the stream. Whether the rate of increase noted in the table from year to year will continue, further measurements are necessary to determine.

RELATION BETWEEN SEEPAGE AND AMOUNT OF WATER APPLIED.

§ 29. An attempt was made to determine the amount of land the drainage of which enters each of the lateral channels and enters the river between the points of measurement, thinking that this might explain some of the exceptional gains. But still better is the amount of water which is applied, if it can be known. A manuscript map was prepared, showing the location of the water rights in the principal canals. A water right usually includes the right to the water for 80 acres. From this map a table was prepared, showing the number of rights draining into the river between the different points of measurement. From the amount of water used by the different ditches during the year, as shown in Table VI., this could be expressed in acre-feet of water, or in the number of acres which would be covered by the water one foot in depth. The inflow can not be expected to be very closely proportional to the area irrigated or the amount of water applied between these points, or not until after a series of years. The return is slow, and there is reason to think that the seepage from some of the outer ditches has not yet reached the river. The construction of seepage ditches, to drain the seepage water from the water-logged land, or to catch the seepage water, also interferes with the normal distribution. They collect and carry the water sometimes a number of miles from where it appears. The effect of the seepage ditches is to increase the apparent return near the lower end of the stream. The amount of water lost from the canals is much more than from an equal area of irrigated land. An area of one acre forming part of a canal channel loses as much water as 200 to 400 acres of land under ordinary irrigation. The losses near the heads of the canals, especially those near the mountains, is greater than the average. An estimate of the number of acres of canals would be desirable before the study can be completely satisfactory.

From Table VI., we find 260,000 acre-feet of water is applied to 106,000 acres. This includes loss and waste from the canals, and is equivalent to a depth of 2.45 feet over the entire area irrigated. If this depth were applied by the smaller canals too, we have 284,000 acre-feet applied in the whole valley.

As a rule, the smaller canals have earlier appropriations from the river, and therefore use water more freely; hence it is safe to assume that at least 284,000 acre-feet of water have been applied to the irrigated area. The amount of water which is applied is affected by the stage of water in the river. When the river is high the canals are full, water is unstinted. If low, the amount used is decreased. In this case the ditches of later construction are the first to suffer. The development of storage reservoirs has increased the amount applied late in the season, especially since 1892. At present the reservoirs already in use in the valley of the Cache a la Poudre have a storage capacity of about 48,000 acre-feet. Of the 284,000 acre-feet applied to the whole valley, about 35,000 acre-feet is applied so that it drains into the channels running into the Platte. Deducting this, as it does not affect the inflow into the Poudre, we then have an inflow reaching the Poudre of 104 cubic feet per second, from an application of 250,000 acre-feet, or a constant flow of one cubic foot per second from each 2,400 acre-feet applied. The amount is actually greater than 104 second-feet, because of the amount, at present unknown, which is caught by the seepage ditches. As one cubic foot per second corresponds to 724 acre-feet in the course of a year, there is a seepage return of 724 acre-feet from 2,400 acre-feet of water taken from the river. If the seepage from the outer canals has not yet reached the river, then an actual application of much less than the 2,400 acre-feet gives the observed return. What the exact proportion is cannot be determined in this valley for some years to come, after all the land irrigated furnishes its portion of the seepage to the stream.

§ 30. Bringing together the amount of increase in different parts of the Cache a la Poudre and the area of irrigated land which drains into the same section, we have Table VII. In the third column is given the amount of water applied to that portion of the valley whose natural drainage is into the river between the points indicated in the first column In the fourth column is given the per cent. of the total amount applied to the whole valley. In the column headed "Computed inflow" is given the amount of inflow there would be if the inflow were in exact proportion to the amount of water applied. How much land will furnish underflow to a given part of the river cannot be very closely told, even with detailed knowledge of the topography and the location of the farms where water is applied. The course of the underground drainage can be told in most cases, until the river bottom is reached. Thence the channels often end in sloughs, and sometimes follow old river channels, or the water is collected in seepage ditches, which carry it sometimes for considerable distances. From our present maps the limit of the drainage areas cannot be told with sufficient accuracy to make the areas and the amount of water applied, given in the third column, anything but an approximation. The table shows, however, that the relation is close enough to be more than accidental, and in future years, when the influence of the outer area begins to be felt, may be expected to be closer.

It shows that there is a reason for the large amount of increase observed in the last few miles of the Poudre, before it empties into the Platte.

In the case of the increase from the No. 2 canal to the Pump house, and from the Pump house to the Ogilvy ditch, it may be stated that a portion of the drainage above the Pump house enters the bottoms above that place, and does not enter the river until below that point. While the water applied is counted in the section above the Pump house, the seepage is included in the section below. It has not been possible to estimate this, and it is therefore noted as a disturbing condition. Likewise, some of the seepage which should enter the next section between the Pump house and the Ogilvy ditch, enters the river lower down.

TABLE VII.

	Distance in Miles.	Water Applied.		Average Inflow from Seepage.			
		Acre-feet.	Per Cent. of Total.	No. Years Observation.	Observed.	Computed.	Observed gain per Mile.
Canon to L. & W. canal..........	7.25	18,400	7	9	15	8	2
L. & W. to No. 2 canal............	10.10	51,800	21	9	21	21.6	2
No. 2 to Eaton canal....	3.0	37,000	15	..	....	....	....
Eaton to No. 3....................	9.0	30,300	12	..	....	....	....
No. 3 to Pump house, Greeley....	3.0	46,700	18	..	....	....	....
No. 2 to Pump house, Greeley....	15.0	114,000	45	7	28.6	48	2
Pump house to Ogilvy ditch......	2.5	23,100	9	8	19.2	10	8
No. 2 to Ogilvy ditch.............	17.5	137,100	55	9	45.2	57	2.5
Ogilvy to mouth of Poudre.......	4.0	42,700	17	8	23.8	18	6
Beyond mouth of Poudre.........	....	38,000	..	..	....	....	....

THE EFFECT OF TEMPERATURE ON THE INFLOW.

§ 31. The effect which temperature might have upon the amount of inflow was not considered of any importance until the unexplained differences caused a consideration to be given to its possible effect. It is known that low temperatures increase the viscosity of water. The effect is especially noticeable in the flow through small tubes, so much so that five times as much water will pass through a capillary tube at 200° as at 32° F. The effect has been noticed on the amount collected by drains, and in varying the discharge in cases like those of the gathering pipes of the Denver Water Co., in the bed of Cherry creek. A comparison between the soil temperatures at the Colorado Agricultural College and the inflow into these gathering galleries has been made in bulletin 38 of the Utah Experiment Station. As our measurements of the seepage were nearly all taken in the same month, it was not thought that the difference of temperature would be sufficient to affect the quantity of flow. But it may have a much greater effect than was at first thought probable. The water-carrying stratum lies at different depths, and is of different thicknesses. Its temperature therefore varies. Besides, the descending water carries down the temperature of the surface to some extent. Still, the indications of the soil thermometers may be taken to show the variations in the temperature of the seepage water at the time of gaging, and hence give the means of estimating the effect of temperature.

The readings of the soil thermometers will not be far from the temperatures of the soil at the corresponding depths throughout the Cache a la Poudre and the Platte valleys. There are three sets of thermometers: One in well-drained irrigated soil; one in low, undrained irrigated soil, the water standing within six feet of the surface; and one in well-drained unirrigated soil. At a depth of six feet the variation during the year is from 20° to 24°, being least in the low ground. At three feet in depth the range is 32°. At six feet the highest temperature of the year is reached early in September, the lowest early in March. Its temperature thus lags six or eight weeks behind the temperature of the surface. At three inches depth the annual range is about 70°. With the range of temperature at the depth of six feet, other conditions remaining the same, one-third more water would flow in August than in March, and at a depth of three feet, nearly one-half more.

But as the gagings of the different years were made at almost the same time, the difference in temperature is comparatively small, and the effect in different years for the same month will be less marked. Nevertheless it is not insignificant.

The table shows the average temperature at three and six feet depth during the time of the gagings of the Poudre river, and the amount of inflow found is shown in the fourth column.

Had the temperature been uniformly 60° instead of that observed, the amount of seepage would have been that given in the last column. This is under the supposition that the temperatures at three and six feet in depth from the surface will be the most influential. The correction is obtained by determining graphically the co-efficients of viscosity from the co-efficients, at 32°, 50°, 68°, etc.†

TABLE VIII.

TEMPERATURE OF SOIL AT 3 AND 6 FEET BELOW SURFACE, AND ITS EFFECT ON SEEPAGE.

Year.	Thermometers. Set A.	Thermometers. Set B.	Am't of Seepage in Poudre River.	Am't Corrected for Temperature of 60°.	
Oct., 1889	57.8	59.4	99.0	101	Set A in dry, well-drained irrigated soil.
Oct., 1890	58.7	56.2	100.8	104.8	Set B in low ground, water standing within six
Oct., 1891	55.7	54.9	84.6	90.4	feet of the surface.
Mar., 1892	38.9	40.0	*96.	122.0	
Oct., 1892	60.4	59.9	101.6	101.4	
Nov., 1893	51.5	53.4	98.7	108.6	
Mar., 1894	36.2	37.9	82.3	107.2	
Aug., 1894	64.3	62.5	118.2	113.5	
Oct., 1895	52.2	52.3	164.4	187.4	

* To Ogilvy ditch.

The amount of return throughout the year is sensibly the same, the principal disagreement being the one for March, 1892, when the gain in less than the full distance would have been 122 second-

† Daniell's Physics, p. 306.

feet, and in 1895, when the gain was much greater than in previous years. The large gain corresponding to March, 1892, is probably due to the fact that this measurement was taken immediately following a storm, which had covered the ground with snow, and, slowly thawing, had filled the surface of the soil. Such a case as has been shown by King, makes its influence felt at once on the underground water, even though the intermediate space be dry. The return for 1891 is less than the average amount. There is a doubt concerning that gaging. The measurements of the lower part of the stream from the Pump house, at Greeley, to the mouth of the Poudre, were made by Messrs Hope and Trimble, who continued down the Platte, while the upper ones were made by other parties. The results of the lower party were taken and compared with those of the upper. It is possible that the interval of one day, or the use of different meters, may have had some effect.

There is a sensible increase after allowing for the effects of temperature.

RAPIDITY OF FLOW OF SEEPAGE OR UNDERFLOW WATER.

§ 32. Inquiries for information regarding the movement of underground waters is so frequent, that though it was not intended to say anything on the subject in this bulletin, it is desirable to give a brief statement of the facts as they appear to be.

Direct evidence of the speed with which water passes through any considerable distance underground is almost entirely wanting. Attention has been awake to evidence bearing upon the question, but in the course of extensive travels over much country for some years almost none has been encountered. Cases where lands have been seeped subsequent to the construction of a ditch have been sought, but most cases have been complicated by other conditions, which make the answer anything but conclusive. Subsequent experience has also led to the conclusion that the appearance of seepage may give very unreliable testimony. For example, on the grounds of the Colorado Agricultural College a well was sunk about 200 feet from a canal and about ten feet lower. In the course of some measurements on the well, it was found that whenever water was turned in the ditch the water began to rise in the well within twelve hours. There is every reason to doubt that water passed that distance in that time. The case is similar to that where water is turned in a hose. If the hose is already full of water, water immediately begins to run from the lower end. If the hose is empty, some time will be required to fill the hose before the water begins to run. If already full, the pressure is transmitted in very short time, and the increase which is seen very often in the flow of seepage when water appears in a neighboring canal may be due to the transmitted pressure, rather than to the direct passage of water.

Where there is a periodical change in the head supplying the water, as in the case of the canals, there may be a series of underground waves affecting the height of the ground water. The rise and fall of such a wave, which started years before, may be mistaken for the rise and fall due to the periodical rise in the canal.

Thus the case of the Natron ponds, which rise in March, and are located thirty-five miles from the Nile, and which Storer (*Agriculture*, 1:56) attributes to the rise of the Nile of the previous September, is probably such a case.

§ 33. The best case met with was near Montrose. A deep gulch starts in the mesa below the Montrose canal. Passing across this depression the glistening in the moonlight of the alkaline deposit on the shale at the bottom attracted my attention, and on inquiry it was learned that this began to show slightly two years after the canal was used, and in considerable quantity in three years. The distance from the canal is three miles. This would make the speed about one mile per year.

§ 34. Direct experiment on the rapidity under field conditions have been unsatisfactory or inconclusive. Col. E. S. Nettleton, as Chief Engineer of the U. S. Irrigation Investigation for the Department of Agriculture, aided by W. W. Follett, attempted to determine the rapidity in the sands of Cherry creek, and on the Rio Grande, but with inconclusive results, except to come to the conclusion that the velocity was very slow. *

In the sands of the Fountaine qui Bouille, Mr. D. C. Henny concluded that the water had a velocity of about seven feet per hour. † The method of arriving at this determination is not given. From other evidence it would seem to be excessive.

Water Commissioner J. T. Hurley, of Orchard, reports that under the Weldon Valley canal the seepage has progressed one and one-half miles in five years. In one case under the Larimer County canal, according to Mr. N. C. Alford, it was five years before seepage showed at a distance of forty rods from the canal, though the slope was considerable. In one case near Greeley, according to Mr. S. A. Bradfield, it seems to have taken about ten years to go two and one-half miles.

§ 35. The rate is certainly slow, and observers throughout the State whose attention has been called to it now agree upon its small progress. A few years ago most of them believed in a rapid flow, as still do most of the adherents in the belief that there is a great "underflow" under the plains.

Comparison with familiar facts would lead one to expect slow progress. The water in passing through sand and gravel must

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* Final report Artesian and Underflow Investigation; Pt. 2, p. 34.

† Quoted by J. D. Schuyler, report as consulting engineer to the Pueblo Gravity Water Co.

pass through small openings, which form a series of minute, tortuous and long tubes. It is a fact of common observation that the pressure of water is much reduced by attaching a short length of hose or pipe. In the case of flow through sands, the openings are many times smaller, and the length may be very great, hence no matter how great the fall, the effect of the pressure is throttled by the friction.

§ 36. In the lack of direct field evidence, we need to resort to laboratory experiments. An accomplished French engineer in investigating the water supply for the city of Dijon, experimented upon the flow through sand. He used a cast iron tube twelve feet long and twelve inches in diameter filled with sand, measuring the amount of water which passed through under different heads, and determined the relation between the pressure and the velocity. *

§ 37. From the experiments of Darcy developed by Dupuit †, it is found in minute channels the velocity varies directly as the head, and may be expressed by the equation,

$$v = k\,i$$

in which v represents the velocity, i the inclination (being the head or fall in a given distance divided by the distance), and k a factor which varies with the kind of soil, size of interstices, etc. This factor varies widely in different soils. It can be determined by experiment in specific soils, and the results there obtained applied to others of similar character.

Table IX. is an attempt to put into tabular form, which will be practically useful, the value of the factor k for different cases. The table gives the factor by which the rate of inclination or grade (expressed by the fall in feet divided by the distance in feet) is to be multiplied to give the velocity in feet for the unit of time given in the corresponding column. The table is made from data obtained from the filters of London, Paris and Berlin, through Professor Nazzini, of Rome. ||

§ 38. Since water is more viscous at low temperature than at high, the formula given in § 37 should evidently include a factor depending upon the temperature. From the experiments of Poiseulle ‡ this factor would be $1+.00187\,(t-32°)+.00007\,(t-32°)$, for any other temperature than freezing.

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* Darcy, Les eaux publiques de la ville de Dijon.

† Traîte de la conduite et de la distribution des eaux. Darcy and Dupuit I have not had the opportunity to consult at first hand.

|| Idraulica pratica, 1:608.

‡ Recherches experimentales sur le mouvement des liquides dans les tubes de tres petite diametre. Quoted, Jamin et Bouty, Physique, tome 1, pt. 2, p. 100; also see Daniell's Physics, p. 308.

TABLE IX.

TABLE FOR VELOCITY OF FLOW THROUGH PERMEABLE SOILS.

Values of k in formula, $v=k\,i$, for different units of time: v is velocity in feet; i is the inclination or fall in feet per foot.

Kind of Material.	Size Grains, in Inches.	Voids, Proportion of.	Velocity.			
			Per Second.	Per Hour.	Per Day.	Per Year.
Minute Gravel	.08	0.41	.024	86.47	2075	757520
Coarse Sand	....	0.38	.0026	9.33	224	81730
Fine Sand	.008	0.35	.00047	1.69	40.5	14777
Sandy Soil	....	0.30	.00022	.79	18.9	6897
Sandy Clay	....	0.25	.00012	.42	10.2	3725
Clay	....	0.20	.00003	.12	2.8	1035
	....	....	.00008	.295	7.1	2587

Example.—What distance will water pass through coarse sand in a year, inclination about 1 in 100?

Here i=1-100. If the sand averages 1-10 inch diameter, without finer particles, it would approach what is here designated as minute gravel. In one year the distance would be the number 757,520 multiplied by the inclination, 1-100, giving a distance of 7,575 feet, or about one mile and a half. If in coarse sand, as here termed, a distance of about 800 feet.

If the movement is downward, then i is 1. If there is a head in addition, then i may be greater than 1.

§ 39. An opportunity to measure the loss by seepage from a canal, and, indirectly, the rapidity of passage of water through the soil, occurred at the time of making the seepage measurements. The Fort Morgan canal is of considerable size. It was measured about three miles below the headgate. Another measurement was made at a point 7.4 miles from the first, at the head of the old flume across Bijou creek. Two small laterals between were withdrawing water. This was measured and taken into account. For much of the distance the canal skirts the bluffs between the bottoms and the up-lands. For part of the way the soil is very sandy. At the first point of measurement the canal was carrying 208.28 second-feet; at the second point, 183.83 second-feet. The intermediate laterals withdrew 4.37 second-feet. Hence the loss, including seepage and evaporation, amounted to 20.08 second-feet. The evaporation from the surface, averaging forty-five feet wide, under the conditions of temperature of water and air cannot exceed one-fourth of one cubic foot per second, by use of formula in annual report of 1891.*

Practically, therefore, the whole loss is seepage. This stretch of the canal has not been cleaned for some years, except that in

* Annual report, Section Meteorology and Irrigation Engineering, Report Colorado Experiment Station, 1891, p. 51.

1895 some material was taken from the bed of the canal to strengthen the banks.

§ 40. A new section had been built on the same canal to avoid a long flume on the old line. Water had been running in the new portion for three weeks at the time it was visited. The total length of the new portion is 10,100 feet, including 400 feet of flume. A measurement was made of the water of this section, both at the upper and lower ends. Some water was running through the old flume. The amount decreased from 109.15 second-feet, to 97.67 second-feet, in passing through the new channel, or there was a loss of 11.48 second-feet. The new flume was so nearly water tight that its leakage may be neglected.

§ 41. In these two cases we may estimate the rapidity of the flow of water through the soil. In the first case, the loss of twenty feet took place in a distance of 7.4 miles. The average width of the channel was 45 feet, hence the area of the canal in this distance was nearly forty-one acres. The loss corresponds to a layer of water of 11.7 inches deep in twenty-four hours. As the water occupies a space of about one-third of the sand, its velocity through the sand is three feet per day. It is unquestionably true that the loss takes place at unequal rates in different portions of this stretch, so that this rate, as in those which follow, is an average one for the section considered.

In the second case, the loss was 11.48 second-feet in a distance of 9,700 feet of channel. The average width was forty feet, giving an area of nine acres covered by the water. This corresponds to the loss of a layer of water 2.53 feet deep over the whole area of the canal. For half of this distance the canal extends along the sand bluffs which line the west side of Bijou creek, and is from thirty to ten feet above the channel of the creek. It is in a compact material, some of which needed to be blasted in constructing the channel. On the east side of the creek, it passes through a loose sandy soil, which slopes about one per cent. toward the creek. From evidence since obtained from the canal superintendent, Mr. Dingman, it seems probable that the loss from the west side is small or is insensible. A hole bored under the channel, and within a few inches of the water, was perfectly dry. If the loss is from the east side only, the rate must by twice as great as if from both sides, or would correspond to a layer five feet in depth per day over this portion of the canal. This would correspond to a velocity through the sand of about fifteen feet per day.

§ 42. On the Hoover ditch, running at the base of sandy bluffs, but with the bottom of the ditch covered with a fine silt, the loss in a distance of 1,500 feet was at the rate of 1.2 feet in depth for twenty-four hours, or a velocity of 3.6 feet per day through the sand.

§ 43. On the Muzza canal, in Italy, the loss is equivalent to a layer 1.7 feet deep per 24 hours. The canal runs through an exceedingly pervious soil, and has a great fall.

The Naviglio Grande, of Italy, loses a layer of water ten inches deep. The Canale Martesana, a layer 1.5 feet deep daily. The three canals above mentioned have been built for some 700 years.

The Centreville and Kingsburg canal, in California, from data given by C. E. Grunsky, of San Francisco, loses an average of five feet in depth, for six miles, in twenty-four hours. In one particular mile, where the loss is excessive, because of porous soil as well as from the location of the canal, near the edge of a bluff, the daily loss amounts to a layer fifteen feet in depth. This is an extreme case. * Another case of a great loss occurred in the Cavour canal, of Italy, at the crossing of the Dora river. This was by an artificial embankment. At first the loss amounted to a layer nearly twenty feet in depth. This was afterward very much reduced by using muddy water and allowing the silt to settle, and fill and cover the surface.

If we consider that in each of these cases the water occupies one-third of the volume of the sand, the distance it flows in twenty-four hours would be three times the thickness of the layers noted above, or from 2.5 feet on the Naviglio Grande to 60 feet in the Cavour instance.

It may be said, in passing, that the amount of loss from the canals may be much reduced by the settlement of fine clay or sediment. In one case, in the Cache a la Poudre Canal No. 2, where the seepage had made a considerable area so wet as to be impassable with teams, a check built for other purposes, by causing the deposition of silt, was sufficient in a few years to lessen the seepage so that the land became passable.

Another instance, illustrating the same effect, was shown in a canal near Greeley. When first built, considerable damage was done from the raising of the ground water and flooding cellars in some parts of town. After a few years the cause of complaint disappeared, silt sealing the bottom of the canal. In 1895 sand was obtained from the bottom of the ditch, where the ditch crossed a ravine, and where there was a good deposit of sand suitable for building purposes. The top layers of the sand were partially cemented. Within a few months after water was turned in complaint arose regarding the influx of water into the cellars. Ten days after the water was turned out of the canal, the water began to

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* Since the above was in type, additional data, obtained through the courtesy of Mr. Grunsky, indicate losses of depths of 1.5, 1.7, and .6 feet, from stretches of the Kings River and Fresno canal; of 2.8, .25, and .4 from portions of the Fresno canal, and 1.2, 1.9, 3, 7 and 6.4 feet from certain laterals, the velocity through the soil being about three times as great.

go down in the cellars, falling about six inches in three weeks, and eighteen inches in a little over two months. A measurement of the amount of water in the ditch was made October 16, at the time of gaging the river, both above and below the point where the great loss was suspected. The quantity in the canal decreased from 25.86 cubic feet per second above the place, to 20.80 a little distance below, or a loss of 5.06 cubic feet per second. The total distance between the two measurements was forty-six rods. The total area of water surface was not noted, but with the increased breadth of the canal at the ravine crossing it is about one-half an acre. This would be equivalent to a depth of twenty feet, over the area wetted by the canal, in twenty-four hours.

SOURCE OF THE INCREASE.

§ 44. Whether the water forming this increase to the streams comes from the rainfall or from the waters applied in irrigation, is important to determine if possible. From the nature of the case, it is not possible to indentify the water, but a comparison of the increase between different regions of greater or less irrigation gives some basis for a conclusion. If the increase is partially or wholly from irrigation, it follows that the inflow will increase from year to year, as the amount of irrigation increases; that the lower reaches of streams will have a more regular supply; that the increase will show itself farther down stream, making it possible to gradually bring more land under cultivation; that many of the dry streams will become living ones; and that the damage which riparian owners in this and other States have claimed to be done by irrigation on the upper portions of the rivers will become less as time proceeds. If the inflow comes from and is due to the rainfall, then we cannot look for benefits of this kind, and those on the lower reaches cannot hope for a future lessening of the damages.

§ 45. Such gradual increase of the streams is common in countries with considerable rainfall, but the size of the streams and the invisibility of the small sources serve to mask it. The lack of measurements prevents the fact from being noticed. The rainfall in Colorado averages less than fourteen inches per annum. With this amount of rainfall, or with the rainfall of exceptional years, would there be any return to the stream without irrigation?

§ 46. There was no observation of the phenomenon before irrigation was practiced. But neither was there settlement. Irrigation was practiced for some years on the bottom lands before the use of water was sufficient to dry the stream bed, and thus make it possible to notice a small inflow, either by its effect on the volume of the stream, or by exposing the points of inflow. If there was any such inflow, it certainly was not sufficient to prevent the Platte from going dry in 1863 and other years. At the time of the first measurement of the Poudre by Col. Nettleton, in 1887, the increase amounted to eighty-seven cubic feet per second.

§ 47. Where there is abundant rainfall, there is no question but that it furnishes a supply to the streams through underground passages, with effects similar to those noticed in the measurements of these streams. The amount which thus percolates through the ground is the portion of rainfall remaining after the run-off and the evaporation have been supplied. We have no direct observations under our conditions to determine positively how much, if any, of the rainfall remains to supply the underground water of the soil. Lawes & Gilbert, of Rothamstead, have maintained a series of drainage gages for a number of years. In the twenty-two years, from 1871 to 1892, fifteen to sixteen inches of the rainfall passed through forty to sixty inches of soil, and joined the subsoil water. This would be available for springs, and doubtless largely increased the volume of the streams draining the country. This was out of a total rainfall averaging 29.95 inches. Hence it follows that some thirteen inches in the humid atmosphere of England was required for evaporation from the surface of the soil, which was left uncropped and free from vegetation.

§ 48. With a smaller rainfall, it is not probable that the evaporation would be less. The greater dryness of our climate, the greater amount and intensity of the sunshine, which heats the surface of the soil intensely, are conditions which favor evaporation. The uniform dry condition of the soil shows that there is none too much for the evaporation alone. Our average rainfall is but little more than the amount which was evaporated from the soil in England, and some of this runs directly to the streams. It does not seem probable that there can be any left for percolation into the subsoil, except under unusual circumstances. In 1895, when eighteen inches of rain fell, not much more than usual was available for evaporation and percolation, since with the heavier showers a larger proportion runs off.

That the inflow comes almost entirely from irrigation is shown indirectly by the well-known effect of irrigation upon the height of water in the ground. Before irrigation, the distance to water is generally great, and the quantity frequently scanty. The application of water in large quantities to the surface, as in irrigation, fills the subsoil when porous, and raises the level of the ground water as much as forty to sixty feet in some cases. This establishes a steeper grade to the surface of the water in the soil, and gives the conditions which causes the water to pass through the ground with greater rapidity, and also with larger cross-section, thus increasing the amount of flow from both causes. The great distance to the ground water before irrigation, the scanty supply, the low grade of its surface, would in itself show that the amount received from the natural rainfall is small, and if this furnishes any inflow at all to the streams, it must be but a small proportion of the amount at present furnished under the conditions introduced by irrigation.

§ 49. From the mountain water-shed of the Poudre river our observations show that from four to six inches of water runs off from the whole area during the course of the year.* From the plains included in the measurements reliable observations are lacking. From the curve shown, by F. H. Newell, in the report of the U. S. Geological Survey for 1892-3, the amount of run-off may be estimated as from two to four inches. The amount varies with the soil, the slope of the ground, and the character of the rainfall.

When the precipitation is in slight showers, nearly all the rainfall evaporates within a short time, without penetrating more than the surface of the soil. It requires a heavy rain to saturate more than the surface, and furnish some water for percolation. In the ordinary condition, a rainfall of two inches will penetrate not over ten or twelve inches. Heavier rainfalls within a short time are needed before there can be any percolation from the rain. On beds of pure sand most of the water immediately soaks in, and very little is lost either by evaporation or by run-off, hence it is that water is generally found at moderate distances from the surface in the sand hills. There have been but twenty-two months in eleven years of observation at Fort Collins in which the total rainfall in one month has exceeded two inches, and in only eleven cases has as much as this fallen in one week. If the rain falls rapidly a larger proportion runs off than when there is time to soak into the ground. The case most favorable to percolation which our records show is in 1895, when two rainfalls, each of 2.5 inches, followed each other with only a few days interval. The first one nearly all soaked into the ground. The second fell on a ground already saturated and nearly all ran off, causing unusually high water in the streams in consequence. There are only one or two other cases in which as much as three inches fell within a few days. But even here, the most favorable of the cases, if the ground is dry, which is its ordinary condition, there cannot be much percolation, and it is very doubtful if there is any.

If, however, the ground is already wet, as may be the case with the lands which have been irrigated, and the surface is loose and porous so as to absorb the rain as it falls, as is the case with cultivated lands, there is reason to expect that the rain will cause an increase in the underground flow. The rainfall alone, without the irrigation, would not cause it, and it is a consequence of the artificial conditions introduced by irrigation, and may properly be considered as due to irrigation. A portion of the unusual increase

*Annual reports, 1890, 1891, etc.

found in 1895 is probably due to this cause. The inflow for 1895 was sixty second-feet more than the average. The rainfall was over four inches more than the average. Yet the extra sixty feet throughout the year would be given by a depth of one inch over 40,000 acres. If this comes from the rainfall, we must conclude that but very little of the extra rainfall was effective. As irrigation water is applied more freely because the supply in the river is greater, it seems more probable that the larger amount is due rather to the more water used than directly to the greater rainfall, though at present the effects cannot be entirely separated.

§ 50. Direct evidence bearing on the question was sought in the Platte measurement of 1894, but with negative results. If there be any substantial increase from such source, then the channels which conduct the drainage from a large area should show some indications of it. There are a number of such channels leading into the Platte, each of which drains over 1,000 square miles. This is more than the mountain water-shed of the Poudre river above its exit from the mountains. As the surface of the rock or impermeable surface has the same undulations as the surface of the ground, the underground drainage must follow essentially the same lines of drainage as the surface. This is shown plainly in the excellent sections taken at various points across the plains by Col. Nettleton and Mr. Follett.* One of these sections was across the valley of the Platte at Sterling.

The streams following these drainage lines, while permanent near their upper ends, are almost never flowing near their outlets into the Platte. It has generally been believed that these streams furnish much water to the Platte through the sand of their beds, and it has been a favorite article of belief among the adherents in the underflow idea. If this be the case, it ought to be shown by taking a measurement of the river above the mouth of the stream and below, far enough apart to include the bed of sand forming the channel. Even if the increase is not noticeably great, the rate of increase might well be expected to be greater than for the average of the stream.

§ 51. In order to test the question, I instructed the observers, in 1894, to measure the river above the important drainage channels, and also below. This was done by Messrs. Trimble and Preston, with the results shown in the detailed tables, and brought together in Table X. In most cases the channel spreads out into the bottoms of the Platte, so that it is sometimes necessary to make the measurements several miles apart, in order to include the expected inflow.

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* Reports Artesian and Underflow Investigation, 1890-1, 1892, U. S. Department Agriculture.

At the time an estimate based on the flow through the sands and the amount which might be expected, had not been made, and the results were so much less than had been expected—in some cases, in fact, showing an actual loss—that it seemed advisable to secure the measurements of another year, to confirm or disprove the results, before reporting them. In 1894 the volume of the river was so small that the errors in the measurement should be small. In 1895 the volume of the river was so great that plans had to be changed, and the number of measurements reduced. Enough, however, were taken to confirm the essential accuracy of those of 1894, and a personal inspection of the channels, with this in mind, indicates that at the best the increase from such sources must be small.

§ 52. The number of cases in which there is a loss instead of a gain is striking; and even granting that there is no increase from these streams, a loss was not expected. It may be said that the second measurement has been taken too near the outlet to catch the underground flow. In most cases this is not the case. The topographical features—the narrowing of the bluffs or some other feature—usually guided the choice of the second point. The map and the detailed tables of the 1894 and 1895 measurements will give a fair chance to make an independent comparison. In the case of the Bijou, the second gaging in 1894 was taken near the head of the Platte & Beaver canal but a short ways below the Bijou. In 1895 it was taken over a mile lower down the stream, and where the bottoms were narrow. A third point of measurement was taken in 1894 at the head of the Platte & Beaver supply ditch. Comparing the gain between the point above the Bijou and this place, we find a slight gain, but it is still less than the average of the river. There is very little irrigated area draining into this section, and it is especially little between the first and second points of measurement. There is some loss for the whole distance from evaporation, but during the time of these measurements it is difficult to account for a loss of more than one cubic foot per second per mile from this cause. It has been suggested that these loses are due to the varying depths of the bed of sand under the Platte, and the nearness of the bed rock in places. There is evidence that the thickness of the layer of sand varies, but definite data is lacking. If this be the cause of the loss, it would suggest that the bed of the Platte is washed out below the entrances of most of the streams, or else is filled with a coarser and more porous sand. The gain due to the nearness of the rock in some places should correspond to the loss at other places. At the measurement above the Bijou creek, there is a reef of rock. It shows for most of the width of the stream, and, at any rate, leaves only a small channel of sand. The gain, however, while more than in many other places, has not been marked enough to give great weight to this cause.

The question needs to be left open for future information. But the result, however, shows that the gain from the natural underground drainage cannot be much at best, and is probably nothing, at least too small to be measured.

The rainfall given in Table X. as the average for the given water-shed is derived from observations taken at stations on or close to the water-shed. It may be considered as a fair average of the amount falling upon the area draining into the channel. As the stations are few in number and the records not complete, the amounts are approximations of varying degree of reliability.

The drainage areas have been determined with a planimeter by measuring the area tributary to each stream from a map published by the Post-Office Department. They show the extent of the area tributary through these dry streams. Were the run-off in the course of a year equivalent to a depth of only 1.4 inches over the water-shed, each 1,000 square miles would give an average flow of 100 cubic feet per second; or, a run-off of a depth of one inch in a year, from the basin of the Bijou, would give a constant discharge of 100 cubic feet per second.

A calculation by aid of Table IX. shows that the amount derived from the inflow from these streams must be small. The breadth and depth of the beds of sand are unknown. If we assume a bed 80 rods wide and 1 thick, or an area in cross-section of one-half acre, and a fall of thirty feet per mile, then from Table IX. the velocity may be expected to be from 2 to 8 feet in 24 hours. As this is the flow through the interstices of the soil, which are one-third only of the section of the sand layer, the whole amount corresponds to from 1 to 4 acre-feet in 24 hours, or to a constant flow of less than 2 cubic feet per second.

It is not surprising that the measurements do not show any decided gain from such sources.

TABLE X.

INCREASE OF RIVER AT MOUTHS OF STREAMS.

(The negative sign indicates a loss.)

	Drainage Area. Square Miles.	Average Rainfall. Inches.	Gain of Platte, 1894. Second-feet.	No. of Miles Between Measurements.	Gain per Mile, 1894.	Gain of Platte, 1895.	No. of Miles Between Measurements.	Gain per Mile. 1895.
Box Elder creek	627	12.7	—51.05	3	—17.02	—35.27	4.5	—8
Crow "	1,443	11.5	....	....	....	....	....	....
Lone Tree "	536	11.5	12.16	1.5	8.11	114.2	3.5	33
Lost "	390	....	....	....	....	....	....	....
Kiowa "	470	16.3	5.26	3.	1.72	—34.16	9	—3.8
Bijou "	1,425	14.5	—45.43	2.8	—16.2	—3.97	4	—1.00
	....	....	5.92	9.8	0.60	...	....	....
Pawnee "	600	....	3.52	1.75	2.01	....	....	....
Cedar "	514	....	9.71	1.5	6.5	....	....	....
Lodge Pole "	2,500	13.4	....	....	....	—47.6	9.5	—5.01

§ 53. The fact that, as a whole, the gain is small is a striking one, and even more so that there is in so many places an actual loss.

It, then, seems true that the amount of inflow brought down by these sands is much less than has been believed.

It seems difficult to account for as great losses at such points as is shown by some of the measurements, although the loss can be but little.

§ 54. We have not been able to secure enough detailed information of the location of the irrigated lands along the Platte, to be able to make a comparison in detail of the inflow and the irrigated area. The areas irrigated stretch along the Platte, usually near the river. The area watered near Fort Morgan is, perhaps, the most extensive, and farther from the river than the others. The number of acres which are tributary to each portion is not known closely enough to state in acres. But, making a general comparison, we have the following table. The most that can be said from it is, that the amount of increase bears a relation, in a general way, to the extent irrigated.

§ 54. Comparing the distribution of the inflow on the South Platte river with the irrigated lands, taking the average inflow as given in Table V., the average inflow to the State line is 2 feet per mile.

TABLE XI.

	No. of Miles.	Average Increase.	REMARKS.
From mouth of Poudre to Hardin ditch...........	8	62.0	Receives seepage from about 10,000 or 12,000 acres watered from Poudre, also from Upper Platte.
From Hardin ditch to Putnam ditch....................	11	17.2	Little irrigation — Hardin, Illinois and Corona ditches.
From Putnam ditch to Fort Morgan canal...............	14	57.8	Putnum ditch; large part of Weldon Valley canal.
From Fort Morgan canal to Platte & Beaver canal.......	11	46.6	Most of Fort Morgan canal, remainder of Weldon Valley, Deuel & Snyder, and Pyott.
From Platte & Beaver canal to Snyder	14	49.9	Part of Fort Morgan canal, Platte & Beaver canal, most of Platte & Beaver supply.
From Snyder to Merino........	18	55.4	Some of P. & B. supply ditch, P. & B., and Fort Morgan canal; most of South Platte ditch, all of Edwards and Johnson, Snyder, and Tetsel ditches.
From Merino to Sterling......	14	33.7	Large part of Pawnee, Springdale ditches, and other Sterling ditches.
From Sterling to Iliff.........	9	17.7	Remainder of the Sterling group.
From Iliff to Crook	17	20.3	The Iliff ditch.
From Crook to State line.....	36	21.3	Almost no irrigation.
Total gain...............	149	298.7	

EFFECT OF IRRIGATION ON THE UPPER PORTIONS OF THE STREAM.

§ 55. A question which arises in connection with the application of water and which has been warmly disputed, is as to the effect on the lower stream of irrigation on the upper portions of a stream. In the way in which land has been brought under cultivation, it has happened in most cases that lands along the lower portions of the stream have been settled, while lands above have later been brought under cultivation. It follows then that these latter lands will often see the water go by to supply those others which were first improved. In some places it has been contended that the application of water to the upper lands is an actual benefit to the lower lands, and in some cases the contention has been partially granted.

It is evident that the water which returns to the stream returns slowly. It returns sooner when the distance is short and the gravel is coarse. The volume of the stream fluctuates between wide limits, while the effect of passing through the ground is to even the flow, and hold the water until later in the season. Usually the streams are high early in the season, and in June have more water than can be used; they are low in August. If this retention by the upper lands is such as to diminish the height in June and increase the amount in August, the result is evidently a benefit. As the effect of the subtraction of the water from the stream is immediate, while the return is slow, the abstraction of water in low stages will be felt more than the return from the seepage. Hence, for a portion of the time at least, it seems that the use of water on the gravelly plains of the upper parts of our streams will be a benefit to the lower portions, irrespective of the date of their respective rights. Just when the effect of the direct diversion is greater than that of the return could be told by investigation in the particular cases, but would manifestly vary according to the circumstances.

There has been a tacit acknowledgment of benefit of irrigation on the upper portions of the stream in some of the water districts of this State in the fact that the upper ditches have been permitted to withdraw water without interference from the Commissioners or from the ditches with earlier rights. This has doubtless been partly due to the fact that the amount used by them is small. But some weight has been given to the claim that irrigation on the upper grounds stored water which entered the river in other parts of the year, when it was more useful to the lower ditches. The question will doubtless arise in specific cases in this State and others. The length of time during the season when such irrigation will not be injurious to the later rights, can be told by special gagings carried on throughout the year, on the plan followed by Vigan.

WILL THIS INVESTIGATION APPLY TO OTHER VALLEYS?

§ 56. In the valleys here measured irrigation has been practiced for thirty-five years; to a small extent on the bottoms for twenty or twenty-five years, and extensively for fifteen years. In the case of the Poudre, the lands are some of them twelve or fifteen miles from the stream. On the Platte, they occupy a much narrower strip. The conditions of the subsoil, the amount of water applied, the dip of the impermeable stratum of clay or rocks, the coarseness of the gravel, all affect the time and amount of the return. But given time enough, it seems probable that these results will apply closely to other valleys as well. A certain amount of water is required by the crops for the purposes of growth. In round numbers, 300 to 350 pounds of water is used for every single pound of dry matter produced. On some soils it is possible by skillful irrigation to apply but little more than is required by the crop and evaporated from the soil. Under such economy, there is little water which can pass away by percolation. To the economical irrigation induced by scanty and high-priced water is due the little or no return water noticed in Southern California. This is also influenced by the relatively small acreage. The narrow strip of the lower Platte and the more copious irrigation explain partially, if not entirely, the larger amount returned to the stream per acre, while the remote places of application on the lands of the tributaries of the Upper Platte shows a reason why the inflow there is relatively less. These may not completely explain the difference. Time, and added observations, will be needed to determine.

The same or similar phenomena have been observed to some extent elsewhere.

"When the Ganges canal was constructed, the whole available "cold season supply was taken from the river, yet at a distance of "only a few miles the discharge in the river was found to be very "considerable, and further on it increased to such an extent that the "supply taken by the canal was found to be little missed." *

§ 57. In Italy the effect of irrigation does not seem to have been noticed in the rivers, but principally in the large number of springs to which irrigation seems to give rise, and which are developed by digging in Lombardy and other provinces, and which the geological conditions do not seem to be sufficient to account for. ||

The losses from canals is well known, and the damages caused to neighboring lands by the seepage is a fruitful source of suits at law. In the contract of the Cavour canal with the Sesia Associa-

*H. G. McKinney, Irrigation in Upper India, paper before the Royal Society, New South Wales, 1883.

|| Cagnassi, Irrigazione nella Provincia di Novara.

tion, for instance, the association becomes responsible for all damages from this cause.

§ 58. "I am inclined to think that the seepage is much "greater and of more importance in Colorado than anywhere in "California, for, while I know that such percolation does exist in "various places in the irrigated districts, I cannot recall a single "place where it takes place in any such volume as in your country. "The Santa Ana river is affected by seepage from Riverside and "San Bernardino valley, so that the volume of supply for the "Anaheim and Orange canals below is rather increasing than "diminishing, but the extent of this return is conjectural." †

"Some years ago the people owning water rights along the "lower parts of our mountain streams imagined that the use of the "water by parties located some distance above them would seriously "interfere with their water rights and prove very injurious to the "land below. Experience has proved that this fear was groundless "to a large extent. Indeed, it is now found that a large use of water "in the early summer on the upper lands insures a more plentiful "supply in late summer for the lower lands." ‡

Hon. Geo. P. Marsh, for a long time our minister to Italy, in *The Earth as Modified by Human Action*, in commenting on the results of Vigan (§ 59) states that it is generally estimated that from one-third to one-half of the water applied to the fields is absorbed by the earth, and this, with deduction of the amount evaporated, absorbed by vegetation, and entering into new organic compounds, returns to the streams or descends to greater depths. In Colorado a much smaller proportion of the water applied runs off and a much larger proportion is absorbed, as the system of wet meadows, or *marcite* and rice irrigation, does not prevail in Colorado. The measurements on the Poudre indicate that at least 30 per cent. of the water taken from the river returns through the seepage. If water is applied as freely until the seepage from the outer lands reaches the river, the amount of return waters will be greater than this amount.

OTHER INVESTIGATIONS.

§ 59. The phenomenon of return waters has been apparently but little noticed and less written upon. It was the subject of an investigation by the government engineers of France some thirty years ago in the valley of the Tet,* in southeastern France, where the question became important, as it is in some places in Colorado, in the dispute between water users of the lower valleys and those of

† Manuscript letter from J. D. Schuyler, Consulting Engineer, Los Angeles, California.

‡ Extract from manuscript letter from President Geo. Q. Cannon, of Utah.

* Vigan, Annales des Ponts et Chaussees, 1867.

the upper portions of the stream. The earlier canals, some built by the Moors before 1000, A. D., were taken out from the lower portions of the stream, the later ditches near the head.

The lower canals desired to close the upper ones. The latter claimed that the water that was applied by them in irrigation returned to the river to a great extent, and thus had the effect of making the stream more constant in its flow, and, therefore, was as a whole advantageous for the lower users. During several years a system of measurements was carried on at different places on the stream and included all the water that came into the stream through the smaller tributaries. Measurements were made daily by the local officers. The valley is one the total length of which is something like fifty or sixty miles, and the total area irrigated is 32,000 acres. The cultivation consists largely of wheat, beans, alfalfa, meadows, and gardens, with small quantities of potatoes and flax. A biennial rotation is practiced which dates from the Moors. Grain is usually watered three times, once at the time of sowing, in November. Irrigation is practiced throughout the whole season. In the upper valley wheat is not watered. Beans are watered from the middle of July to the middle of September. From the data obtained, M. Vigan reached the following conclusions: The return waters are derived from all irrigated lands of the valley, varying according to the crops, amount of water used in each season, thickness of the soil, its composition, and the slope of the impermeable layer. He concludes that, in the bottom lands, which form a bed about a mile wide along the stream, and are abundantly watered, from the first of March, that the return waters from this source are sufficient to compensate for the losses caused by irrigation during the greatest part of the low water. He also concludes that, in the area forming a strip two or three miles wide, with a very deep layer of permeable soil, the return waters come to the surface only in some places; that the greatest part of the springs which are caused flow unused in the subsoil and return frequently to the sea. On these lands irrigation occasions considerable loss; hence he concludes that, in case of an application for water right in the stream for canals, or ditches, which are to be newly constructed, the concession should be refused, except conditionally. In case water is lacking in the other canals, then the new ones should be closed. In general, under the conditions existing in that valley of the Tet, irrigation at the upper portions of the stream with water taken at periods of high water, is beneficial to the lower portions of the stream. The water thus applied gradually returns to the stream in such quantity that the stream is not so low as if the irrigation had not been practiced.

Some of the measurements of the Poudre river have been given in the Colorado Agricultural Experiment Station Report, 1891, p. 45-50.

Also see reports of the State Engineer of Colorado, 1885-6, p. 205-208; 1889-90, p. 559-570; 1891-92, p. 51-65; 1893-4, p. 176-192.

In bulletin No. 38, of Utah Experiment Station, Prof. Fortier has given some measurements for one year, showing the amount on some Utah streams, and leading to essentially the same conclusions as Vigan. Prof. Fortier's study is a valuable contribution to the subject.

A discussion by Senator David Boyd of the applicability to the Arkansas valley of conclusions from the Platte measurements, occupies part of a report of a special committee on the State Canal No. 1, Tenth General Assembly, p. 40-49.

In the Annales des Ponts et Chaussees, 1883, p. 34-60, M. Bazaine has a study on *L'Influence des Irrigations sur l'Altitude d'une nappe souterraine* occasioned by the observations of the effect of irrigation from the sewage of Paris on the ground water of the sewage farms of Gennevilliers. It has little application to the present discussion, except as it deduces the equation of the surface of the underground water, which is parabolic.

CONCLUSIONS.

We may draw the following conclusions from the observations and considerations shown. The facts are presented in sufficient detail to show the bases of these conclusions, or to enable independent conclusions to be reached, if the reader so desires:

1. There is a real increase in the volume of the streams as they pass through the irrigated sections.

2. There is no such increase in the streams as they pass through the unirrigated sections. On the contrary, there is an actual loss, even when the drainage of a large area enters.

3. The increase is more as the irrigated area is greater.

4. The increase is approximately proportional to the irrigated area, and it seems probable that with more intimate knowledge of the amount of water applied and the features of the drainage, the proportions would be found to be close.

5. The amount of the increase depends very slightly, if at all, upon the rainfall, and, so far as it does, it is influenced principally by the rainfall on the irrigated lands. Only where the lands are already saturated, is the rainfall sufficient to cause seepage.

6. There is no perceptible underflow from the side channels, even where they drain several thousand square miles.

7. The inflow is practically the same throughout the year. It is more in summer, less in winter, principally because of the effect of the temperature of the soil.

8. The passage of the seepage water through the soil is very slow, so that it may take years for the seepage from the outlying lands to reach the river.

9. The amount of seepage is slowly, but constantly, increasing.

10. It may be expected to increase for some years to come.

11. An increased amount of land may be bought under cultivation, with time, more especially on the lower portions of the streams.

12. The seepage being nearly constant throughout the year, while the needs are greatest in summer, the use of storage will best utilize the water from inflow.

13. The seepage from one thousand acres of irrigated land on the Poudre river gives one cubic foot per second constant flow; on the Upper Platte, one foot to about 430 acres; on the Lower Platte, one foot to 250 acres. The difference is due mostly to the greater distance for the seepage to reach the main stream, and to the time and amount of water applied.

14. One cubic foot per second of inflow is obtained on the Poudre river for each 2,400 acre-feet applied, or the inflow is about one-third as much as the water applied.

15. On the Poudre river about 30 per cent. of the water applied in irrigation returned to the river.

16. The use of water on the upper portions of a stream, when water is not immediately needed by prior appropriators, will increase the flow of the stream late in summer and prevent such low stages as it would have without this regulating action.

17. The seepage water is already an important factor in the water supply for the agriculture of the State. The capital value of the water thus received in the valley of the Cache a la Poudre alone is not less than $300,000, and perhaps $500,000, and for the Platte is from $2,000,000 to $3,000,000. It is large for the other streams, but of unknown amount.

18. An actual loss is incurred in carrying a stream like the Platte through sandy beds.

19. Ultimately, the returns from seepage will make the lower portions of such valleys as the Platte more certain of water, and probably enable a larger acreage to be grown.

20. The results here shown may be expected to apply with limitations to other valleys similarly situated, where irrigation is

as copious, crops the same in character, subsoil and rock strata of much the same inclination. Where the soil is less pervious, a greater time must elapse for these results to hold good.

21. Measurements are greatly needed in the Arkansas and Rio Grande valleys, for the determination of facts which will soon become of importance. In the Rio Grande, especially, because of the claims made by Mexico that irrigation in Colorado is proving an injury to her people and infringing privileges guaranteed them by treaty. If the results of this investigation apply to the Rio Grande, then any injury must be largely compensated by the return, and the greater regularity in the flow produced in the river.

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The diagrams have been drawn by Mr. J. D. Stannard, who has also aided the laborious work of reduction of the observations; Mr. Trimble has also aided extensively in the same work, and in the field work, as noted in the detailed observations, and also in preparing and checking the tables.

Through oversight, credit was not given, on page 32, in a part of the edition, to Mr. P. J. Preston, for Measurement No. 5, made under direction of the State Engineer.

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Cattle Feeding in Colorado.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

MAY, 1896.

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Cattle Feeding in Colorado.

Colorado is pre-eminently a grazing state. Few crops can be raised without irrigation, and the total irrigated area of the State is about 2,000,000 acres, or one acre in about every thirty-three. The remainder of the State can be used for nothing but grazing.

Part of the land is occupied by sheep, especially in the south middle portion of the State. Most of the counties east of the mountains support some sheep. There is not much difference in the number of sheep and number of cattle, but the sheep require so much less land per head that the total area of the State occupied by cattle is much more than that used by sheep.

The cattle ranging districts are scattered over the entire State and with considerable uniformity. There are in round numbers about 700,000 cattle in the State. The earlier cattle of the western ranges were so-called native stock, such as is now raised on the ranges of Texas and New Mexico. Much of this is still on the ranges of the southern half of Colorado. The improved breeds have made more headway in the other half of the State, especially in North Park and Estes Park and the foothill and plains country from Boulder northward. The earlier importations were of Durham blood. This breed was found well adapted to the varied conditions of Colorado, whether on the plains, foothills, or elevated parks, and has been more used than all the other improved breeds together. The only other pure breed that has been largely used is the Hereford, or Whiteface, as it is commonly called here. This breed is especially adapted to hilly pastures and is probably fully as good as the Shorthorn for most Colorado ranges. Attempts have been made to bring in other breeds such as the Polled Angus, the Galloway, and the Red-polled. All feeders now recognize the advantage of having no horns on the cattle when they are put into the feeding corrals, and it was natural that they should attempt to raise cattle that would be hornless from birth. These polled cattle have made but little headway in the State, the cattlemen preferring to stick to the Hereford and Shorthorn breeds and dehorn their stock.

RANGING AND WINTER FEEDING.

All the cattle of Colorado are ranged through the summer, and the greater part are also wintered on the range. But the free, open range in this State is a thing of the past. There was a time, but a few years ago, when the whole San Luis Valley, as large as a New England state, was one vast winter range for cattle. As many as 250,000 head have been driven from their summer ranges on the mountains to spend the winter in this valley.

But agriculture is superior to grazing, not only in this valley, but in all the valleys that can be irrigated east of the mountains. The cattle have been driven out by the plow. The cattle of the San Luis valley have shrunk to 60,000, though this decrease is partly due to the sheep overrunning some of the ranges formerly used by cattle.

With the advent of permanent settlers, a great change has come over the methods of ranging. Formerly, by mutual agreement of the cattlemen, certain favorable portions were set aside for winter range. But these favorable spots are the ones that would first be taken up by the settler, compelling each cattleman to look out for his own winter range. Fences have come in to keep cattle on the land where it is desired they should remain, or still more commonly, to keep them and other cattle out of the lands that are to be reserved for winter use. Drinking water is a necessity on all ranges. Temporary summer streams are common in the hills and on the plains, but permanent streams are scarce anywhere in Colorado. It did not take the cattlemen long to learn that if they controlled the water they held the key to the neighboring range. This is usually done by buying or leasing the sections or quarter-sections that include the permanent running streams and fencing them against all cattle but their own. This gives them free use of the range on both sides to the next water-shed. Five miles of stream can usually be controlled by leasing and buying not more than 1,500 acres of land, and give the cattleman the use, without cost, of an extra 10,000 to 20,000 acres. Often the owning or controlling of four quarter-sections at the mouth of a valley virtually controls the range of the whole valley. These conditions necessitate much smaller herds and a larger number of cattle owners than under the former system of the open, free ranges.

Most of the cattle of the State are now owned and run in bunches of 300 head or less.

The bane of the cattle business in Colorado, as elsewhere, is the cattle thief, or "rustler." If it were not for the danger of loss from this source, the cattle could be left to themselves most of the time through the summer, and, by the use of fences around the winter range, but little time would necessarily be devoted to them the rest of the year. But the rustler is omnipresent, and if it were known that nobody was looking out for any given herd, it would rapidly disappear. This necessity for riding the range nearly all the year largely increases the cost of running cattle, especially considering the small size of the bunches.

All degrees of winter feeding exist. There are few winter ranges so good that the animals will gain in weight during cold weather. The first frosts come in September, and from then until the new grass starts the next May, animals on the range do well if they hold their weight. This leaves but five months in the year for the animal to grow and seven months for it to stand still or even go backward.

It is evident that, if winter feed were good enough to keep the animal growing all the time, it would bring the animal to marketable size in a much shorter time. The present tendency of cattle raising is in this direction. A large number of cattle in the State are wintered on range feed mostly in the bottom land. A still larger number are fed through part of the winter on native hay cut along the streams. A smaller number are wintered on tame hay, largely timothy that has been sown for that purpose, and a still smaller number are brought out of the hills and parks to winter in the irrigated regions on alfalfa hay. The latter form is, of course, the most expensive and its advantage is merely a question of the amount of growth made as compared with the value of the hay eaten. But few cattle would be fed in the irrigated regions if alfalfa was their only feed. It happens, however, that, although the plow has destroyed the range, yet it has substituted the stubble fields. To utilize the stubble both of grain and of alfalfa and the straw of the grain, is the principal reason for wintering cattle in the irrigated regions. All this good feed material would otherwise be a total loss. Grain stubble and the straw that goes with it sells for winter feeding at from seventy to one hundred dollars per quarter-section. The cattle get considerable grain from the stubble and from the chaff at the straw stacks. It is not expected that cattle wintered in this way will gain in weight, but it is a rather cheap way of carrying stock through the winter.

In whatever way stock are wintered, there are few feeders in the State that do not make some arrangement for giving their stock extra feed in cases of unusually severe storms. They thus reduce the risk of running cattle, and in the course of years greatly reduce the winter losses. When cattle were allowed to rustle for themselves, there was a profit in the business, on the average, because beef was high and summer feed cost nothing. But when the severe storms did come many a herd was almost wiped out of existence, and the owners ruined financially. Stock raising under such a system was gambling on the weather of the next winter. As the price of beef fell, the business could not stand such a heavy drain on its profits and the cattlemen either went out of the business or made provision for a more certain winter feed. The most trying time of the year for stock is the months of March, April, and May, when the stock, already weakened by wintering on scant rations, are turned off the stubble fields onto the summer ranges. The new grass is not yet sufficient to supply their wants, and late storms often do enormous damage. A stack or two of hay carried over until this time is often the most profitable crop of the year. Many farmers carry hay to the range, and the cattle soon learn where to go for fodder during storms.

The most economical winter feeding is that where the summer range is near the winter range, so that the cattle can be left as long as possible on the summer range and, when brought to the winter range, they are then near the place where the hay was cut. Under these conditions they can gather their own living, except in case of storms or deep snows. Hay is then fed without moving them from the range. The usual amount is ten pounds of hay per head per day. They may need to be fed but a couple of days, before the weather moderates, or this feeding may in extreme cases last continuously for months, as it did in the winter of 1894-95 on some ranges. The hay is fed scattered on the ground, cattlemen having found by experience that but little is thus wasted and there is a saving of the cost of racks and the considerable danger of accidents that come from the crowding and pushing of rack-fed cattle.

Straw can be profitably used as a large part of the food for cattle that are being fed through the winter. West of the main range in Colorado, where the number of cattle is large as compared with the land sown to grain, nearly all the straw is so used. The same is true of the San Luis valley, which produces a large amount of straw, but also winters a great many cattle. On the plains east of the foothills there is more straw than cattle, and the surplus straw is usually burned.

MARKETING.

There is no definite age at which the old cows are sent to market. There have been times and places in the history of ranging cattle when the cows were never gathered, but allowed to remain on the range until they died of old age. The present custom is to gather up the farrow cows and sell them off in the fall, adding to them such heifers as prove barren and such old cows as seem to have passed their prime.

There is a wide difference in the age at which steers are sold for beef. Steers coming five years old used to be the standard beef cattle, and when they live all the year on the range with no extra winter feed they will scarcely get their growth in less time. By better care, more liberal winter feeding, with an infusion of the blood of the pure breeds, this time can be largely shortened. The general rule at the present time is, to sell as soon as they reach a live weight of a thousand pounds. If the steers have good enough winter feed so that they hold their own, they will reach this weight the fall after they are three years old. With a little better winter feed and better breeding they can reach the same weight at two years past. The steers that go to market from Colorado at the present time are about evenly divided between the two ages.

A few breeders of well-bred stock that feed liberally during the winter, are able to shorten the time still one year more and produce steers that will weigh a thousand pounds at twenty months old. It cannot be said that any one of these ages is the best, but the tendency of cattlemen is to feed better and market earlier. The younger the steers are sold, the more head can be kept on a given range, the smaller the investment, and the quicker the returns.

Most of the Colorado steers that are shipped out of the State are sold for feeders, that is, they are sold to Kansas and Nebraska men who feed them for three or four months on corn and then send them to the market for beef. Some of the steers are sold directly from the range, but the great bulk are fed on hay for two or three months and then go east for the grain feeding. The business of grain feeding these steers in Colorado is yet in its infancy, and opinions differ as to whether it can with profit ever become the principal method of handling them. Colorado is not a corn state, and it looks reasonable that it should be cheaper to ship the steer to the corn producing districts rather than to ship the corn west to Colorado and then the fattened steers eastward. It has so far proved profitable to bring in corn for sheep feeding; but this success is largely due to the Colorado climate and the possession of large amounts of cheap alfalfa that cannot be fed to the sheep unless it is accompanied with grain. The problem with steers is somewhat different. Alfalfa alone can be fed to steers and they will make a reasonable growth. The question before the feeder is, whether, if grain is fed in addition, they will grow enough faster and sell for enough more per pound to pay for the grain and leave a fair margin of profit for the extra risk. Incidentally there ccmes in the additional fact that the alfalfa is raised on the farm, while the grain will usually have to be purchased with money advanced by the banks at a high rate of interest.

A few figures will show the conditions of the two methods of feeding. Steers are usually bought in the fall with a three per cent. shrink and sold in the spring with a four per cent. shrink. In the fall of 1895 cattle off the range, if of good quality, sold for about $2.85 per hundred pounds live weight. A 1,cco-pound steer would therefore cost one thousand pounds, less three per cent. shrink, or 970 times $2.85, or $27.65. A good steer on hay alone should gain a pound a day in live weight. At the end of a hundred days' feeding, the steer would weigh 1,1co pounds and sell with a four per cent. shrink, or 1,056 pounds. The steer will have eaten and wasted about two tons of hay, so that if sold for one-half a cent a pound more than it cost, it would return $3.86 per ton for the hay. Each ten cents increase, or decrease, in the selling price makes a difference of fifty cents per ton in the amount realized for the hay.

When steers are grain fed to make beef of them they are fed the first sixty days on hay and the next ninety on hay and grain. The grain feeding in connection with alfalfa will seldom go higher than eight pounds of grain per day per head, and this maximum amount will be reached by the middle of the grain feeding period. This gives six hundred pounds of grain for each steer. The grain takes the place of some of the hay, so that in the whole five months, the steer eats and wastes about three tons of hay. The growth should average about a pound and a half a day for the whole period, or two hundred and twenty-five pounds. At $15 per ton, the six hundred pounds of grain would cost $4.50 To return four dollars per ton for the hay, the steer will have to sell for ninety cents per one hundred pounds more than it cost. The question before the feeder is, therefore, whether the chances of grain fed cattle selling for ninety cents per hundred more than they cost, are greater or less than the chances of hay fed cattle advancing fifty cents per hundred more than their cost. This is a difficult question to answer. The average of the markets for several years makes the two systems about equal, and since the hay feeding involves the less risk, most Colorado feeders have adopted this method. On April 1, 1895, hay fed steers sold for $1.15 per hundred more than they cost cff the range the October previous, while the following year the difference was but forty-five cents. The markets of these two years show that cattle feeding is largely a lottery. The final gain or loss depends primarily on the feeder being a good buyer, and getting stock that will fatten well at a fair price. After this he is at the mercy of the general tendency of the market. He may lose on his investment after careful feeding and good care, and the market may turn in his favor, as it did the winter of 1894-95, and give good returns to even poor feeders.

A question that greatly troubles all cattle feeders is, to know what is the best time to sell. It can be said in general that there is no "best" time. The week of highest prices one year may show the lowest prices the following year.

The consumption of cattle is fairly constant for the whole year, and the prices for the same grades of cattle do not differ to any great extent; but, owing to the influnce of supply and demand, the market is varying a little up and down all the time. Cattle are bought and fed on so narrow a margin that these small variations of twenty-five cents per hundred may make all the difference of gain or loss on the transaction.

It is in general true that the longer cattle are kept and fed the higher price per pound they will bring in the market. So long as there was a large demand for heavy cattle for export, there was almost no limit to the weight and fatness that could be put onto steers. Within the last few years a change has taken place in the wants of the market. There is a smaller demand for heavy, fat 1,600-pound steers, and an increasing demand for well fattened 1,100 to 1,300-pound animals. This change has been especially marked during the winter of 1895-96, until now there is but little difference in the market value of the two classes. Indeed, the past season has witnessed several cases of the lighter steer selling for the higher price. Under such conditions there is no incentive for attempting to grow the big steer, and the most profitable transaction now is to market the steer as soon as he can be gotten fat after he reaches a thousand pounds live weight.

COST OF RANGING CATTLE.

The cost of running cattle on the range varies from $2 to $4 per head per year, according to the conditions of range and the amount of winter feeding.

In the foothills and parks where some hay has to be provided for winter and enough land owned or leased by the cattleman to insure his winter range from intruders, one man can take care of about 300 head of cattle of all ages. He can also put up the seventy-five tons of hay that would be needed for winter with the aid of extra help for a few weeks. The present prices on the range are about $15 per head for cows, $12 for yearling steers, $17 for two-year-old steers, and $25 for three-year-old steers, making a mixed herd of 300 head worth about $4,500. The value of the range, with what fences, corrals, tools, etc., that the cattleman would need, would be about $2,000. The items of expense would therefore be as follows:

Wages of herder, 12 months @ $30	$360 00
Extra help in haying	20 00
Taxes @ 2½ per cent. on ½ the valuation	80 00
Total	$460 00

This $460 represents the cash outlay for herding 300 head for one year, or about $1.50 per head. On some ranges, salt would need to be fed, some giving as high as twenty-five pounds per head per year. Some cattlemen have found it advantageous to keep a small amount of grain on hand to feed to weak cows and young calves in March and April. A ton of grain will usually be an abundance for the cows in a herd of 300 head. These two items of salt and grain would add twenty-five cents per head per year to the cost of ranging stock.

The above items are the ones in mind by the writers who claim that cattle can be run for less than $2 per head per year. To make a complete statement there must be added the interest on the investment:

Int. on value of range, $2,000 @ 6 per cent. .	$120	00
Int. on value of cattle, $4,500 at 6 per cent. .	270	00
Total	$390	00

The interest account is therefore about $1.25 per head, raising the total cost of ranging to $3 per head per year.

On the plains where the cattle can be run in larger herds, some of the items above would be lowered. But the extra expenses of the general round-up would be enough to bring the total cost to fully as much as the above estimate.

GROWTH AND LOSSES.

One of the first questions asked by a prospective cattleman is, What will there be for sale each year from the herd? This depends on two things, first, the per cent. of calves, and second, the per cent. of loss in the calves and in the older stock.

The number of calves dropped varies with the number and vigor of the bulls used, and the care taken by the herdsman to insure service. It is customary to keep one bull for each twenty-five cows. A larger per cent. of calves will be dropped if the bulls run in the herd all the time, but in this case so many calves come in the winter and die from exposure that more and stronger calves are raised by keeping the bulls away from the cows until summer, so that most of the calves will be dropped in the late spring. It is best that the heifers should not calve for the first time until they are fully three years old. If the bulls are kept away from the herd except in the fall about forty per cent. of the heifers will drop their first calves when two years old and the rest of them not until the next year. Under good conditions, there should be eighty calves dropped from each hundred cows in the herd, but the number of these that will be alive next spring is very variable. When the cattle are well cared for in the winter, and the herdsman is on duty all the year around, the herds in the foothills and parks ought not to lose more than five per cent. of their number each year. On the plains, it is customary to allow ten per cent. to cover losses. These losses occur through stealing, starvation, lightning, miring in bogs, spring colds, and accidents. Cattle are very apt to get mired in the spring by going on the swampy land after the first green grass, and they have so little strength at this season that they cannot release themselves. Much higher losses than the above sometimes occur. When the cows and their calves are left to take care of themselves on the open range with no extra winter feed scarcely fifty per cent. will reach one year old. During the severe winter of 1894-95, four times the ordinary amount of hay was eaten by some herds, and others that were left on the range lost sixty per cent. of the whole herd.

Such losses, both in calves and older stock, used to be expected every four or five years by the cattlemen of Colorado from 1875 to 1885, and the business was so profitable that it could stand an average annual loss of twenty per cent. The margin of profits is now too small to take any chances, and by winter feeding the losses have been reduced to from five to ten per cent.

What will there be for sale each year from a mixed herd numbering 300 head? On the basis of there being eighty per cent. of calves dropped and an average of five per cent. of losses, a herd of 300 head will consist in the spring of:

Cows	55
Three-year-old heifers	37
Two-year-old heifers	39
One-year-old heifers	42
Three-year-old steers	39
Two-year-old steers	41
One-year-old steers	43
Bulls	4
Total	300

About forty per cent. of the two-year-old heifers would drop their first calves during the summer and these, with the calves from eighty per cent. of the three-year-old heifers and the same proportion of the older cows, will give a total of ninety calves, one-half of which would be steers and one-half heifer calves. As five per cent. of these would be lost, there would be on hand the next spring forty-two yearling heifers and the same number of yearling steers to take the place of those of the year before and keep the number good.

There would be the thirty-nine three-year-old steers for sale in the fall and some of the cows. How many cows should be sold would depend on the object of the breeder. If he wishes to enlarge his herd he would sell as few as possible. If he wishes to keep the herd constant at three hundred head, he would sell enough of the cows so that in the spring he would have the same number as the year before. On the average this would be about twenty-five.

For a herd on the plains, or anywhere that the annual losses amounted to ten per cent., a natural herd of three hundred head would be composed of:

Cows	70
Three-year-old heifers	31
Two-year-old heifers	36
One-year-old heifers	42
Three-year-old steers	36
Two-year-old steers	39
One-year-old steers	42
Bulls	4
Total	300

There would be ninety-six calves dropped during the season and thirty-six three-year-old steers for sale in the fall with twenty cows.

It is not to be expected that all herds will be made up of exactly these proportions. Even in a natural herd, that is, where all have been raised and none bought, the losses will vary from year to year, producing variations from these figures which represent averages for many years on many herds. The largest variations in herds are caused by buying in young stock, so that the herd has a disproportionately large number of steers compared with the cows. Or, the opposite condition comes from selling off in a single season more than the three-year-old steers. The former is the more common condition in the northern part of Colorado where many thousand young steers are brought in each year from the south and turned onto the ranges. The latter is common in southern Colorado and especially in New Mexico and Texas, where the steers are largely sold at one-year-old to go onto the northern ranges.

The estimate given shows an annual cost, not including interest, of about $500 for running a herd of 300 head. The yearly sales are about thirty-eight head of three-year-old steers and twenty-two farrow cows. The steers should bring $30 and the cows $15 per head, or a total income of $1,470. Deducting the $500 expenses, leaves net returns of $970, or about fifteen per cent. interest on the investment.

SHIPPING.

The people of Colorado eat 100,000 head of cattle every year. The larger part of these are old cows with a liberal sprinkling of barren heifers and a still smaller number of hay fed steers. Almost no grain fed cattle are consumed by Colorado markets. The largest local market of Colorado is Denver, which buys as many steers as all the other markets of the State combined. The other principal market for Colorado cattle is Omaha. Very few steers are shipped directly from Colorado to Chicago, because as a usual thing they are not fat enough to bring a high price in that market. Quite a number of shipments from southern Colorado are made to Kansas City. From most of the shipping points in Colorado, cattle will reach Denver with forty pounds shrinkage in live weight; will sell at Omaha or Kansas City with a sixty-pound shrink, and will weigh in Chicago 100 pounds less than when they started in Colorado. When steers are sold at the farm an allowance of four per cent. is made, which is just about what the steer will shrink in going to Denver. If the steers are to be shipped to Denver, they must sell there for as much as they would on the farm plus the cost of freight, feed, commission, yardage, and expenses of the man who accompanies them. These items would be, per head, about fifteen cents for feed, fifty cents for commission, twenty-five cents for yardage, and about thirteen cents per hundred pounds for freight. The expenses of the attendant will hardly be less than fifty cents per head, making the total cost of marketing a 1,000-pound steer $2.20. To make any profit from shipping the steer, it must bring more than twenty-two cents per hundred pounds above the price that could be obtained on the farm.

If the shipment is to be continued to Omaha or Kansas City, there will need to be added about seventeen cents per hundred for freight, fifteen cents per head for feed, and another fifty cents per head for attendant's expenses. These, added to the twenty pounds more of shrinkage, require that the steer shall sell in Omaha or Kansas City for an advance of twenty-eight cents per hundred pounds to agree with the Denver price.

The expenses would be more from Omaha to Chicago than from Denver to Omaha, making a difference of about forty cents between these two markets. The costs of getting the steer from Denver to Chicago is, therefore, about sixty-eight cents per hundred pounds; from the farm to Omaha, about fifty cents; and from the farm to Chicago, ninety cents, these figures including the shrinkage. With these heavy expenses and the greater risk, it is no wonder that a large proportion of Colorado cattle are sold on the range or farm to professional cattle buyers, who are more experienced in the business.

Experiments in Feeding Steers at the College Farm.

During the winter of 1894-95, several experiments in steer feeding were carried out on the College farm. They included tests of different classes of steers and of various kinds or combinations of feeds.

Eighteen steers were fed, comprising three groups of six each. The first group consisted of six grade Durham steers, four years old that had been raised on a farm as skim-milk calves. They had been well fed and wintered, making large framed, well formed steers, of about 1,300 pounds weight. They were taken off good alfalfa stubble when bought and were in fair condition, but not at all fat. They were brought to the farm November 15th.

On December 6, six grade Polled Angus steers were purchased. They were late summer calves of the year before; being thus seventeen months old and averaged about 700 pounds, varying from 660 to 760 pounds. They had been hay fed during the winter and had been brought from the summer range to alfalfa stubble about the middle of November. A week later six more steers were purchased, being of the same general breeding and care as the first lot of four-year-olds, but two of them were nineteen months old and the other four, thirty-one months old. The yearlings weighed about 830 pounds, and the two-year-olds a little over 1,000 pounds each. These were also brought off alfalfa stubble. The eighteen steers, therefore, consisted of six four-year-olds, four two-year-olds, and eight yearlings.

The six four-year-old steers were fed cut alfalfa hay and cut corn stalks for the first twenty days, with the exception of two days on whole oat hay, which they did not like, and two days on whole alfalfa, which they ate fairly well. This same oat hay was afterwards cut up and fed to them and they ate it rather under protest. During the first thirty days they ate:

Alfalfa fed. . . . . 5,267 lbs., or 29 lbs. per head per day.
Corn stalks fed, 1,325 lbs., or 8 lbs. per head per day.

Total fed. . 6,592 lbs., or 37 lbs. per head per day.
Refuse . . . . 617 lbs.

Total eaten, 5,975 lbs., or 33 lbs. per head per day.

This thirty-three pounds eaten per head per day consisted of about twenty-seven pounds of alfalfa and six pounds of corn stalks. Of this feed the steers gained about a pound per head per day.

The black steers were put at once on cut alfalfa and in the nine days from December 6, to 13, they ate 945 pounds, or seventeen pounds per day per head.

When the third lot of steers came, December 15, all three lots were put on the same cut alfalfa, and in the four days from then until December 19 they ate as follows:

FEEDING RECORD, DECEMBER 15–19.

	Average Age, Years.	Average Weight, lbs.	Alfalfa Hay Eaten, lbs.	Hay per Head per day. lbs.
Four-year-olds	4.6	1274	764	32
Two-year-olds	2.3	967	504	21
Yearlings	1.4	703	465	19
Average	2.8	981	578	24

On December 19, the four-year-olds were changed to whole alfalfa hay instead of cut, the rest still having the cut hay, and all from the same lot of hay as before.

FEEDING RECORD, DECEMBER 19–27.

	Average Weight.	Hay Eaten.	Hay Eaten per Head per Day.	Hay eaten per day per 1,000 lbs. weight.	Gain per head per day, Dec. 12 to 27.	Hay Eaten per Pound of Growth.
Four-year-olds	1289	1749	36	27.8	1.0	36
Two-year-olds	984	1044	22	22.4	1.7	13
Yearlings	736	934	19	25.8	2.2	9
Average	1003	1276	26	25.3	1.6	16

It will be seen that the steers did not eat an amount of hay proportioned to either their size or their age. The large steers ate not only the largest quantity, but also the most for each 1,000 pounds of their weight; while the yearlings, although eating the least per head per day, did not eat the least per 1,000 pounds weight. The amount of hay required to produce a pound of growth is almost exactly proportional to the age. While this exact proportion is not continued through the subsequent feeding, yet, in general, the oldest steers have required the most food for each pound of growth and the youngest steers the least. Attention is especially called to the amount of hay per head per day. It is customary in Colorado to allow fifty pounds of hay per day per steer, and this is the amount thrown daily into the feed racks. Not nearly all of this is actually eaten by the steers. The racks are cleaned out each day and about ten pounds of the hay removed. While of the other forty pounds the steers cannot eat more than thirty pounds, and the steers under consideration, though averaging just a thousand pounds live weight, ate only twenty-five pounds. The figures show that, under the ordinary method of feeding in Colorado, the steers waste from ten to fifteen pounds of hay per day per head, or from twenty to thirty tons for each hundred tons fed.

In the tests given above, the steers were fed in deep, narrow boxes, that were cleaned out every day and the amount given as eaten is the difference between the amount fed and that weighed back, so that it includes whatever waste the steers made. The refuse hay taken out of the mangers each day was fed to bulls, cows, and horses, and all eaten readily. In fact it is better horse feed than whole hay. On December 27th, the steers were separated into six groups, one of each lot of steers being put into each group.

The groups and feeds are given below:

Pen.	Name of Steer.	Age.	Weight.	Feed per Head per Day.
1	Little Roan	4.6	1212	5 lbs. cut fodder corn. 15 lbs. cut alfalfa. Cut alfalfa ad. lib.
	No. 5	1.4	693	
	Red Ear	2.6	1068	
	Average	2.9	991	
2	Strawberry	4.6	1381	5 lbs. cut fodder corn. 15 lbs. cut alfalfa. 6 lbs. cracked wheat. 20 lbs. cut beets.
	No. 3	1.4	801	
	Baldy	1.6	808	
	Average	2.5	997	
3	Spot	4.6	1357	5 lbs. cut fodder corn. 15 lbs. cut alfalfa. Cut fodder corn ad. lib.
	No. 2	1.4	684	
	Calico	2 6	928	
	Average	2.9	990	
4	Brindle	4.6	1255	5 lbs. cut fodder corn. 15 lbs. cut alfalfa. 35 lbs. corn ensilage.
	No. 4	1.4	723	
	Cody	2.6	1009	
	Average	2.9	996	
5	Whitey	4.6	1273	5 lbs. cut fodder corn. 15 lbs. cut alfalfa. 30 lbs. cut beets.
	No. 6	1.4	811	
	Sandy	1.6	871	
	Average	2.5	985	
6	Red Leg	4.6	1259	5 lbs. cut fodder corn. 15 lbs. cut alfalfa. 8 lbs. cracked wheat.
	No. 1	1.4	704	
	Cherry	2.6	1222	
	Average	2.9	1062	

Each steer was fed daily five pounds of cut fodder corn, ears and all cut into quarter-inch lengths, and also fifteen pounds of alfalfa cut into two-inch lengths. In addition to this, each steer in pen No. 1 had all the cut alfalfa it could eat, i. e., more was fed each day than the steers would eat and the balance weighed back each day. In the same way pen No. 3 was given all the cut corn fodder they would eat. Pen No. 4 had all the corn ensilage they would eat up clean, which was found to be thirty-five pounds per head per day. Pen No. 2 had, in addition to coarse feed, six pounds of cracked wheat and twenty pounds of cut beets; these were all eaten up clean, as were also the thirty pounds of beets given to pen No. 5. Pen No. 6 was started on ten pounds of cracked wheat, but the steers were not able to handle it. It was cut down to six pounds and finally raised and and held at six pounds of cracked wheat and two pounds of corn chop per day per head. Of the hay and cut fodder corn considerably more was fed than was eaten, the balance serving to feed six head of horses and proved an economical way of using up the coarse fodder.

The steers were weighed every two weeks, the endeavor being to weigh them about ten o'clock in the forenoon, after feeding and before watering. The weighing was always done before watering, but it varied two hours in time, and this made quite a difference in the amount of feed taken into the system, especially in the pens eating beets and ensilage. Some wide differences in weights are probably due to this cause.

FEEDING RECORD, DECEMBER 27 TO JANUARY 9.

No. of Pen.	Hay Fed.	Fodder Corn Fed.	Refuse.	Hay Eaten.	Fodder Corn Eaten.	Wheat and Corn.	Ensilage.	Beets.	Total Digestible Dry matter per day per head.	Gain per day per head.
1	1132	210	265	911	166	......	....	....	12.3	1.4
2	883	281	306	653	205	205	....	700	15.9	2.9
3	630	843	331	488	654	......	....	....	11.5	2.7
4	630	210	208	474	158	......	1147	....	13.9	2.5
5	843	281	333	593	198	......	....	950	12.5	2.6
6	843	281	271	635	218	354	....	....	15.7	3.5
Total	4961	2106	1714	3754	1599	559	1147	1650	13.6	2.67

FEEDING RECORD, JANUARY 9 TO JANUARY 23.

No. of Pen.	Hay Fed.	Fodder Corn Fed.	Refuse.	Hay Eaten.	Fodder Corn Eaten.	Wheat and Corn.	Ensilage.	Beets.	Total Digestible Dry matter per day per head.	Gain per day per head.
1	1120	210	217	939	174	....	....	....	12.7	1.0
2	804	268	353	539	180	252	....	840	15.8	1.4
3	630	880	342	493	675	......	....	....	11.8	0.6
4	630	210	220	465	155	......	1470	....	15.6	1.4
5	780	260	281	555	204	......	....	1260	13.4	2.4
6	780	260	285	552	203	374	....	....	15 0	−1.6
Total	4744	2088	1698	3543	1591	626	1470	2100	14.0	0.8

FEEDING RECORD, JANUARY 23 TO FEBRUARY 6.

No. of Pen.	Hay Fed.	Fodder Corn Fed.	Refuse.	Hay Eaten.	Fodder Corn Eaten.	Wheat and Corn.	Ensilage.	Beets.	Total Digestible Dry matter per day per head.	Gain per day per head.
1	1120	210	277	889	164	.....	....	....	12.1	2.0
2	825	275	360	555	185	252	....	840	16.0	2.5
3	630	910	366	484	690	......	....	....	11.8	2.4
4	630	210	321	389	130	......	1470	....	14.6	−0.3
5	825	275	300	600	200	......	....	1260	14 0	0.0
6	825	275	264	627	209	335	....	....	15.3	0 1
Total	4855	2155	1888	3544	1578	588	1470	2100	14.0	1.1

FEEDING RECORD, FEBRUARY 7 TO FEBRUARY 20.

No. of Pen.	Hay Fed.	Fodder Corn Fed.	Refuse.	Hay Eaten.	Fodder Corn Eaten.	Wheat and Corn.	Ensilage.	Beets.	Total Digestible Dry matter per day per head.	Gain per day per head.
1	1120	210	267	896	167	......	....	....	12.1	—1.9
2	810	270	428	468	184	252	....	840	15.1	1.5
3	630	890	304	506	710	......	....	....	12.3	—0.1
4	630	210	282	418	140	......	1470	....	14.9	3.1
5	822	274	314	586	196	......	....	1260	13.7	1.9
6	822	274	207	667	222	336	....	....	15.9	1.7
Total	4834	2128	1802	3541	1619	588	1470	2100	14.0	1.0

FEEDING RECORD, FEBRUARY 20 TO MARCH 6.

No. of Pen.	Hay Fed.	Fodder Corn Fed.	Refuse.	Hay Eaten.	Fodder Corn Eaten.	Wheat and Corn.	Ensilage.	Beets.	Total Digestible Dry matter per day per head.	Gain per day per head.
1	910	210	92	826	202	......	....	....	11.6	0.0
2	630	210	120	540	180	252	....	840	15.9	1.0
3	630	700	169	550	611	......	....	....	11.9	1.1
4	630	210	183	493	164	......	1470	....	16.1	—1.2
5	714	238	115	628	209	......	....	1260	14.3	1 2
6	714	238	62	667	223	336	....	....	15.9	2.1
Total				3704	1589	588	1470	2100	14.3	0.7

FEEDING RECORD, MARCH 6 TO MARCH 18.

No. of Pen.	Hay Fed.	Fodder Corn Fed.	Refuse.	Hay Eaten.	Fodder Corn Eaten.	Wheat and Corn.	Ensilage.	Beets.	Total Digestible Dry matter per day per head.	Gain per day per head.
1	760	180	167	628	145	198	....	....	14.3	1.2
2	552	184	96	480	160	216	....	540	15.3	—1.4
3	480	600	132	427	521	......	....	....	11.3	3.0
4	540	180	170	412	138	27	945	..	14.3	—0.4
5	612	204	137	519	160	......	....	810	12.4	—1.7
6	612	204	92	543	181	298	....	....	15.6	—0.1
Total	3556	1552	794	3009	1305	729	945	1350	13.9	0.5

FEEDING RECORD, DECEMBER 27 TO MARCH 18.

No. of Pen.	Hay Fed.	Fodder Corn Fed.	Refuse.	Hay Eaten.	Fodder Corn Eaten.	Wheat and Corn.	Ensilage.	Beets.	Total Digestible Dry matter per day per head.	Gain per day per head.
1	6162	1230	1285	5089	1018	198	....	....	12.6	0.62
2	4504	1488	1663	3235	1094	1429	....	4600	15.8	1.41
3	3630	4823	1644	2948	3861	......	....	....	11.9	1.59
4	3690	1230	1384	2651	885	27	7972	..	15.1	0.88
5	4596	1532	1480	3481	1167	......	....	6800	13.6	1.15
6	4596	1532	1181	3691	1256	2024	....	....	15.7	1.06
Total	27178	11835	8637	21095	9281	3678	7972	11400	14.1	1.12

The pens gained as follows in total weight during the 81 days of the test:

Pen No. 1 .... 150 ℔
" " 2 .... 342 ℔
" " 3 .... 357 ℔
" " 4 .... 213 ℔
" " 5 .... 273 ℔
" " 6 .... 252 ℔

Total .... 1,587 ℔

This is an average of 88 pounds per head, or one and one-tenth pounds per day per head.

SHRINKAGE FROM DIFFERENT FEEDS.

On March 13, the steers were weighed in the forenoon after feeding and before watering. They were presumably about half full. The same day they were weighed in the middle of the afternoon, after drinking, and when they probably had the heaviest weight of the day. The variations between the weights are decided. The steers weighed on the average 37 pounds more, full than half full. Pen No. 1 showed 49 pounds; pen No. 2, 36 pounds; pen No. 3, 21 pounds; pen No. 4, 12 pounds; pen No. 5, 57 pounds; pen No. 6, 46 pounds. The pen on the ensilage shows the least gain, which was to be expected; but the beet pen, showing the most, was decidedly contrary to expectation.

In individual steers, "Little Roan," on hay, gains 70 pounds; "Strawberry," on beets and grain, 85 pounds; and "Cherry," on grain, 66 pounds; while "Calico," No. 4, No. 3, and "Baldy," each make less than 15 pounds gain.

WEIGHTS AND SHRINKAGE

No. of Pen.	Feed.	Weight Dec. 27.	Weight March 13 a. m., half full.	Weight March 13 p. m., full.	Weight March 18 p. m., no water.	Weight March 19, Denver.	Probable weight if sold at farm.
1	Alfalfa	991	1,065	1,114	1,041	1,042	1,090
2	Wheat and Beets	997	1,148	1,184	1,111	1,100	1,164
3	Fodder Corn	990	1,115	1,136	1,119	1,033	1,126
4	Ensilage	996	1,115	1,135	1,067	1,018	1.120
5	Beets	985	1,097	1,154	1,078	1,075	1,126
6	Wheat	1,062	1,183	1 229	1,148	1,175	1,206
Ave.		1,003	1,120	1.159	1,094	1,074	1,139

No. of Pen.	Gain from Dec. 27 to March 13, a. m.	Gain from Dec. 27 to Denver weight	Shrink from probable weight if sold on farm to Denver weight.
1	74	51	48
2	151	103	64
3	125	43	93
4	119	22	102
5	112	90	51
6	121	113	31
Average	117	70	65

The steers were shipped to Denver on March 18, at six o'clock p. m. They were not watered on the 18th, and were weighed in the afternoon before driving to the cars. So that the farm weight represents considerably less than full weight, and, on the average, it is 28 pounds less than the half-full weight of March 13, in the forenoon; showing that the steers had not eaten much food, not having water. They went to Denver that night, were unloaded into the corrals, fed and watered. They all drank, but ate scarcely anything. They were then weighed separately about nine o'clock in the forenoon. There is an average shrink of twenty pounds from Fort Collins to Denver, and a shrink of forty-six pounds from March 13, a. m., weight. If sold in Fort Collins, it would have been "any time after 11 a. m., after feeding and watering," and would probably have given an average weight of 1,139 pounds, which is 65 pounds more than the Denver weight. The Fort Collins weight would have been subject to a four per cent. shrink, or 46 pounds, which would leave the Denver weight 21 pounds less than the Fort Collins weight with a four per cent. shrink. This is the average, but for the several pens the results are quite different. The difference between the Denver weight and Fort Collins weight with 4 per cent. shrink is, four pounds for pen No. 1; eighteen for pen No. 2; forty-eight for pen No. 3; fifty-seven for pen No. 4; six for pen No. 5; and seventeen for pen No. 6. Omitting the two pens that were fed on corn fodder and corn ensilage, the other pens together differ but eleven pounds from a four per cent. shrink. It can be said then, that, on ordinary feed, a four per cent. shrink represents very closely the difference between farm weight and Denver weight. Or, to put it in another way, cattle shrink about four per cent. from Fort Collins to Denver. When it is remembered that ten per cent. is the commonly estimated shrink from Fort Collins to Chicago, it will be seen how much advantage Denver has over the latter market

RELATIVE VALUE OF DIFFERENT FEEDS.

Corn Fodder and Corn Ensilage.---Pen No. 3 ate 2,948 pounds of hay and 3,861 pounds of corn fodder; while pen No. 4 ate 2,651 pounds of hay, 885 pounds of corn fodder, and 7,972 pounds of corn ensilage. Each pen was fed all it would eat, and if both pens consumed the same amount of nourishment, then, by subtraction (changing the surplus of alfalfa to its approximate equivalent of corn fodder), 3,373 pounds of corn fodder is equivalent to 7,972 pounds of corn ensilage. Then 2.4 pounds of ensilage is equal to one pound of corn fodder, or 100 pounds of ensilage is equal to 42 pounds of corn fodder.

As already stated, this is on the supposition that, in each case, the steers took equivalent amounts of nourishment. Or, it shows the relative amounts that will be eaten of each if the steers are fed *ad libitum*. According to the chemical composition of each, 100 pounds of ensilage should be equal to 66 pounds of corn fodder. This shows a wide difference between the two. A possible explanation is that, in cold weather, it requires quite a share of the full feeding value of the ensilage to evaporate the extra water it contains.

The steers in pen No. 4, on ensilage, gained but little more than half as much as those in pen No. 3, on fodder corn, which shows still more unfavorably for the ensilage. Pen No. 3, weighed in Denver 43 pounds per head more than it weighed December 27, while pen No. 4 weighed only 22 pounds more, or just one-half the net gain. Some of the other pens weighed over a hundred pounds more.

If sold at Fort Collins with a four per cent. shrink, the gain in weight of pen No. 3, would have been 136 pounds per head, while that of pen No. 4, would have been 124 pounds per head. But both of these pens shrunk heavily in shipping, much more so than any other pens. If sold on the farm, not much difference would have been shown in the two pens; but what difference there was would have been in favor of fodder corn over ensilage.

Alfalfa and Corn Fodder.—The steers in pen No. 1 ate 5,089 pounds of alfalfa, 1,018 pounds fodder corn, and 198 pounds of grain, while those in pen No. 3 ate 2,948 pounds of alfalfa, 3,861 pounds of fodder corn, and no grain. Subtracting, leaves 2,141 pounds of hay plus 198 pounds of grain, which is equal to 2,843 pounds of fodder corn. This makes 100 pounds of hay equal in feeding value to about 112 pounds of corn fodder. Figured from hay to ensilage through fodder corn, gives 100 pounds of hay, equal to 269 pounds of ensilage. Alfalfa gave 150 pounds gain, and fodder corn 357, taking the weights on the farm. In Denver, the hay gives 153, while fodder corn only 129, making the two about equivalent, pound for pound, for feed. If the comparison is made on any basis of Denver weights, the ensilage made the least gain, fodder corn next, alfalfa next, and all nearly alike. If on any basis of farm weights, fodder corn is best, ensilage next, and alfalfa last, with not much difference. The steers that were fed alfalfa and fodder corn sold for the same price per pound each being ten cents per hundred pounds more than the ensilage pen.

Alfalfa and Grain.—Taking the difference between the food eaten by pens Nos. 1 and 6, leaves 1,308 pounds of alfalfa on the one side, and 238 pounds of fodder corn, plus 1,826 pounds of grain on the other. Or, the addition of a pound of grain in the ration scarcely takes off a pound from the hay eaten. This means that animals fed grain will take more total food than those fed alfalfa alone. The grain-fed steers gained nearly double as much as the hay fed.

Alfalfa and Beets.—Pen No. 5 ate 6,800 pounds of beets more than pen No. 1, and 1,839 pounds less of hay; or, one pound of hay for each 3.7 pounds of beets. This is not far from the chemical equivalent of the two. But the beets made just twice as much gain, on the basis of farm weights and 1.8 time as much on Denver weight, showing a decided advantage in the beets.

Alfalfa compared with Grain and Beets.—Pen No. 2 eats 4,600 pounds of beets, 1,231 pounds of grain, and 76 pounds of corn fodder more than pen No. 1, and only 1,854 pounds less of hay. Showing that stock take much more total food with grain and beets than with hay alone. The gain was also more than twice as much on the heavier feed, whether counted on the farm or in Denver.

Grain and Beets.—A comparison of pens Nos. 5 and 6 indicates that a pound of grain can take the place of about 2.6 pounds of beets. Theoretically, the grain-fed steers consumed the more nourishment and they made the larger gain on Denver basis and the smaller, judged by their weights, at the farm. The average of the two is about even. Commercial gains of the two are also about the same. On the face of the experiment, the beets and grain have done equally well, but the grain-fed steers received a set-back from over feeding. Hence, it is hardly safe to say what would be the comparison on even terms.

Beets compared with Grain and Beets.—The stock took much more food on grain and beets than on beets alone. They made a third more gain on the farm and a seventh more in Denver. Judged by either standard, extra grain fed with the beets did not yield a return equal to its cost.

Grain compared with Grain and Beets. A comparison of pens Nos. 2 and 6, seems to show that the total nourishment eaten is about the same. The gains are in favor of the grain and beets on the farm, and in favor of the grain alone in Denver. Financially, the two gave equal results. When it is remembered that the grain was far from its best it will be seen that the grain alone was, on the whole, superior to the grain and beets. Or in other words, the beets added to the grain ration paid less than $3 per ton. It will thus be seen that both beets alone and grain alone have given better returns than the two when fed together.

It is particularly to be noted that the pen with beets and grain ate no more total nourishment than those on grain alone, i. e., the extra beets did not enable more food to be taken. But it should also be noted that both grain and grain and beets gave more food digested than beets alone.

This indicates that thirty pounds of beets per day is a little too much for even a steer to handle.

FOOD TO PRODUCE A POUND OF GROWTH.

When the steers came to the farm they averaged 981 pounds live weight, and on March 31, under the same conditions, 1,120 pounds, a gain of 139 pounds per head, or an increase of 15 per cent. in live weight. They ate an equivalent to 45,000 pounds of hay, and 6,528 pounds of grain. Thus, each pound of growth required 18 pounds of hay and 2.6 pounds of grain, costing 5.6 cents per pound of growth. Figured in the same way, it cost 4.6 cents for each pound of growth put on the sheep fed at the College during the same winter. After deducting freight and the other expenses of marketing, the steers sold for about 3.7 cents per pound, and the sheep for 5.05 cents per pound. The sheep paid for their feed in their growth, leaving the increase of value of the carcass for profit ; while each pound of growth in the steers cost more than it sold for, making a loss to be met from the increased value of the carcass.

RELATIVE CHANCES OF PROFIT IN FEEDING STEERS AND SHEEP.

A 1,000-pound steer bought at three cents a pound live weight, with a three per cent. shrink, will cost $29.10. After feeding for three months on hay and a little grain, it should weigh in Omaha, 1,090 pounds. The expenses for grain, labor, and interest, that is all the cost, except the hay, would be about $4.45, and the shipping expenses, $4.75, a total of $9.20. If sold for a cent a pound more than it cost, the returns would be $43.60, or a margin of $5.30 per steer for the hay. This would make a return of $2.65 per ton for alfalfa. Each ten cents taken off or added to the selling price of the steers will make a difference of about 55 cents per ton in the amount received for the hay.

Twenty 50-pound lambs, or 1,000 pounds of lambs will weigh in Chicago, after fattening, 1,600 pounds. They will cost for the expenses of shipment, $15, and, with grain at $12 per ton, the expense for grain, labor, interest, and dipping, will be $23, a total of $38.

If bought at three cents and sold for five cents, the cost will be $30, and the selling price $80. This leaves a margin on the twenty lambs of $12, or a return of $3 per ton for hay. Each ten cents change in the selling price makes a difference of 40 cents per ton in the returns for the hay fed.

It is evident that at these prices there is not much difference in the profits or returns from the two classes of stock. The whole problem is, therefore, narrowed to the single question, which is the more likely to happen, a difference of one cent per pound between the cost and selling price of hay fed steers if marketed in Omaha, or a difference of two cents per pound between the cost of lambs in the fall and what they will sell for on the Chicago market?

The prices of different years would give different answers to this question. During 1894-95, lambs cost $1.35 per head, with the freight paid to Omaha, which would be about $2.24 per hundred pounds live weight; and they sold for $5.50, or three and one-fourth cents per pound more than they cost. The fall of 1895 lambs cost $1.65 each, or $2.84 per hundred pounds. They sold on the average for a little less than two cents per pound more than they cost.

The steers that cost $2.50 the fall of 1894, brought $4 in Omaha four months later, while many steers that cost $3 the fall of 1895 brought at Omaha, in March 1896, but $3.50.

There is certainly a great difference of profits in these two years, but the profits in either year are not much different with sheep and cattle.

On the average, sheep have paid a little better than cattle; and, since a given change in the market affects the profits from sheep less than those from cattle, there is less danger of loss from the slight daily fluctuations of the market that are continually occurring.

Another item strongly in favor of the sheep is, the less first cost compared with feed eaten and final return. To eat 200 tons of hay requires about 100 steers at a cost of $2,900. While in sheep it requires 1,000 head at a cost of $1,600, or about one-half of the cash invested. As most of the feeding is done in this country on money borrowed from the bank, it follows that much more hay will be eaten from each $1,000 invested if the hay is fed to sheep.

MARKET PRICE AS INFLUENCED BY FEED.

When the steers were ready for market, the buyer for the Colorado Packing Company, of Denver, Mr. C.Burkhart, came to Fort Collins and priced each steer separately and then priced the bunch as a whole. The price as a whole figured within four cents per hundred of the price of each separately. The separate prices have therefore been taken as the selling price of each steer. The selling prices were as follows:

Little Roan,	$ 3 85	Pen No. 1.
No. 5.	3 70	
Red Ear,	3 85	
Average,	$ 3 80	
Strawberry,	$ 4 00	Pen No. 2.
No. 3,	3 80	
Baldy,	3 80	
Average	$ 3 87	
Spot.	$ 4 00	Pen No. 3.
No. 2,	3 70	
Calico	3 70	
Average,	$ 3 80	
Brindle,	$ 3 80	Pen No. 4.
No. 4,	3 50	
Cody,	3 80	
Average;	$ 3 70	
Whitey,	$ 3 90	Pen No. 5.
No. 6.	3 80	
Sandy,	3 80	
Average,	$ 3 83	
Red Leg,	$ 4 00	Pen No. 6.
No. 1,	3 60	
Cherry,	4 00	
Average,	$ 3 87	

The pens getting grain and beets and grain alone return the highest prices. Beets did next, then alfalfa and fodder corn, with ensilage last. The difference between ensilage and grain is 17 cents per 100 pounds, or a difference of more than $1 per ton for the hay, due to difference in quality of the animal as a result of the feed. It may be that this is due somewhat to the individuality of the animal and not to the feed, since Brindle was the poorest of the four-year-olds at the outset.

When compared by groups, the four-year-olds average 3.92, the yearlings 3.68, and the two-year-olds 3.82. The mature steers sell for considerably more than the younger ones, or 24 cents per 100 pounds, equivalent to about $1.50 per ton for the hay, or enough to easily change profit to loss had they been bought at the same price. But the four-year-olds cost 3 cents and the yearlings 2.65, so that the younger steers sold for a greater advance over the cost than the older. The two-year-olds cost 15 cents less than the four-year-olds and sold for 10 cents less. In general, the relation of cost and selling the price of the three bunches is within 5 cents of the average.

PROFITS OF DIFFERENT FEEDS.

The original cost of the steer added to the value of the hay at $4 per ton, eaten from the time the steer reached the farm until December 27, gives what has been figured as the cost of the steer December 27. If to this is added the cost of the food eaten during the test, it gives the cost of the steer at Denver.

The condensed statement for the six pens is as follows:

No. of Pen.	Cost Dec. 27.	Value of food eaten Dec. 27 to March 18.	Selling price in Denver.	Cost, plus food Dec. 27 to March 18.	Selling price more than cost.	Amount return for the hay eaten.
1	$ 84 70	$ 14 19	$115 24	$ 98 89	$16 35	$ 26 53
2	82 36	29 32	124 29	111 68	12 61	19 28
3	84 32	15 53	114 95	99 85	15 10	20 98
4	84 81	19 68	109 98	104 49	5 49	10 79
5	83 44	23 46	119 87	106 90	12 97	19 93
6	87 41	27 00	128 36	114 41	13 95	21 33
Total	$507 04	$129 18	$712 69	$636 22	$76 47	$118 84
Average	87 84	21 53	118 78	106 04	12 74	19 81

It will be seen from this, that the largest increase in in market value is made by the pen on beets and grain, followed by the grain, and then by the beets; the least by the ensilage. The value of the food eaten follows in the same proportion for the first three, but the alfalfa pen is the cheapest food, and the fodder corn next, leaving the ensilage about the middle. It should be remembered that these figures are based on the prices of $4 per ton for alfalfa and beets, $5 per ton for fodder corn, $3 for ensilage, and $15 for grain, being as nearly as possible the relative cost of production, and with no relation whatever to the relative feeding value. The total quantity of actual nourishment is not much different in the food of the several pens and the difference in the cost price is governed by the large differences made in prices compared with real feeding value. The feeding value of the fodder corn was probably about a quarter less than the alfalfa, and it has been figured to cost a quarter more. Ensilage has been figured at $3 per ton; whereas its feeding value would be one-half that as compared with alfalfa at $4 per ton.

The pens having the concentrated food grew the fastest, hence they made the largest increase in market value, but the market cost of their food was so great that they did not yield a correspondingly large amount of net profit. This net profit, or difference between selling price and cost plus the value of food, is most in the alfalfa and least in the ensilage. This is principally due to the fact that alfalfa at $4 per ton gives a pound of digestible material at a less price than in any of the other foods. The fodder corn comes next to the alfalfa, and is nearly as much notwithstanding the high price set on the fodder. Grain comes next, followed by beets alone and grain and beets. The three pens of concentrated food are closely even in this respect.

RETURNS FOR ALFALFA.

If from the gross receipts is subtracted all the expense except the hay, the difference may be counted as what was received for raising and feeding out the hay. All things considered, for a man on a small farm, who does not feed more stock than he can take care of himself, this is the fairest way of calculating profits. For the outside feeder, there needs to be taken into account the net profit, minus interest, the value of his own time, all incidental expenses for horses, wagons, etc., and enough more to compensate for the risk. The home feeder has this simple problem before him: I have raised my hay. I have on hand my own teams and all equipments. In what way can I put in my time through the winter to get the largest net return from the hay I have raised?

On this basis, the alfalfa pen, of course, gives the largest return, followed by the other four pens, except the ensilage, just about even and ensilage last. But the amount of hay eaten by the pens is quite variable, and, when put into the amount received per ton, it stands as follows:

No. of Pen.	Hay Eaten.	Selling Price More than Cost, Less Hay.	Net Return for Alfalfa Per Ton.
1	5089	$26 53	$10 42
2	3336	19 28	11 55
3	2938	20 98	17 70
4	2651	10 79	8 12
5	3481	19 93	11 47
6	3691	21 33	11 56
Total	21186	118 84	11 80

When figured to return per ton for alfalfa eaten, the fodder corn shows much better than any other, with ensilage as the least. The other four are not much different, but the alfalfa pen though showing the least, yet makes the surprising showing of about $10.50 per ton, when two and a half tons were fed to three steers.

It is also shown in this view of the case, that much less hay was eaten by the other pens than by the alfalfa pen, so that to consume a given amount of hay would require more cattle, a larger outlay, and a greater risk. The extra return for the alfalfa per ton when fed with grain, beets, or both, would not more than repay the extra interest.

Looking at the matter from the point of return per ton for alfalfa fed, the alfalfa and fodder corn pens have done decidedly the best. This is the same result obtained by considering true net profit. As to which of these two pens did the better, it would be difficult to say. They are about even.

EFFECT OF AGE ON PROFIT.

In this test there were used three groups of steers, four-year-olds, two-year-olds, and yearlings. Comparing these groups there is obtained the figures below :

	Average Weight, Dec. 27.	Average Weight, Mch. 13.	Gain in Weight.	Weight in Denver.	Shrinkage in Ship'g.	Per Cent. of Shrink.	Gain in Weight from Dec. 27 to Denver.
Four-year-olds..	1289	1419	130	1358	61	4.3	69
Two-year-olds...	984	1091	107	1042	49	4.5	58
Yearlings	736	849	113	821	28	3.3	85

The four-year-olds gained the most rapidly of the three groups, and the two-year-olds the slowest. On shipping to Denver, the four-year-olds also shrunk the most, this extra shrinking more than overcoming their extra growth ; so that the yearlings made more gain from December 27 to their weight in December than either of the other groups. These latter differences, however, are not great, amounting for the extremes to about one-fifth of a pound of growth per head per day.

When account is taken of the food eaten, as well as the growth made, the results are as in the subjoined table :

	Average Weight.	Gain in weight Dec. 27-Mch. 13.	Pounds digestible matter eaten.	Pounds digestible matter to 1 pound growth.	Value of food eaten.	Value food eaten for 1 lb. growth.
Four-year-olds ..	1354	130	1434	11.0	$8 65	$.067
Two-year-olds...	1037	107	1059	9.9	6 67	.062
Yearlings........	792	113	961	8.5	6 20	.055

The amount of food required has varied according to size, the four-year-olds eating one-half as much again as the yearlings, and the amount required for each pound of growth follows in about the same proportion. There is not so much difference in the value of the food eaten for each pound of growth, because the larger animals ate a proportionally larger amount of coarse fodder. The oldest animals ate the most value of food for each pound of growth, and the youngest the least.

If to the cost of the steer when delivered on the farm, there is added the value of the food eaten between then and December 27, when the experimental feeding began, the financial account from then until they were sold stands as follows :

	Cost Dec. 27.	Selling price in Denver.	Excess of selling price over cost Dec. 27.	Value of food eaten Dec. 27 to March 18.	Profit per steer.	Return for alfalfa per ton.
Four-year-olds ..	$39 97	$51 67	$11 70	$8 65	$3 05	$ 8 00
Two-year-olds...	27 23	37 83	10 60	6 67	3 93	10 50
Yearlings........	17 61	29 27	11 66	6 20	5 46	16 00

There is not much difference between the excess of the Denver price over the December 27 price for the three ages of steers. But the older steers have eaten so much more food than the younger as to make nearly two dollars and a half difference per head in the profits of the feeding. This is notwithstanding the fact that the older steers sold at an average higher price per pound. When figured on to return per ton for alfalfa, the difference is ever greater, the youngest steers doubling the return from the oldest.

If instead of starting December 27, the estimate is made from the time the steers reached the farm, the results are much the same and are given below :

	First cost.	Selling price in Denver	Excess of selling price over first cost.	Value of all food eaten.	Profit per steer.	Return for alfalfa per ton.
Four-year-olds .	$37 43	$51 67	$14 24	$11 19	$3 05	$ 6 20
Two-year-olds . .	26 73	37 83	11 10	7 17	3 93	10 00
Yearlings	16 87	29 27	12 40	6 94	5 46	12 30

SUMMARY OF COMPARISON BY AGE.

These results can be summarized and show that the four-year-old steers grew the fastest ; or, a better expression would be, that they gained in live weight the fastest, since they had already grown their frame and on our feeding, they were putting on flesh and fat. At the same time these old and large steers ate a large quantity of food, the amount as compared with the smaller steers being nearly proportional to their live weights. The extra feed more than overbalanced the more rapid growth and made the amount of food eaten for each pound of growth and the cost of this food the largest of the three classes.

The shrinkage in shipping the large steers was about as much more than that for the small steers as they had gained more in live weight. So that the three classes in Denver weighed each about the same number of pounds more than when first put on feed.

In total net profit and in amount returned for alfalfa, the large steers show the poorest returns, and the smaller steers the best.

The important lesson to be learned from this test is, that well-bred steers that have been wintered on hay the first season can be profitably fed for beef and marketed when they are coming two years old. This cuts off from one to two years from the present common method of running cattle on the range. It allows more head of stock to be kept on a given range and adds at least one-half to the number that can be turned off each year.

Cattle Feeding in 1895-96.

For the feeding tests of 1895-96, 15 steers were purchased. They were grades of mixed Shorthorn and Hereford on native stock. Three of them were two-year-olds and the rest a year older, i. e., coming four the spring of 1896. They reached the farm the evening of October 22, 1895, after being driven forty-seven miles in two days. They were weighed at noon of the next day and divided into five lots of three each. Pens Nos. 1 and 6 received nothing but alfalfa hay. Pen No. 2 was fed alfalfa hay and beets, beginning with five pounds of beets per head per day and increasing a pound a day until twenty-five pounds was reached. This amount was fed constantly until January 8, 1896.

Pen No. 3 began on alfalfa hay and ten pounds of corn ensilage, increasing to twenty pounds and remaining at that amount until December 19, when barley was fed in its place. The remaining three steers were turned into a fairly good pasture and were fed in addition all the hay they would eat.

FEEDING RECORD NOVEMBER 7, TO DECEMBER 19.

No. of Pen.	Hay.	Ensilage.	Beets.	Gain in weight.
1	4552	....	....	90
2	4283	....	3015	88
3	4472	2250	....	80
6	4230	....	....	115
Pasture	....	....	....	55

Feeding on Alfalfa alone.—Pens Nos. 1 and 6 received nothing but alfalfa, but Pen No. 6 gained 25 pounds more per head with a little less hay eaten. This would seem to indicate that the steers in Pen No. 6 were somewhat better than those in Pen No. 1, although to the eye they seemed to be closely equal. The fact that, when put on grain feeding, Pen No. 1 on corn surpasses Pen No. 6, on barley and beets, notwithstanding the seeming better quality of the steers in Pen No. 6, gives added weight to the superior feeding value of corn.

The total amount of hay eaten by Pens Nos. 1 and 6, from October 23 to December 19, is 11,581 pounds. This is for six steers fifty-seven days, or 34 pounds of hay per day per head for steers that weighed on the average 1,220 pounds. If steers eat according to weight, this would be 25 pounds per day for a 1,000-pound steer. During this time there was taken from their mangers twelve pounds of hay per day per head. This refuse was fed to horses and stock cattle, so that it should not be charged against the steers. This refuse amounts to just one-fourth of the entire hay fed. The amount charged as eaten also includes the amount thrown out of the manger, trampled under foot, and wasted. The proportion of refuse holds good to the end of the winter, though the steers eating beets leave much more hay than those on grain alone. On alfalfa alone the average of the six steers from November 8 to December 19 is a gain of 112 pounds in live weight in 42 days, or 2.4 pounds per head per day. This is a greater gain than was made by either of the pens having ensilage or beets. Indeed, the poorer of the pens on hay did better than either of the ensilage or beet pens.

Alfalfa and Ensilage.—During the feeding of 1894-95 the ensilage gave the poorest result of any of the feeds used. The record is much the same for the following year. From November 7 to December 19 the three steers in Pen No. 3 ate as much hay as the average of Pens Nos. 1 and 6 that had hay alone. But, in addition to this, Pen No. 3 ate 2,250 pounds of ensilage nearly equivalent to another thousand pounds of hay, and gained less in live weight than the steers on hay alone. Thus, the addition of ensilage to the ration produced a less gain in weight from one-fifth more food. The only explanation is, that the entire feeding value of the ensilage was employed in getting rid of the extra water taken into the system with the ensilage, i. e., the ensilage was worse than thrown away.

The result of two years' feeding of ensilage shows that it is not a profitable feed for steers that are fed in the open air without shelter. These results, however, have no bearing on the question of feeding ensilage to milk cows stabled in a warm barn.

Alfalfa and Beets.—The beets were eaten greedily and were fed in liberal quantities. The steers ate 3,015 pounds of beets from November 7 to December 19 and, in addition, about as much hay as the steers that had nothing but hay. As they gained less on hay and beets than they did on hay alone, the beets were apparently more than wasted.

The pens on hay and beets and on hay and ensilage consumed nearly the same amount of food value and gained almost exactly the same amount in weight.

Fall Pasture for Steers.—During the first few days after the steers were turned into pasture they filled out nicely, but when cold weather came they almost ceased growing and from November 7 to December 19 they gained scarcely one-half as much as those fed in the pens. It was so evident that they were not doing well on pasture that, December 19, they were brought to the yards and put on hay and corn. They had, however, received such a set back that they did not recover from its effect for more than a month. Even when sold in Denver, four months later, their total gain was 79 pounds less than that of the rest of the steers.

HEAVY GRAIN FEEDING.

Heavy feeding began December 19, though the steers did not receive the largest amount of grain until about the first of March. All the pens received alfalfa hay and, in addition, Pen No. 1 received corn; Pen No. 2, wheat and beets; Pen No. 3, barley; and Pen No. 6, barley and beets.

RECORD OF FEEDING, DECEMBER 19 TO APRIL 6.

No. of Pen.	Hay.	Corn.	Wheat.	Barley.	Beets.	Gain in weight per head	Shrinkage in shipping.
1	9195	2334	....	237	756	155	8
2	7938	237	2352	....	6936	163	—27
3	8898	....	....	2574	....	76	—37
6	7524	....	237	2256	5694	141	—66

Corn versus Barley.—A comparison of Pen Nos. 1 and 3 is a test of corn and barley, each fed without beets.

The two ate nearly the same amount of hay and much the same of grain. The extra grain eaten by Pen No. 3 just about balances the extra hay and a few beets fed to Pen No. 1. Both the nutritive and commercial value of the foods eaten are equivalent. The growth is decidedly in favor of the corn. Not only did the corn make a larger growth, amounting to 79 pounds per head, but this growth was so much firmer that it shrank less in shipment. The corn-fed steers weighed on the market 124 pounds more per head than the barley fed.

This result was unexpected when the feeding began, for barley fed to pigs had given almost as good results as corn. When fed to sheep, barley showed but a slight inferiority to corn. The barley-fed steers began to show soon after they were put onto the feed that they were not doing so well as those having corn. They ate their feed up clean, and with a fairly good appetite, but always looked worse than their neighbors fed on corn.

Corn versus Wheat and Beets.— The feeding of 1894-95 indicated that wheat and corn were about equal in feeding value, pound for pound. It was fair to presume, then, that, if beets were added to the wheat, the two together would prove superior to corn. This expectation was not realized. The winter of 1895-96 was favorable to the feeding of beets as there was but little severely cold weather. Yet, the wheat and beets produced only eight pounds more growth per head than the corn. The growth was soft and shrank considerably in shipping, so that, if judged by the market weights, the corn-fed steers gained 27 pounds each more than those having wheat and beets.

The beets took the place of part of the hay ; the wheat and beet steers eating 419 pounds less of hay and 2,060 pounds more of beets. Since the hay and beets have an equal commercial value, the balance of the beets, 1,641 pounds, was wasted.

Barley versus Barley and Beets.—The preceeding comparison shows that the addition of beets to the wheat ration was without advantage. The opposite results appear, when a comparison is made, between the steers getting barley alone and those getting barley and beets. The one ate 450 pounds more hay and the other 1,646 pounds more of beets. To offset this thousand pounds of beets extra, the steers getting the beets grew nearly twice as fast as those getting barley alone, gaining 141 pounds per head, while the barley fed steers are gaining 76 pounds. Just as those having wheat and beets shrink more in shipping than the corn-fed steers, so the barley and beet steers shrink more than those on barley alone. On the market the steers having barley and beets gained 75 pounds each above their December 19 weight, while the steers eating barley alone gained only 36 pounds.

The steers on barley and beets grow nearly as fast as those on corn, but lose much of this gain in shipping, leaving the corn far ahead.

Wheat and Beets versus Barley and Beets.—The amounts of grain and beets are nearly the same, but the wheat and beets give considerable more growth than the barley and beets. Just as barley alone shrinks more than corn alone, so barley and beets shrink more than wheat and beets. In both cases the barley does not seem to make as hard flesh and fat as the corn or wheat. Judged by the weights on the market, the wheat and beets have made almost double the gain in live weight of the barley and beets.

Relative Consumption of Hay and Grain:—When the steers were eating hay alone they ate 34 pounds of hay per day per head. When grain was added to their rations, they ate less of the hay. From January 8 to April 6, while eating on the average nine pounds of grain, they ate 28 pounds of hay. A pound of grain has nearly as much feeding value as two pounds of hay; but instead of the hay eaten falling off two pounds for each pound of grain eaten, it does not decrease even so much as the weight of the grain. It is evident that when given grain the steers consume each day more actual nourishment than when on hay alone, and to this extra feed is probably due much of the extra growth made at this time.

Shrinkage in Shipping:—The steers were weighed at Fort Collins about five o'clock the afternoon of April 6 and at once shipped to Denver, reaching there the morning of April 7. They were watered and given a little time to eat hay before selling. They were consigned to Clay, Robinson & Company, and by them sold to the Colorado Packing Company, the same firm that had bought our steers a year ago. The price obtained was $3.625 per hundred pounds, being the highest price paid in the Denver market for steers during the season of 1895-96. Through the courtesy of these gentlemen, we were able to get the individual weights of the animals and judge of the amount of shrinkage that resulted from different methods of feeding. The water was shut off from the pens at noon of the day the steers were shipped, hence their farm weight represented them not at their fullest.

Upon being weighed in Denver the steers that had received corn weighed eight pounds per head *more* than at Fort Collins. The steers fed on wheat and beets shrunk 27 pounds; on barley alone 37 pounds; and on barley and beets 66 pounds. The average of all is 28 pounds per head. This is considerably less than the steers shrunk that were fed during 1894-95, the difference being probably due to the much larger amount of grain fed the past season.

It will be noticed that the steers fed beets shrunk more than those receiving nothing but grain; and that the steers eating barley shrunk more than those getting corn and wheat.

W. W. COOKE,
Agriculturist.

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THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 35.

ALFALFA.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

SEPTEMBER, 1896.

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ALFALFA.

WILLIAM P. HEADDEN, A. M., PH. D.

No one can feel the incompleteness of the work presented in this bulletin more keenly than the writer, or regret it more than he does. The original purpose was to make a somewhat extended investigation of the effects of alfalfa growing upon different soils, particularly upon such as had been sown to wheat for a number of successive years until the yield had fallen to an unremunerative point. The results presented are confessedly those of work preliminary to the study proper, but we deem them of sufficient interest to justify their issuance in this bulletin, as they include the composition of the plant at different stages of development for each of the three cuttings—the usual number in this locality—together with the amount and composition of the ash of the whole plant above ground at different degrees of maturity, and also of the separate parts of the plant from the roots to the seed inclusive.

In two instances the soils have been analyzed, and in one the ground water also. This is the approachment made to the original object of the bulletin.

DESCRIPTION AND HISTORY.

The history of this plant has been outlined in previous bulletins published by this and other stations. The following is taken mainly from Miller's Gardener's Dictionary: The root of the cultivated Medick, or Lucern, is perennial, with annual stalks one and one-half to two feet and even almost three feet in height in good ground. The common color of the flower is a fine violet purple, but pale blue and variegated flowers are mentioned as arising accidentally from seeds. Villars affirms that the flowers are white—seldom greenish. Its native place is variously given, it being assigned to Spain and France, the Palatinate, and other portions of Europe. He adds: It may possibly have been originally a native of Europe, continuing to be disregarded until it was imported into Greece from the East after Darius had discovered it in Media, whence its name. It has been culivated "time immemorial" in the southern countries of Europe, and French Lucern seed was imported into England about 1650, but it was entirely neglected for many years, and in 1765 the fact that a farmer in Kent had fourteen acres of it was a matter worthy of mention. Lucern, he continues, has been greatly celebrated for increasing the milk of kine, but Haller, who certainly knew it well, asserts that cattle are apt to grow tired of it and that they are subject to be blown by it.

The culture of this plant by the Greeks is mentioned in their literature for about four and a half centuries, from the time of Theophrastus, 381 B. C., to that of Dioscorides, in the first century of the Christian era, and by the Roman writers through a period of about two and a half centuries from the time of Virgil, to that of Palladius, at the end of the second century, A. D. If the Persians, under Darius, introduced the Medick into Greece from Media, it would fix its date of introduction at about 490 B. C. I have not found any date given for its introduction into the Roman provinces. Its culture in Italy, however, has not been continuous down to the present time. Matthioli, writing in 1558, states that he had never seen it growing (in Italy), but adds: "It is related that it is abundantly cultivated in Spain where it is known by the Arabic name, Alfalfa." This name came with the Spaniards to this continent and has been borrowed by us directly from the Chilians, who, according to Prof. Hilgard, introduced it into California in the early fifties (1854). It was first introduced into this State in 1862 ,the seed being imported from California, which continued to be the source of our seed supply for several years. It has since been introduced into the contiguous states and territories.

CULTURE.

The Kansas State Board of Agriculture published,in 1894 a report devoted to Alfalfa, or Lucern, being for the most part answers given to a series of questions sent out by the Secretary of the Board, by various alfalfa growers in California, Colorado, Wyoming, Utah, Washington, Oregon, Arizona, New Mexico, Nebraska and Kansas, arranged by states and counties. The results given have, without doubt, been arrived at independently in the various regions and probably without any knowledge of the experience and observations of European growers. The accordance between them and those recorded in this report is remarkable, and goes far to show that the general methods of culture in vogue now have been practiced in all essential features for centuries, and are probably the best admitting of general application.

The variations in culture methods are slight, though the accounts given embrace a large variety of soils and climate, and the plant is claimed to meet the requirements of an excellent forage plant under all of them, indicating its adaptability to very varied conditions. The most trying and most fatal conditions to this plant are cold, wet winters and poorly drained or water-logged soils. It has long been observed that stagnant water has a very injurious effect upon this plant, destroying its roots, an observation that Coloradoans have many opportunities of repeating. The writer has seen plants with roots entirely destroyed to within a few inches of the crown, though still producing some growth, and others killed by soils being filled up with irrigation or perhaps seepage water. In the case here referred to the soil was strongly impregnated with alkali; these salts contributed to the effect produced,but I think that the plants would have simply drowned out had there been no alkali. There are many instances of this to be observed throughout the irrigated portions of the state where depressions in the surface become partially filled with water. The principal points given for its culture are, a well prepared seed bed, "fresh and plump" seed to be covered from "very lightly" to "three inches deep," according to different observers, and varying with the climate and soil. In California and Colorado, and generally in the West, the customary practice is to drill in the seed with a protective crop. I have neither seen nor learned of drill culture being practiced except on a small scale.

In regard to the seed, some assert that two years old seed is scarcely worth the sowing, and others are quite radical in their statements as to the value of shrunken or shrivelled seed. The writer will give his reasons for refusing to accept either of these statements under the subject of "Seed." It may not be a general practice for our farmers to sell their first-class seed and use the screenings for their own sowing, but it is certainly not an uncommon practice among them, and the results are satisfactory. It is even claimed by some that no difference can be seen in the results, the screenings producing just as good a stand of healthy plants as the first-class seed. The meaning of the persons making this claim is so evident, that there is no need of any explanation, still it may be stated that they do not claim that there will be more or less plants to the acre, but plainly that the stand will be sufficient to produce as large a crop in the one case as in the other. Some claim that the vitality of the alfalfa seed is at best small and that the shrivelled seed produce puny plants which are even less likely to survive the first summer than plants from plump seed of which, in ordinary field culture, very many perish.

Much stress is laid by some writers upon the necessity of growing the plants in a deeply prepared bed and rather abundant water supply during the first year, in order that they may establish themselves thoroughly, i. e., send their tap roots down deep into the soil. This suggestion has much force as applied to the conditions obtaining here, more, perhaps, than it would have in the East, and is by no means equally applicable to all of our lands. The root system of the alfalfa plant is greatly modified by the soil in which it grows. The so-called first bottom lands of our valleys do not favor the development of as long a root system as the higher grounds do. I have recently had occasion to study some plants which, though they were producing vigorous tops, could scarcely be said to have a tap root; for in no case, did it exceed eighteen inches in length. Had I never seen other alfalfa roots I would have considered them typical, for they were bright, without apparent deformity, and healthy. There was nothing about the plants or roots to indicate anything abnormal. The long tap roots are not always present and the old method of transplanting, as well as the continuance of gopher-eaten plants in some soils, fairly raise the question as to their necessity under all conditions. As stated above, the conditions of soil and climate prevailing here give strong justification for the practice and much force to the recommendation, but too much stress ought not to be placed upon it.

The history of fields of transplanted lucern is interesting in this connection. The practice of transplanting was at one time commended by some European agriculturists. The procedure and culture were briefly as follows: The plants were grown in seed beds in drills, were taken up in August or September, when the plants had attained a length of eighteen inches, the tap root was cut off eight, nine, or ten inches below the crown, the stalks about five inches above it, and they were then set six inches apart in rows, with two feet between the rows. This was subsequently found to be too thick. The plantation was cultivated by horse power; its duration and yield were claimed to be greater than an equal area sown broadcast. The character of the hay produced by the two methods, especially as to its coarseness and the readiness with which it was eaten by sheep, horned cattle, and horses, did not escape observation and comment. Such a method is clearly not to be considered, but they cut the tap root off eight, nine, or ten inches below the crown of the plant, and some asserted that six or seven inches below the crown would be even better. They cut three crops of hay in England and obtained large yields. When they harvested a crop of seed they obtained only one crop of hay and considered the seed crop as injurious to the roots as four cuttings. In Italy from four to six cuttings were made; in Catalonia as many as seven, frequent irrigation being necessary to obtain so many cuttings. The hay from broadcast alfalfa is finer and softer than from drilled. The yield of hay is put at more than four tons. Such are some of the statements made of the practice and results obtained. The life of the plant grown without transplanting is variously estimated at from two to fifty years. The former is evidently too low and the latter is exceptional. Columella gives it at from ten to twelve years, which is more consonant with general observation. Miller observes that, when alfalfa is cultivated and assisted by manure, he has not observed it to decline at any age, but sown broadcast, it declines and even wears out very fast after seven or eight years. From the various statements it is evident that, under some conditions, the tap root is not necessary to the continued healthy growing of alfalfa. The susceptibility of the plant to culture and its requirement for water applied to the surface, its prompt response to the application of fertilizers, and its deportment when transplanted, suggests that we attribute more importance to the tap root than it deserves. Mr. Mills, of the Utah Experiment Station, speaking of the amount of water required by alfalfa and the part the tap root performs in supplying it, says: "Though the roots go deep and probably lift water from below, this water is not furnished rapidly enough to supply the rank growing alfalfa. The only real advantage derived from the long roots seems to be that enough water is thereby supplied to keep the plants from perishing during seasons of dry weather." The complaint that alfalfa plants are difficult to exterminate by plowing them up, is very common, and Tull is quoted as having seen alfalfa plants mangled by the plow for twenty-two successive years and still flourishing. There will be some further similarly suggestive facts found under the discussion of the roots.

It is generally recognized that alfalfa flourishes best in an open loamy soil, but its power to adapt itself to other soils is very evident. Its doing well in heavy clay and light sandy soils, but being less productive in the latter unless well provided with plant food, attest that the plant is a heavy feeder. The range of altitude through which it will flourish is also great; while its range is less than that of timothy, it still reaches quite 8,637 feet on this side of the Rocky Mountains. I have seen a field of alfalfa in the San Luis valley, said to be fourteen years old, with an elevation of 7,900 feet, in which the stand was quite good and the plants healthy. It has also been successfully grown above Telluride, in this State.

VARIETAL DIFFERENCES.

The characteristics of alfalfa, which commend it for general culture by the farmers of the west, do not exhaust its points of interest to them. It is not constant in its specific characteristics, as almost every one has observed, some of the plants differing in color, shape, and size of both stem and leaves, and often very greatly in hue and color of flowers. The variation in color and size of the leaves is often very noticeable, and the suggestion that proper selection and careful propagation might result in establishing varieties with special merits for our climate and soils is no doubt true. The deep-green, narrow-leaved, red-stemmed plants, mostly with deep violet purple flowers, present a very different growth and mature earlier than the lighter green, larger leaved, green-stemmed and, as a rule, lighter-flowered plants. It has not been the writer's good fortune to have the opportunity of seeing many recognized varieties of alfalfa, but the few which I have seen differ less from one another, or certainly in no case more than many individual plants do growing side by side in our alfalfa fields. We have not, as we desired to do, analyzed separate plants to learn whether they have a varying composition. We have found it feasible only to take samples representing the plant as grown for hay. Among the analyses will be found, however, four samples of as many different varieties; three from French seed and one from seed from Turkestan. The results of these samples do not bear out the suggestion made above in the measure that we might expect, but the differences between the three French varieties practically disappeared in our soils and climatic conditions. The same could not be said of the variety from Turkestan. This was distinct in habit and very uniform, and, while the composition of the hay differs but slightly from the others, the agreement between them being as close as we would expect two different samples taken from different parts of the same field to be, there is an advantage in favor of this variety because of habit, growing erect with leafy and numerous stems. As to earliness of maturity, there was but slight difference. I made no endeavor to study the relative draft made upon the soil by these varieties; in other words, the ashes were not analyzed, and only one series of samples was taken and each sample analyzed in duplicate. This is clearly too limited an investigation on which to base other than tentative conclusions, since the composition is so near to the average for alfalfa hay made from plants in the same degree of maturity. It is very probably true, that, so far as these varieties are concerned, the only advantage of any one of them over the others is an advantage due to earliness of maturity, productiveness, or the ratio of stems to leaves, and not in its chemical composition. There are, doubtlessly, other qualities entering into the alfalfa plant affecting its desirability for hay making, but which lie beyond our power to recognize, just as there is a very readily recognized difference between the different cuttings of alfalfa or between old and new hay.

The samples used in the following analyses were taken at different stages of growth for the first and second cuttings and partly so for the third cutting. We cannot give the treatment of every sample in detail without repeating to a wearisome extent. The general method was to select and cut by hand the samples to be prepared. A quantity was weighed off, cut up without loss, placed in a sack, and exposed to the wind and sun until it came to a constant weight. This process was very tedious for samples weighing from five to ten pounds. The samples were then ground, bottled, and sealed. Duplicates were made of some samples, one being dried as above, the other in the hot air bath at a temperature not exceeding 100 degrees. The analyses showed no difference due to the manner of preparation. A higher temperature, however, is not safe; this was especially true with the roots, which showed by both their color and odor that at 110 degrees decomposition of some of their constituents had set in. A temperature ranging below 70 degrees was found to answer well.

The samples were taken to represent the plant without any bloom, beginning bloom, half bloom, full bloom, with seed formed and with mature seed. The plant has been further separated into roots, the outside or bark and interior portion, stems, leaves, flowers, and seed. Two samples were taken early in May before any blossom buds appeared, for the determination of crude fiber, to ascertain how great the relative increase of this substance is as the plant matures. Former analyses made at this Station have made it enormous.

The ashes of the principal samples have been analyzed to aid in forming some clear notion of the amount of plant food, other than nitrogen, required to produce a crop of alfalfa hay. We have no theory concerning the benefit of alfalfa growing to wheat exhausted soils, but simply seek the facts and their explanation to which, as before stated, this bulletin is simply a contribution.

PROTEIDS.

The fodder analyses of the first cutting give the following results for the amount of proteids, dates of collection being omitted except in the first instance. This sample was secured May 5th; plant 21 inches high; no blossoms; buds not visible; stem red; leaves small, dark green; air dried matter (hay) 27.53 per cent.; moisture, 72.74 per cent. Another plant with green stem, broader leaves of light green color, and equally immature as the preceding gave 28.21 per cent. hay and 74.79 per cent. water. The proteids in the above samples were respectively 19.95 per cent. and 21.79 per cent.

Proteids in first cutting alfalfa hay:—

		Per cent.
1.	Plants green, (average of preceding)	20.87
2.	" green, but nearing bloom	15.60
3.	" beginning to bloom	14.30
4.	" in half bloom	14.41
5.	" in full bloom	14.08
6.	" in full bloom	13.95
7.	" just past full bloom	13.38
8.	" in full seed	12.16
	Average	14.85

Proteids in second cutting alfalfa hay:—

		Per cent.
1.	Plants not yet in bloom	16.40
2.	" just coming in bloom	18.47
3.	" in half bloom	16.11
4.	" in ½ to ¾ bloom	13.03
5.	" in full bloom	12.88
6.	" half ripe	12.50
7.	" half ripe	11.65
	Average	14.43

Proteids in third cutting alfalfa hay:—

		Per cent.
1.	Hay, College Farm	12.53
2.	" Rocky Ford Station	13.57
	Average	13.05

The sample from the Rocky Ford Station was unusually leafy, while that from the College Farm was taken from the cock and was average hay.

The following are samples from the Farm Department, all of which were prepared by Prof. W. W. Cooke:

Proteids in first cutting alfalfa hay:—

	Per cent.
1. Hay	17.72
2. "	17.08
3. "	12.15

Numbers 1 and 2 represented individual plants cut May 28th, just before the field was mown. Number 3 is hay from the same field, cut on the 28th, but was damaged by rain.

Proteids in second cutting alfalfa hay:—

	Per cent.
1. Hay	12.15
2. "	12.29
3. Plants just showing bloom	15.26
4. " " " "	16.26

The samples of hay, Nos. 1 and 2, were cut from the same roots as Nos. 1 and 2 of the first cutting.

Proteids in third cutting alfalfa hay:—

	Per cent.
1. Hay	15.83
2. "	12.61
3. "	12.57

Condition of plants at time of cutting not given.

The average percentage of protein found in our samples for the first cutting, including all the different stages of development, is 14.85, but excluding samples cut May 5th, it is 13.98; for the second cutting, 14.43; and for the third, (this is based on too small a number of samples) 13.05. The farm samples show the same relative values for the respective cuttings, though the samples are fewer in number. For the first cutting, 14.92 per cent., for the second, 13.99 per cent., and for the third, 13.47 per cent. Perhaps analysis No. 3—first cutting—of the farm samples, ought not be included in the averages, because it was not gathered into the mow for fifteen days after it was cut, during which time it had been exposed to several rains.

As this is the only sample of alfalfa hay damaged by rains that we have analyzed, we will make mention of it in this place. The average of the analyses made of samples taken from the same field and cut the same day, but dried in an air bath, shows the composition of the prime water-free hay to be:—

	Per Cent.
Ash	12.18
Crude Fiber	26.46
Crude Fat	3.94
Crude Protein	18.71
Nitrogen free extract	38.71
	100.00

The sample of damaged hay gives :—

	Per Cent.
Ash	12.71
Crude Fiber	38.83
Crude Fat	3.81
Crude Protein	11.01
Nitrogen free extract	33.64
	100.00

The total rainfall between May 28th and June 12th, the respective dates of cutting and of putting into the mow, was 1.76 inches. The weather during this time was cloudy and the temperature ranged from 72 to 81 degrees. Any calculations based upon the above, without further data, would evidently be liable to lead to erroneous conclusions, but it suffices to show that the popular estimate of the value of such hay is not far from correct, i. e., about one-half that of good hay. The damage is not simply the amounts of proteids and nitrogen free extract (carbohydrates) lost, but also the loss of those general qualities recognized as essential to good hay. The mechanical loss in such cases is very large. We undertook to determine by direct experiment the total loss by the solvent action of water, fermentation, and handling, but it became evident that the results would indicate nothing of general value because there was no limit at which we would have to stop and no criterion by which we could judge when our experiment had become comparable with the average article (if there be such) of damaged hay. This sample gives us a somewhat definite measure of the sensitiveness of this hay to rain and exposure. The rain fell in three portions: the first fall amounted to .31 inch; the second 1.49 inches; and the third .27 inch, with intervals of two days or more. The weather was cloudy and warm. The mechanical loss of leaves and stems would tend to change the composition of the hay in the direction indicated by the analyses, but for good reasons, we do not consider this to enter largely into this particular case; but attribute the changes in the composition of the hay to the action of the moisture and heat.

Judging by the amounts of proteids in the three different cuttings, the first and second cuttings stand very close to each other in value with the difference in favor of the first cutting. In the farm samples, leaving out the damaged sample, the first cutting is materially the best of the three. I would here remind the feeder, who prefers the second or even the third crop for certain feeding, that the amount of proteids present is not the only measure of good hay. Not only is the quantity of proteids greater in the first cutting, but the yield is also greater and the hay cut just at the beginning of bloom is richer in this constituent than when cut later. From beginning bloom to half bloom the amount of proteids seems to be nearly stationary and the crop is also probably at its maximum. There are no figures accessible to me on this point, but it is in keeping with my observations. If the plant continues to store up organic matter after this period is past, I am inclined to think that the loss by the dropping of leaves, due to the maturing of the plant and the action of the fungus common on our alfalfa, more than compensates for the gain. While I am inclined to think that the farm samples are exceptional in their quality, they confirm the results obtained on the laboratory samples and make the first cutting very decidedly richer than the second. The development of the plants is not given, but as the date of cutting was May 28th and it was intended to cut the field four times, it was probably just before bloom, in which case the apparent excessive richness in proteids is largely and probably wholly accounted for. If the very early cutting be rejected from my series, and I think this should be done for no one would cut the crop so immature, it changes the results in favor of the second cutting.

CRUDE FIBER.

It has been stated by others that this portion of the plant increases materially with age. Our results indicate the same, but not to the extent claimed in a former bulletin issued by my predecessor, wherein he showed it to increase from 12.88 per cent. in hay, cut when the plant was beginning to bud, to 20.23 per cent. in hay made from alfalfa with fully ripened seed. (Bulletin No. 8, of this Station, page 11, analyses Nos. 1 and 4.) The method of determination is given as that adopted by the Association of Official Agricultural Chemists, convention of 1888. Whatever influence of the greater or less succulency of the plant may have upon the amount of crude fiber in the dry matter, it cannot in this case be appealed to to account for the low percentage of fiber, for the percentage of dry matter in the plant is given in some cases even higher than any which we have found. In Bulletin No 8, it is given as ranging from 22 to 50 per cent. of the green weight. In two samples cut on May 5th, we found the dry matter to be 25.2 per cent. and 27.53 per cent., and the crude fiber to be 22.56 per cent. and 29.79 per cent. respectively. These samples were taken from two separate and very unlike plants, grown without cultivation or irrigation. The average of these two, 26.18 per cent., is near the truth for alfalfa hay cut before flowering. Differences in cultivation, and varieties may make a difference of a few per cent.

Laboratory Samples.

Crude fiber in first cutting alfalfa hay:—

		Per cent.
1.	Plants quite young (average)	26.18
2.	" in bud	35.17
3.	" in bud	37.39
4.	" in half bloom	36.54
5.	" in full bloom	40.18
6.	" in full bloom	32.48
7.	" just past full bloom	36.19
8.	" in full seed	46.12
	Average	36.28

Samples numbered 5 and 6 were collected in different localities. No. 5 from heavy first bottom land; the growth was very rank, many of the stems were upwards of five feet in height; and the average diameter of one hundred stems, taken large and small as they grew, was nearly one-fifth of an inch—.19. The lower portion of such stems was woody and devoid of leaves. The stems in numbers 3 and 4 (100 from each sample), were also measured and were only a trifle smaller, having an average diameter of .17 of an inch. The sample on which analysis numbered 6 was made grew on a sandy loam, without irrigation. The plants had an average height of three and a quarter feet; and were very leafy, probably more so than the average.

The following are also laboratory samples of first cutting hay, but made from supposedly distinct varieties, grown on a rich loam, in drills, with irrigation:

Crude fiber in first cutting alfalfa hay:—

		Per cent.
9.	Plants in full bloom	36.39
10.	" in full bloom	32.74
11.	" in full bloom	35.51
12.	" in full bloom	31.96
	Average	34.15

The average of which is 34.15 per cent., while that of Nos. 5 and 6 is 36.33 per cent., which is probably the range of the average percentage of crude fiber of first cutting alfalfa hay cut when the plant is in full bloom; while the average percentage of the samples taken before blooming, including those taken as early as May 5th, is 32.91 per cent., the lowest being 22.56 per cent. and the highest 37.39 per cent., the difference being due to development of the plant and to the differences of conditions under which they were grown, particularly of soil and irrigation.

Crude fiber in second cutting alfalfa hay:—

	Per cent.
1. Plants not in bloom	28.66
2. " coming in bloom	32.46
3. " in half bloom	37.39
4. " in half bloom	37.24
5. " in full bloom	38.06
*6. " past full bloom	31.10
Average	34.15

Crude fiber in third cutting alfalfa hay:—

	Per cent.
1. Hay, College farm	39.35
2. " Rocky Ford station	34.67
Average	37.01

Farm Samples.

Crude fiber in first cutting alfalfa hay :—

	Per Cent.
1. Hay, cut May 28	24.54
2. " " "	24.68
**3. " " "	35.09
Average	28.10

Crude fiber in second cutting alfalfa hay:—

	Per cent.
1. Taken 35 days after first cutting	26.16
2. Taken 35 days after first cutting	29.07
3. Taken about 48 days after 1st cutting	34.59
4. Taken about 48 (?) days " "	38.08
Average	34.37

*This sample was obtained from the farm of Charles Evans, northeast of Fort Collins. The land is high and under irrigation. The alfalfa was average in growth. Its age is not known to us.

**This sample was damaged by rain.

Crude fiber in third cutting alfalfa hay:—

	Per cent.
1. Hay	28.89
2. "	37.39
3. "	34.91
Average	33.70

As already remarked, the results, especially of the laboratory samples for the first and second cuttings, show an increase in the crude fiber as the plant matures, but there is a considerable variation in the samples, with a few apparent contradictions, which is to be explained by differences under which the samples were grown and taken. The determinations were made in duplicate, and sometimes in triplicate, or until we were satisfied that the difference in the results was in the sample and not in the analyst's work. From the beginning of bloom to half bloom, the increase is not very rapid and the averages obtained for the hays of different cuttings are nearly equal, at least not so far apart as public judgment assumes; for the first, 35.21 per cent.; for the second, 34.15 per cent. (laboratory sample), 34.47 per cent. (farm sample); and for the third cutting, 37.01 per cent.; 33.70 per cent., three samples of hay from the farm department.

FAT OR ETHER EXTRACT.

We find in our laboratory samples a considerable variation in the amount of fat. If the differences be expressed in terms of the total fat found, they are large; but if in per cent. of the sample, they are constant. In twenty samples of alfalfa hay, but one yielded as much as 2 per cent. or more of fat soluble in ether, and only one below 1.1 per cent., with the average equal to 1.539 per cent. In the case of the farm samples, though our results on the duplicates were satisfactory, there is no concordance when the series of samples is taken as a whole, one sample falling as low as .86 per cent., and another in the same sub-series giving 2.76 per cent.; and still another 4.20 per cent. We have been unable to discover any reason for such variations in the farm series itself and quite as unable to find out why the two series should be so different. If we neglect the samples of first cutting hay in the farm series and take the samples representing the second and third cuttings, the average for the fat is, 1.641 per cent.; while the average fat content of the twenty laboratory samples is, 1.539 per cent., with most of them quite close to the average.

The fat as determined in the sample in full seed is, doubtlessly, too low (1.03 per cent.) for the reason that any seed which was in the hay was not crushed in the grinding of the sample and would yield so good as none of its fat in the sixteen hours' treatment with ether. We subsequently established this fact by direct experiment with whole unhulled seed. With this one exception, if it is an exception, there is no clearly indicated difference in the amount of crude fat present at the different stages of development examined in this study.

NITROGEN FREE EXTRACT.

The substances embraced under this name, having heretofore been determined by the difference between the sum of the proteids, crude fiber, fat, ash and moisture, and one hundred, will vary inversely as and quite nearly with the substance present in the largest quantity, which is the crude fiber. By this we mean that, if the crude fiber is high, the nitrogen free extract, which includes sugar starch, etc., called carbohydrates, will, as a rule, be lower than in another sample having less crude fiber. If the direct determinations have been made with care, the nitrogen free extract determination will be quite accurate enough for all purposes.

Laboratory Samples.

Nitrogen free extract in first cutting alfalfa hay:—

	Per cent.
1. Plants not in bloom	29.79
2. " not quite in bloom	32.91
3. " half bloom	32.50
4. " full bloom	27.85
5. " full bloom	37.64
6. " full bloom	30.59
7. " full bloom	33.24
8. " full bloom	33.11
9. " full bloom	31.41
10. " just past full bloom	30.41
11. " full seed	29.22
Average	31.69

Nitrogen free extract in second cutting alfalfa hay:—

	Per cent.
1. Plants not in bloom	36.49
2. " coming in bloom	31.58
3. " half bloom	33.29
4. " half bloom	28.90
5. " full bloom	32.02
6. " past full bloom	39.45
7. " past full bloom	38.13
Average	34.27

Nitrogen free extract in third cutting alfalfa hay :—

		Per cent.
1.	Hay, College Farm	31.35
2.	" Rocky Ford Station	34.09
	Average	32.72

It ought to be mentioned, perhaps, that these samples are from different places, some grown with and others without irrigation on different soils. With the exception of analysis No. 4, first cutting, the results indicate that the nitrogen free extract is greatest at or about full bloom.

Farm Samples.

Nitrogen free extract in first cutting alfalfa hay :—

		Per cent.
1.	Hay, cut May 28	35.67
2.	" " " "	36.42
3.	" damaged by rain	30.97
	Average	34.35

Nitrogen free extract in second cutting alfalfa hay :—

		Per cent.
1.	Cut 35 days after 1st cutting	32.77
2.	" " " " "	31.11
3.	" about 48 (?) days after 1st cutting	37.84
4.	" " " " " " "	34.43
	Average	34.04

Nitrogen free extract in third cutting alfalfa hay :—

		Per cent.
1.	Hay	36.78
2.	"	34.81
3.	"	35.84
	Average	34.74

The moisture in our samples of air dried hay ranges from 4 per cent. to nearly 9 per cent., with an average of 6.21 per cent., for the first; 5.94 per cent., for the second and 5.93 per cent. for the third cutting; while the average for all three is 6.03 per cent. Such hay takes on moisture readily. While preparing our first cutting samples, we had a spell of damp weather lasting from July 3d to 6th, during which some samples gained as much as 5.70 per cent. The smaller samples gained more proportionately than the larger ones because there was relatively more surface exposed.

The moisture in the farm samples is higher than in the laboratory samples. This is noticeably the case with the second cutting; the results are, for the first cutting, 7.59 per cent.; for the second, 8.05 per cent.; and for the third, 5.63 per cent. The average of the three is 7.09 per cent., from which we may judge that the moisture in alfalfa hay, under average Colorado conditions, is not far from 6.52 per cent. and not above 7.09 per cent.

ASH OR MINERAL CONSTITUENTS.

This component in alfalfa hay has some importance in general feeding, but very much more for the purpose of this bulletin as a measure of the draft made upon the plant food in the soil, both as to kind and quantity. I have not considered the physiological function of the constituents of the ash to be of such importance as to require any attempt to determine for instance the amount of phosphoric acid existing as such in the hay as fed, but have simply determined the amount of this acid in the ash, as prepared; though it is almost certain that some of the phosphorus determined in the ash as phosphoric acid does not exist as such in the plant. The same can be said of sulphur. The total amount of this in the plant has been determined in several instances; not, however, with the purpose of determining the portion present as sulphuric acid and that present in other forms, but simply to get the total sulphur in the form of sulphuric acid.

The amount of ash in alfalfa hay varies with different plants, different soils, etc. We do not speak here of the variation in the amounts of the different constituents, but simply of the total ash present.

ASH IN ALFALFA HAY.

Laboratory Samples.

First cutting:—

		Per cent.
1.	Plants quite young, (cut May 5)	10.64
2.	" quite young, (cut May 5)	12.16
3.	" not in bloom	10.21
4.	" not in bloom	9.14
5.	" in half bloom	9.30
6.	" in full bloom	10.46
7.	" in full bloom	9.24
8.	" in full bloom	9.94
9.	" in full bloom	10.19
10.	" in full bloom	10.99
11.	" in full bloom	11.34
12.	" just past full bloom	9.93
13.	" in full seed	6.77
	Average	10.03

Second cutting :—

		Per cent.
1.	Plants not in bloom	10.51
2.	" coming into bloom	11.95
3.	" in half bloom	9.48
4.	" in half bloom	9.91
5.	" in full bloom	10.97
6.	" half ripe	8.87
7.	" half ripe	9.98
	Average	10.24

Third cutting :—

		Per cent.
1.	Hay, College Farm	9.38
2.	" Rocky Ford Station	10.28
	Average	9.83

The percentages given above are practically for fine or pure ash, numbers 1 and 2, for the first cutting, being the only ones which ought to be designated as crude ash. The average percentage of ash for the first cutting, after rejecting the first and last two analyses, for no one would cut either of these samples for hay unless compelled to, is 9.08 per cent.; for the second cutting, 10.24 per cent.; and for the third cutting, 9.83 per cent.

Farm Samples.

First cutting :—

		Per cent.
1.	Hay	10.97
2.	"	11.68
3.	" damaged by rain	10.94
	Average	11.19

Second cutting :—

		Per cent.
1.	Hay, cut 35 days after first cutting	9.72
2.	" cut 35 days after first cutting	10.31
3.	" cut about 48 days after first cutting	11.26
4.	" cut about 48 days after first cutting	10.63
	Average	10.48

Third cutting :—

		Per cent.
1.	Hay	10.29
2.	"	9.94
3.	"	9.99
	Average	10.07

These percentages represent the pure ash, excepting the small amount of sand contained in them. The averages for the respective cuttings are as follows: first cutting, 11.19 per cent.; second cutting, 10.48 per cent.; third cutting, 10.07 per cent. The average for the two series is, for the first cutting, 10.35 per cent.; for the second cutting, 10.28 per cent.; and for the third cutting, 9.95 per cent. From which it appears that there is but little difference in the amount of mineral constituents removed by a ton of first, second and third cutting hay; the lowest figures requiring 199 pounds and the highest 205.6 pounds. While the percentage of ash found is not correct, due to loss of some of the constituents of the ash, chlorine and sulphur, these numbers serve to show very clearly that a five ton crop, which is some times obtained, forms a heavy drain upon the mineral elements of plant food, amounting to not less than 871 pounds per acre, after deducting the carbonic acid in the ash, or 1,025 pounds if we do not make this deduction.

WATER IN ALFALFA.

The moisture given up by green alfalfa in becoming well cured air dry hay, is as follows:

		Per cent.
1.	Plants cut very young	74.79
2.	" " " "	72.74
3.	" in bloom	70.90
4.	" in bloom	72.65
5.	" half bloom	73.06
6.	" full bloom	73.61
7.	" full bloom	74.06
8.	" full bloom	73.22
9.	" full bloom	73.67
10.	" full bloom	71.45
11.	" full bloom	74.39
	Average	73.14

Second cutting:—

		Per cent.
1.	Plants not in bloom	71.52
2.	" coming in bloom	74.35
3.	" in half bloom	68.65
4.	" in half bloom	70.40
5.	" in full bloom	74.50
*6.	" half ripe	62.91
	Average	71.08

* Not included in average.

As our analyses of the third cutting were made on hays, as prepared to put in the mow, we have no figures showing the amount of moisture lost in curing.

The average of the eleven samples of first cutting is 73.14 per cent., which means that every 100 lbs. of alfalfa as it stands in the field will give 26.86 pounds of well cured hay for the first cutting. An examination of the preceding table shows that there is not so great a difference in the amount of moisture in the alfalfa at the different stages of its growth at which it is cut for hay, or even for soiling, as might be supposed.

The average for the second cutting is some lower than for the first, but no very immature samples are included. The number of samples is also smaller, i. e., five samples with an average of 71.08 per cent. according to which each 100 pounds green crop gives 28.92 pounds of hay at second cutting. These results are much more uniform, and indicate less loss on account of moisture than those given by others. The average moisture in alfalfa hay, first cutting, is 6.03 per cent., the average of 13 samples, lowest, 3.77; highest, 8.87; for the second cutting, 5.94 per cent., the average of nine samples, lowest, 4.31; highest, 7.25. The average water content of green alfalfa, at time of first cutting, is 74.76 per cent., and at time of second cutting, 72.80 per cent.

Dr. Allen kindly furnished me with the results recorded by Dietrich and Koenig as 76 per cent. at beginning bloom; also 76 per cent. at full bloom. These are averages, the former of results ranging from 72.2 to 82 per cent.; the latter of results ranging from 70.0 to 83.1 per cent. The New Jersey Report for 1888, gives water for first cutting as 79.46 per cent.; for second, 64.37 per cent., alfalfa in drills; 80.61 per cent. for first cutting, 61.69 per cent. for second cutting, when sowed broadcast. The uniformity in our results is probably attributable to our climatic conditions and mode of culture, rather than to differences in the soils of New Jersey and Colorado. The New Jersey averages show the first cutting to contain more water, or to be more succulent than the second; while the results recorded in the Texas Bulletin No. 20, 1892, show the reverse, i. e., for the first cutting, 69.40. per cent., average of four analyses with 62.44 per cent., as the lowest, and 75.65 per cent., as the highest, and for the second cutting, 76.54 per cent. with 71.77 per cent. for the lowest and 81.59 per cent. for the highest.

AMIDE NITROGEN.

The proteids as given represent the whole of the nitrogen. There should, however, be a slight reduction made because of the fact that some of the nitrogen is present in a form of much less value than the proteids. The second column in the accompaning table gives the percentage of the total albuminoids corresponding to the amide nitrogen found. The following is the amount of amide nitrogen found in the respective samples :

First cutting :—

	Per cent. Amide Nitrogen.	Per cent.
1. Plants not in bloom	0.284	11.30
2. " not in bloom	0.187	7.48
3. " in half bloom	0.372	16.16
4. " in full bloom	0.176	7.80
5. " in full bloom	0.230	10.22
6. " in full bloom	0.239	12.26
Average		10.85

Second cutting :—

	Per cent. Amide Nitrogen.	Per cent.
1. Plants coming in bloom	0.517	17.82
2. " in half bloom	0.350	13.59
3. " in half bloom	0.614	29.47
4. " in full bloom	0.393	18.84
Average		19.93

Third cutting :—

Hay, College Farm	0.100	5.03

The proportion of proteids in the nitrogenous substances of alfalfa is represented, according to these results, by 89.13 per cent., for the first cutting ; 79.93 per cent. for the second cutting ; and 94.97 per cent. for the third. The percentage here given for the third cutting being based upon a single sample of hay, and at variance with the other results, is at best doubtful ; it is, however, the result obtained. I have found but one other series of analyses of alfalfa, in which the amide nitrogen is given, i. e., by Mr. H. H. Harrington, in Texas Bulletin No. 20, 1892. The dates on which the samples were taken are given instead of the development of the plant ; but, as the period of collecting covers forty days, I infer that the samples represent successive stages of development corresponding approximately to those given in this bulletin. The third column gives the percentage of total proteids corresponding to amide nitrogen found :

	Per cent Total Nitrogen.	Per cent. Amide Nitrogen.	Per cent.
Apr. 20	2.90	1.08	37.19
" 29	3.19	1.22	38.24
May 11	3.07	1.32	43.01
" 30	2.45	.46	18.77
" 30 (2d cut)	3.77	1.10	29.29
Average			34.31
Alfalfa not irrigated :—			
Apr. 3	4.12	0.13	3.14
" 21	4.11	1.15	28.00
May 11	2.78	0.80	28.85
Average			19.99

According to this series of analyses the proteids make up for the average, 65.69 per cent. of all the nitrogenous compounds in the first cutting alfalfa hay grown under irrigation ; and 70.71 per cent. of those of the second cutting grown under like conditions. But of these compounds, in the first cutting grown without irrigation, the proteids form 86.69 per cent., if we take the average of the three determinations given, or 71.58 per cent. if we leave out the sample taken April 3, which brings it in better accord with the other results.

These two series of determinations show clearly that the total amount of nitrogen in two different samples of hay, grown under different climatic conditions and expressed as proteids, cannot safely be taken as a measure of their relative value for feeding. As an example in point we will compare the Texas sample, collected May 11, with our sample of first cutting hay, made when the plant was in half bloom. According to Mr. Harrington's analysis, the Texas sample shows, nitrogen equal to 19.18 per cent. proteids or albuminoids, and our own air dried sample 14.41 per cent. We should, accordingly, give preference to the Texas hay, but, when we deduct the amides, we find the Texas sample has 10.97 per cent.; while the Colorado sample has 12.08 per cent. of the more valuable albuminoids left. So far as these are a measure of the feeding value of hay, the Colorado sample is really the better. If the plant were to be turned under as a manure, the more nitrogen the better, other things being equal. The difference in the amount of amides present in the two series is very great, but the methods used by the analysts were the same, the figures corresponding closely to the difference in the samples.

Our series of samples shows that the second cutting is richer in amides than the first cutting, which is still the case if we reject analysis No. 3, which seems abnormally high and for which we have no explanation to offer; also, that the amides attain their maximum in the whole plant at about the time of half bloom. It may here be remarked that the flowers, an analysis of which will be given later, are also quite rich in these amide compounds, and their abundance at the time of half bloom may determine the time of the maximum amount of amides. There is not the same fluctuation in our results as is shown in those of Mr. Harrington; they agree in showing a disappearance of these compounds as the plant begins to go out of bloom.

NITROGEN AS NITRIC ACID.

The well-known effect of alfalfa hay, particularly new hay, upon horses and the detection of large quantities of potassic nitrate in cornstalks grown under peculiarly favorable conditions, suggested the possibility of the occurrence of nitric nitrogen in this rapidly growing plant. The albuminoidal nitrogen was determined according to Stutzer's method, the filtrate rendered alkaline and subjected to distillation until ammonia ceased to be given off. The residue was acidified with sulphuric acid, run in from a graduate, and the nitric acid reduced by nascent hydrogen with the usual precautions, and after complete reduction, rendered alkaline again and distilled. The average of the results thus obtained gave us exactly the average of the blanks made with our reagents by Kjeldahl's method. The number of tests made was eighteen, and the nitric nitrogen was absent or present in exceedingly minute quantities. The roots were not tested for nitric nitrogen, but as the amids are present in them in rather large quantities, it is doubtful whether they contain more nitric nitrogen than the rest of the plant.

THE PLANT.

The preceding paragraphs have dealt with the whole plant as represented in hay, including leaves, flowers, and stems. The laboratory samples were prepared in such a manner as to preserve all the plant, and they consequently preserve the natural ratio of the different parts of the plant, which is not true of field-cured hay. In the succeeding paragraphs is given the composition of the separate parts of the plant, i. e., stems, leaves, flowers, seeds, and roots.

STEMS AND LEAVES.

Reference has already been made to the size which these attain, the diameter of 300 stems giving an average of nearly .17 of an inch, and they attain a hight of five and one-half feet under favorable conditions. It is a somewhat hackneyed observation that horses eat them (stems) more readily than they do the leaves, if not all too coarse; while cattle prefer the leaves. The percentage of stems and leaves, including flowers, varies with different plants from 40 to 60 per cent. A very leafy, small-stemmed plant may have more than 60 per cent. leaves and, consequently, less than 40 per cent. stems, but the stems of an average plant will amount to between 40 and 60 per cent. These numbers are of importance when it concerns hay making, as common experience teaches that the leaves are readily lost if the hay is not handled carefully and advantageously. In as much as many of the smaller stems may go with the leaves, the loss in making hay can, and in some cases, does amount to from 50 to 60 and even more per cent. We undertook to determine, by weight, this loss in making hay, but desisted after a very brief trial for reasons similar to those given under the subject of damage done to hay by rain. We have been led by our experience and observation, to the conclusion that the minimum loss from the falling off of leaves and stems in successful hay making amounts to from 15 to 20 per cent., and in cases where the conditions have been unfavorable, as much as 60 or even 66 per cent. of the dry crop, or, for each 1,700 pounds of hay taken off the field, at least 300 pounds of leaves and small stems are left, and, in very bad cases, as much as 1,200 pounds may be left for each 800 pounds taken. Of course, the latter is extreme, but it does occasionally happen even in this land of perpetual sunshine. The chemical loss has been referred to under proteids, farm sample, first cutting, analysis No. 3.

The stems loose 59.79 per cent. of their weight in curing, and yield 40.21 per cent. of air dry substance with the following composition:

	Water.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Total Nitrogen.	Amide Nitrogen.
Air dried	5.41	4.91	.94	6.34	54.40	28.00	1.015	0.07
Air dried	5.71	4.99	.85	6.35	54.32	27.79	1.015	[0.07]
Water free	....	5.19	.953	6.479	57.51	29.87	1.035	....
Water free	....	5.30	.900	6 469	57.61	29.72	1.035	....
Digestible	....	....	.456	4.63	25.00	20.21	.....	....

Ratio, 1 : 10.

This shows the stems to be very high in crude fiber and low in nitrogen free extract, while the proteids are almost equal to the average amount in timothy hay and the fat is less than one-half as much. Assuming the coefficient of digestibility for the stems to be equal to the average coefficient of digestibility for alfalfa as given by the New York and Colorado Stations, we have in the stem the following proportions: Digestible fat, .456 per cent; proteids, 4.63 per cent; crude fiber, 25.00; nitrogen free extract, 20.21 per cent., with a nutritive ratio of 1.10, requiring the addition of about 1.31 per cent. of digestible proteids to make the nutritive ratio 1 : 7.8, Wolff's standard ratio for horses at moderate work. The stems used in the above analyses were very coarse for alfalfa stems, and the proportion of fine stems was small. I interpret the high percentage of crude fiber as indicating this, which I otherwise know to be a fact. The stems as selected by horses from the hay probably approach considerably neared to the ratio of an agreeable, sufficient, and advantageous ration than that deduced from the above analyses. The amide nitrogen is very low.

LEAVES.

The samples of leaves were carefully picked free from all stems. They were not free from the fungus, which causes the dark brown spots and which is described in the Third Annual Report of the Delaware Station, 1890, page 79, under the name of *Pseudopeziza Medicaginis;* also in New Jersey Report for 1889, pages 152-160, as *Phacidium Medicaginis.* This fungus was so prevalent at the time of gathering the leaves, that the avoidance of every affected leaf was practically impossible. The affected leaves were not sufficient in number to have any perceptible effect upon the results. Analyses of affected leaves may be found in the New Jersey Report referred to above. Fresh leaves yield 68.72 per cent. water and 31.28 per cent. air dried matter. The water is low, for one cannot pick them without their wilting somewhat.

COMPOSITION OF LEAVES.

Condition.	Moisture.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Total Nitrogen.	Amide Nitrogen.
1. Early bloom	4.63	14.29	2.94	24·33	13.12	40.70	3.892	....
2. Early bloom	4.93	14.48	2.96	23.33	13.15	41.16	3.732	....
Water free	....	15.03	3.08	25.50	13.76	42.63	4.088	....
Water free	....	15.54	3.11	24.50	13.83	43.42	3.920	....
3. Early bloom without irrigat'n	8.40	13.60	4.10	22.18	10.67	41.05	3.549	....
4. Early bloom, without irrigat'n	8.53	13.35	3.43	22.60	10.66	41.45	3.639	....
Water free	....	14.84	4.77	24.24	11.37	44.78	3.878	....
Water free	....	14.61	4.75	24.69	11.65	45.30	3.950	....
5. Half bloom	8.62	11.39	4.28	22.30	12.48	40.90	3.568	....
6. Half bloom	8.38	11.39	4.28	23.31	12.48	40.60	3.733	....
Water free	....	12.48	4.69	24.30	13.65	44.88	3.892	....
Water free	....	12.48	4.69	25.29	13.65	44.09	4.046	....
7. Past full bloom	4.49	14.50	2.88	20.20	16.16	41.77	3.232	.506
8. Past full bloom	4.52	14.51	3.05	20.20	16.00	41.72	3.232	....
Water free	....	15.19	3.02	20.73	16.92	44.14	3.319	....
Water free	....	15.19	3.19	20.73	16.72	44.17	3.319	....
Digestible	....	....	1·47	14.75	7.43	28.40	....	....

Nutritive Ratio—1 : 2.7.

The high percentages of ash and proteids are the salient features of the composition of the leaves. Using the same coefficients of digestion as before, we obtain a nutritive ratio of 1:2.7, a very close ratio and one on which probably no animal will do so well as on a wider one. The large percentage of ash may have some effect upon the taste of the leaves; such is readily conceivable. The ash constituents will be discussed later in connection with the fertilizing value of the leaves. As the mechanical loss suffered in hay making consists very largely of leaves, they play an important part in the improvement of the soil observed in such as has been to alfalfa for a few years and in the quality of the hay.

FLOWERS.

The flowers do not constitute at any period in the growth of the plant a large percentage of the whole, but as their appearance is the sign of the approaching retrogression of some of the food constituents, or indicates the turning point in the life of the plant, we have submitted them to analysis to aid in tracing the course of development and also of the mineral constituents. The water in them is quite as much as in the average plant, i. e., 72.69 per cent.; and the air dried matter 27.31 per cent. This sample was gathered with great care and then sorted, so that there should be nothing but the racemes of flowers, without seed pods, except very young ones. The racemes taken presented the largest number of full blown flowers and probably contained the maximum of food stored up preparatory to the formation of seed.

COMPOSITION OF THE FLOWERS.

	Moisture.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Total Nitrogen	Amide Nitrogen.
Air Dried	4.46	9.41	2.11	21.33	19.92	42.77	3.413	.692
Air Dried	4.78	9.68	....	21.48	20.08	......	3.437	......
Water Free	....	9.85	2.21	22.35	20.85	44.74	......	......

The ash scarcely differs from the amount present in the whole plant, but the proteids and nitrogen free extract are very much higher; the former seemed probable without the analytical results and it is almost evident that they should be rich in carbohydrates. The function to be fulfilled by the accumulation of these two important components does not come within the scope of this bulletin, even if we were competent to discuss it, but it is suggestive that these two components are also present, the proteids in even larger proportion, in the seed. The ether extract, however, does not foreshadow the large amount of oil in the seed. The proteids are most abundant in the hay, when cut at about half bloom, as the flowers themselves do not form a sufficient percentage of the hay to account for the total increase; it is probable that there is really more proteids elaborated just before or at this period of growth than at any other. In making this statement we bear in mind the total weight of the plant as well as the percentage composition. Some of our analyses indicate that the dry matter contains a higher percentage of proteids if the hay be made from very immature plants, (samples cut on May 5,) but others cut at a later date, the (plants not yet in bud) do not show the same richness in albuminoids; and Mr. Harrington's series, Texas Bulletin No. 20, leaves it doubtful whether it be true, that the dry matter from very immature plants contains a higher percentage of proteids than that cut at a later stage of growth, but previous to the formation and ripening of the seed. The analyses of the leaves shows the proteids to be practically stationary from early bloom on, but to decrease after the plant has past full bloom.

We have treated so far principally of the compounds entering into the question of hay making and have selected our samples with the view of gaining information as to the best time for cutting, the influence of high or low land, and of irrigation. The results are tabulated below, being given on a hay or air dry basis. I have chosen to do this because such results correspond more nearly to the article with which our average reader is familiar than if they were reduced to the basis of dry substance. The results reduced to this basis may be found in the appendix. The statements made under the subject crude fiber seem pertinent to the other food constituents and the plant in general. The water in the hay does, as is clearly understood, make some difference; but it varies so little that its effect upon the relative results is negligible. The fats are present in comparatively small quantities, being equivalent to from 3 to 5.5 per cent. digestible carbohydrates and do not vary enough in the different samples to show clearly that the variations are due in any way to the stages of plant development; while the fat—ether extract—in Mr. Harrington's analyses (Texas Bulletin No. 20) is very much higher throughout than mine, and, in the irrigated alfalfa, shows a diminishing percentage as the season advances. The sample, which had no irrigation, shows the reverse. The fat content as shown by Mr. Voorhees's analyses (New Jersey

Rep. 1888), is also somewhat higher than mine, showing an average for hay, supposing it to contain 8 per cent. moisture, of 3.31 per cent., for drilled alfalfa and 3.02 per cent., for broadcast. The minimum is found in the third cutting, broadcast, with .53 per cent. As four cuttings were made they were probably cut quite immature. The percentage of fat, however, in Mr. Voorhee's samples agrees quite well with our farm samples, first cutting. None of the analyses show that there is as a rule more fat in the dry material of the very early cutting than in that of maturer plants.

Using the coefficients of digestion, 46 for crude fiber and 68 for nitrogen free extract, these being the average of the coefficients found by the New York and Colorado stations for the respective substances, we find the total digestive carbohydrates, neglecting the fats, to range between 36.41, as a minimum, and 40.51, as a maximum, or a variation of 4.1 per cent., including samples cut green, beginning bloom, half bloom, and full bloom, as well as the first, second and third cuttings. The proteids, as stated under this topic, appear to attain their maximum at the beginning of bloom and remain practically stationary until half bloom, or a little later, when they diminish rather rapidly. This period, during which the loss and the gain in the proteids is nearly equal, is the most advantageous time to cut for hay, both for quantity and quality, so far as the composition is a criterion. Hay possesses certain general qualities which make it acceptable to the animal and which are not dependent upon the composition. Many persons, I am informed, give preference to the second or third cutting for certain feeding. The composition of the respective cuttings shows but very little difference, the following figures giving the averages for each:—

	Ether Extract.	Crude Proteids.	Digestible Carbohydrates.
First cutting	1.54	14.85	38.03
" "	—	13.98*	
Second cutting	1.40	14.43	38.06
Third cutting	1.46	13.03	39.15

The average precentage of proteids for the third cutting is based upon the two samples of hay, which alone, would not be sufficient, but the average for the samples from the farm department makes it only 13.47 per cent., and the results of Mr. Voorhee's analyses give, for the third cutting of hay, allowing 8 per cent. moisture, 13.67 per cent. These figures for the first and second cuttings are nearly

*Not including samples cut May 5th.

the same, with a slight difference in favor of the second cutting if we reject the very early cuttings (May 5th). This, however, is compensated for in part by the larger quantity of amids present. The third cutting is inferior in composition to either of the others. The following table, presents, in tabulated form, the analyses of the different samples; first, those prepared by ourselves in the laboratory; second, those received from the farm department.

Laboratory Samples.

Number.	Number of Cutting.	Condition at Time of Cutting.	Moisture.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Amide Nitrogen.
1	1	Very immature	4.85	12.16	....	21.79	*22.56	.. ...	....
2	1	" "	5.15	10.64	....	19.95	*29.79	......	....
3	1	Not in bloom	4.17	10.21	1.94	15.60	35.17	32.91	.284
4	1	" " different locality from preceding	7.86	9.14	1.52	14.30	37.39	29.79	.187
5	1	Half bloom	6.04	9.30	1.19	14.41	36.54	32.50	.372
6	1	Full bloom, without irrigation	4 49	9.24	2.20	13.95	32.48	37.64	.176
7	1	Full bloom, low land	6.30	10.46	1.13	14.08	40.18	27.85	.230
8†	1	Full bloom, high land	7.14	9.94	1.40	14.54	36.39	30.59	....
9†	1	" " " "	7.46	10.19	1.54	14.83	32.27	33.24	....
10†	1	" " " "	3.77	10.99	1.40	15.22	35.51	33.11	....
11†	1	" " " "	7.60	11.34	1.67	15.92	31.96	31.41	....
12	1	Just past full bloom	8.87	9.94	1.40	14.54	36.39	30.59	....
13	1	In full seed	4.70	6.77	1.03	12.16	46.12	29.22	....
1	2	Not in bloom, without irrigation	6.48	10.51	1.46	16.40	28.66	36.49	....
2	2	Coming into bloom, upland	4.40	11.95	1.14	18.47	32.46	31.58	.517
3	2	Half bloom	6.61	9.91	1.18	16.11	37.24	28.90	.350
4	2	Half bloom	5.29	9.48	1.52	13.03	37.39	33.29	.614
5	2	Full bloom	4.31	10.97	1.76	12.88	38.06	32.02	.202
6	2	Half ripe, upland, with irrigation	7.24	8.92	1.99	12.08	30.99	38.79	....
1	3	Hay, College Farm	5.78	9.38	1.61	12.53	39.35	31.35	.100
2	3	Hay, Rocky Ford Station	6.08	10.28	1.31	13.57	34.67	34.09	....

LEAVES, ETC.

..	....	Leaves, with irrigation	4.93	14.48	2.96	23.33	13.15	41.16	....
..	....	" " "	4.63	14.29	2.94	24.33	13.12	40.70	....
..	....	" " "	8.40	13.60	4.10	22.18	10.67	41.05	....
..	....	" without irrigation	8.53	13.35	3.43	22.60	10.66	41.45	....
..	....	" " "	8.62	11.39	4.28	22.30	12.48	40.90	....
..	.. .	" half bloom without irrigation	8.38	11.39	4.28	23.31	12.48	40.60	...
..	....	" " " "	4.49	14.50	2 88	20.20	16.16	41.77	....
..	....	Plants past full bloom	4.52	14.51	3.05	20.20	16.16	41.72	....
..	....	Stems	5.41	4.91	.94	6.31	54 40	28.03	.070
..	....	Flowers	4.46	9.41	2.11	21.33	19.92	42.77	.692
..	....	Seed	6.35	3.19	14.41	29.26	9.35	37.04	....

* Not included in average.
† Samples 8, 9, 10 and 11 grown in drills.

Farm Samples.

Number.	Number of Cutting.	CONDITION AT TIME OF CUTTING.	Moisture.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Amide Nitrogen.
1	1	Individual plant	7.27	10 97	3.89	17.72	24.54	35.67	....
2	1	Individual plant	6.71	11.68	3.43	17.08	24.64	36.42	....
3	1	Hay, damaged	9.61	10.94	3.44	9.95	35.09	30.97	....
1	2	Individual plant	4.88	9.72	.82	12.15	34.59	37.84	....
2	2	Individual plant	3.71	10.31	1.17	12.29	38.08	34.43	....
3	2	Individual plant	11.61	11.26	1.69	15.26	29.07	31.11	....
4	2	Individual plant	11.75	10.63	2.43	16.26	26.16	32.77	....
1	3	‡ Sample, Field D	6.28	10.29	1.93	15.83	28.89	36.78	....
2	3	Prime hay	4.71	9.94	1.24	12.01	37.29	34.81	....
3	3	Prime hay	5.58	9.94	1.11	12.57	34.91	35.84	....

‡ Sample somewhat charred in drying.

ALFALFA AND CLOVER HAY COMPARED.

The plants from which these hays were cut, were growing side by side under identical conditions, were cured in the same manner, and are comparable in every respect. The clover was very vigorous; the flowers were very nearly half turned; the stems were stout, but leafy; and the whole plant was in prime condition. The hay was cured in a sack as before described in the account of the preparation of our alfalfa samples. A sample of alfalfa also in prime condition and in half bloom is chosen for the comparison. The green clover yielded 24.25 per cent. of hay, and 75.75 per cent. of water, and the alfalfa 26.94 per cent. of hay and 73.06 per cent. of water.

	Moisture.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Amide Nitrogen.
Clover, heads half turned	5.36	10.17	1.88	13.43	28.97	40.20	.155
Clover heads,half turned	5.22	9.97	2.03	13.43	28.83	40.53	....
Water free substance	....	10.75	1.99	14.18	30.61	42.46	....
Water free substance	....	10.52	2.15	14.18	30.42	43.74	....
Average, water free	....	10 63	2.07	14.18	30.52	43.10	....
Alfalfa, half bloom	6.04	9.30	1.19	14.43	36.54	32.50	.372
Alfalfa, half bloom	6.29	9.33	1.51	14.43	36 38	32.06	....
Water free substance	....	9.89	1.26	15.37	38.88	34.60	....
Water free substance	....	10.06	1.61	15.37	38.53	34.43	....
Average, water free	....	9.98	1.43	15.37	38.71	34.51	....

The coefficients of digestion for good quality clover hay is given, in Massachusetts State Experiment Station Report for 1893, as 48 for crude fiber, 49 for proteids, 43 for ether extract, and 58 for nitrogen free extract; and for alfalfa, 46 for crude fiber, 73 for proteids, 51 for ether extract, and 68 for nitrogen free extract.

One hundred pounds of this clover hay contain, when perfectly dry, 47.49 pounds digestible food, of which 6.95

pounds is proteids, while the alfalfa furnishes 54.43 pounds digestible food with 11.22 pounds proteids. The green alfalfa crop yielded in this case almost 2.5 per cent. more dry matter, which contains about 7 per cent. more digestible food than the clover.

ALFALFA, RED CLOVER AND PEA-VINE ENSILAGE COMPARED.

The loss in making alfalfa hay, together with other considerations, has led to some experiments in making alfalfa silage. The following samples were received, one in late summer and the other in late winter. The condition of each was considered good, and cattle were reported to eat them freely, even in early fall when they had access to green pasture. The average dry matter, as determined in three samples, is 30.19 per cent.

Sample No. 1—Farm Department—Silage made from first cutting :—

	Moisture.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.
1. Alfalfa Ensilage	8.98	13.19	2.93	14.18	30.77	29.95
Water Free	....	14.46	3.22	15.57	33.49	33.25
2. Alfalfa Ensilage	2.21	11.91	1.19	17.63	36.06	31.00
Water Free	....	12.19	1.22	18.02	36.89	31.70
3. Pea-vine Ensilage	4.71	14.91	3.24	10.95	30.06	36.13
Water Free	....	15.63	3.40	11.03	31.39	38.54
4. *Red Clover Ensilage	....	9.30	4.10	15.00	29.90	41.70

*Expt. Sta. Bul. No. 11, p. 52.

These samples of ensilage were in good condition when received at the laboratory. The alfalfa silages, particularly No. 2, had a marked disagreeable odor and taste ; the pea-vine ensilage was bright, with an agreeable odor and a pleasant acid taste. Mr. Empson, of Longmont, through whose kindness this sample was furnished, informs me that the vines used in making silage are of varieties grown by their company for canning. The peas are threshed out and the vines are put in silos and subsequently fed to sheep or lambs. The vines are cut when the crop is in best condition for canning. It is evident that this pea-vine silage is poorer than pea-vine silage would be by whatever of nitrogen, etc., is removed in the peas. The ash in the pea-vine silage is really not so high as appears in the analysis. It amounts to 8.96 per cent., after the deduction of sand. It will seldom be advantageous for the farmers of this country to make their alfalfa crop into ensilage, but if they should choose to, the ensilage produced, as shown above, will compare favorably with a very good quality of alfalfa hay, and is quite as well adapted to this use as red clover or peavines. Alfalfa, when stacked with a great deal of moisture in it, sometimes passes through a fermentation, producing a hay which may be considered as intermediate between alfalfa hay and ensilage. In the cases which have been called to my attention this result has been obtained by accident, and, of course, without special care or extra labor. This is very near to the so-called brown hay; its color is reddish and it is a very agreeable fodder to cattle.

As to the digestibility of either the ensilage or of this red or brown hay, I find no data; but cattle fed on either are said to thrive admirably, and it seems probable that the digestibility in these cases does not differ materially from that of the field-cured hay. In making alfalfa ensilage, the silage must be carefully protected from the influence of conditions producing further changes than those producing the ensilage fermentation. The following analysis of damaged ensilage will enforce this statement:

	Moisture.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.
Damaged Alfalfa Ensilage	5.90	17.89	2.34	15.47	46.18	12.22
Water Free	....	19.01	2.49	16.41	48.90	13.19

The decrease in the percentage of nitrogen free extract and the increase in that of the ash and crude fiber are equally noticeable.

What the loss of dry matter was in either of these cases I do not know. Storer, in his Agricultural Chemistry, quotes the loss of dry matter in making alfalfa ensilage at 27 per cent. The amide nitrogen was not determined in these ensilages, and, while it is known that there is a retrogressive change in the nitrogenous compounds in making ensilage, I have no data on which to base an approximate estimate of the loss of these in either of the preceding instances. The damaged ensilage is richer in total nitrogen than the prime ensilage, No. 1, and the nitrogenous compounds seem to have changed slowly; this, however, is subject to modification, due to the formation of amides; also a small amount of ammonia from the albuminoids.

ELEMENTS OF PLANT FOOD TAKEN FROM THE SOIL.

The leguminous plants, to which order alfalfa belongs, store up in their stems a large amount of nitrogen which they are believed to obtain largely from the atmosphere, and for this reason they are considered as nitrogen gatherers, adding to the soil more nitrogen than they draw from it, provided the plants are not removed, but fall where they grow or are plowed under. But, when the hay is taken off the field, the problem is a different one, and whether it adds to the nitrogen in the soil or takes from it, depends upon the ratio of the nitrogen in the leaves and stems which fall and decay upon the soil to that taken from the soil proper in the form of nitric nitrogen. As I know nothing of the value of this ratio, I am compelled to content myself with the general results which are well known; still, under the discussion of the roots, we shall see that there are reasons why we are justified in doubting whether the store of nitrogen in the soil is added to by growing alfalfa; on the contrary, while this plant is provided with tubercles—micro-organisms which enable it to appropriate atmospheric nitrogen—it is also a greedy feeder upon the soil nitrogen.

The benefits which accrue to soils cropped to alfalfa are unquestionably great, but whether they are lasting, or call for a quick rotation in order to be maintained, is still to be established. The case of the other elements of plant food is not involved by any compensation as in the case of nitrogen; but every pound taken away is at the expense of the supply in the soil. As our soils have not been under crops of any kind very long, and to alfalfa only a short time, it is a reasonable assumption that the average mineral constituents of the ash correspond very nearly to the requirements of the plant. The quantities given by our analyses, representing plants supplied with an abundance of available food, are probably high enough.

The accompanying table gives the ash constituents taken from the soil with every 1,000 pounds of hay. The sand, carbon, and carbonic acid are rejected in this table. There may appear to some to be a discrepancy between the table as given on page 31, and the following; the two are, however, the same as concerns the following subtances contained in the ash:

POUNDS PLANT FOOD PER 1,000 POUNDS ALFALFA HAY.

Cutting.	Condition of Plant.	Silica.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Lime,	Magnesia.	Iron Oxide	Alumina.	Manganese Oxide.	Potash.	Soda.	Total.	Nitrogen.
1	Green...........	1.158	4.923	4.349	9 655	22.352	3.159	.371	.159	.163	29.720	1.174	77.183	24.96
1	Green...........	1.006	4.031	4.323	5.169	21.528	3.314	.386	.147	.109	25.848	1.237	67.098	22.89
1	Half bloom.....	.924	4.105	4.418	3.865	21.690	3.343	.295	.165	.109	26.078	1.434	66.426	23.08
1	Half bloom.....	1.404	4.138	5.230	6.288	22.182	5.523	.369	.235	.174	22.209	1.708	69.461	21.40
1	Full bloom.....	.813	4.839	5.182	10.052	25.522	3.509	.248	.083	.156	22.398	.869	73.671	23.16
1	Full bloom.....	1.808	4.015	3.412	6.829	25.647	3.776	.074		.064	28.137	.857	74.619	22.53
1	Full seed.......	.706	3.474	2.705	4.851	12.934	2.864	.261	.157	.155	17.985	2.586	48.678	19.46
2	Begin'g bloom..	.917	4.709	7.306	10.359	31.038	4.031	.360	.066	.230	30.324	2.223	91.563	28.91
2	Half bloom.....	.631	4.812	7.356	10.174	26.626	3.824	.259	.109	.156	27.930	1.838	83.715	25.89
2	Full bloom.....	.919	4.882	7.194	10.541	28.390	4.358	.363	.186	.205	26.076	1.073	84.187	20.61
2	Past full bloom.	1.353	4.238	4.257	8.428	27.426	4.124	.115		.084	10.643	.948	70.616	20.85
3	Hay.............	.402	3.397	3.087	40.839	18.694	3.605	.175	.081	.107	24.693	4.255	63.335	18.95
..	Red clover......	1.831	3.661	1.260	2.573	23.778	5.227	.102	......	.203	25.160	.223	64.018	21.49
..	Flowers	2.971	7.248	5.887	4.593	15.948	3.720	.957	1.110	.191	24.076	3.787	70.487	34.12
..	Leaves..........	2.673	4.367	16.704	7.009	45.425	7.626	.821	.814	.317	13.196	5.396	104.348	31.77
..	Leaves..........	1.009	5.114	13.062	8.665	33.042	5.395	.344	.273	....	21.277	4.411	92.592	35.68
..	Leaves..........	1.048	4.661	9.381	10.906	52.569	5.839	.602	.141	.266	15.846	1.062	102.221	35.49
..	Leaves..........	1.159	4.900	15.356	8.490	50.488	6.425	.610	.139	.447	15.447	5.157	108.618	38.92
..	Stems...........	.790	2.198	1.711	2.934	7.002	2.563	.225	.233	.082	13.184	4.110	35.032	10.09
..	Stems...........	1.099	3.039	2.392	4.102	9.768	3.604	.328	.334	.112	18.394	5.710	48.882	......
..	Stems...........	.731	3.769	1.297	6.381	9.117	2.915	.340	.183	.098	20.817	2.813	48.461	......
..	Stems...........	1.015	3.272	1.254	6.525	11.671	2.871	.239	.244	.097	24.159	.721	52.068	......

These results show that, with each ton of first cutting hay, there is removed an average amount of 143 pounds of ash constituents; with each ton of second cutting hay, 165 pounds; and with the third cutting, 127 pounds per ton. Our sample of red clover gives 128 pounds against 143 pounds for the alfalfa. The following are the amounts of the most important plant foods taken from the soil and air by the successive cuttings of alfalfa and red clover hay per ton of 2,000 pounds:

	Nitrogen.	Phosphoric Acid.	Potash.	Sulphuric Acid.	Chlorine.	Lime.	Magnesia.
First cutting................................	46.00	8.69	51.46	8.97	13.95	46.40	7.54
Second cutting..........................	48 13	9.32	51.99	13.06	19.75	56.74	8.17
Third cutting	37.90	6.79	49.39	6.17	8.16	37.39	7.21
Average for alfalfa hay	44.01	8.27	50.95	9.40	13.95	43.51	7.64
Alfalfa in full seed	38.92	6.95	35.97	5.41	9.70	25.87	5.73
Red clover, heads half turned...........	42.98	7.32	50.32	2.52	5.15	47.56	10.45

This table gives the amount of plant food removed by a ton of average hay; but if the amount removed by an average crop is desired, we have taken 1.65 tons for first cutting, 1.2 tons for the second cutting, and 1 ton for the third cutting. This is estimated on a yield of 3.8 tons for the three cuttings, which is not far from the average crop. This correction changes the total amount of mineral matter removed from 167.23 to 169.26 pounds. Actually weighed crops seem not to be of record in such numbers as to give them value as a basis. That four, five and more tons have been cut per acre, is not doubted, but such yields are not the rule. The land of the Rocky Ford Station has yielded a trifle over five tons and so has land near Loveland, in this county, and doubtless at many other places, but these are large and not average yields. Estimated yields are seldom too low and measured tons are only approximately correct, but they serve a good purpose when nothing better is available. Adopting the judgment of sixteen farmers of Colorado, some of whom are known to the writer as practical and conservative men, we make the average yield 3.7 tons per acre. Mr. A. A. Mills, of the Utah Station, makes the yield from measured areas 4.24 tons per acre. These figures seem exceedingly conservative when compared with many current estimates, but they are fully high enough for the average crop and close approximations to its upper limit.

ALFALFA SEEDS.

The ordinary analysis of the seed is given in the table on page 31, and the ash analysis in the appendix. The fat or oil—ether extract—was determined by both my assistant, Mr. Ryan, and myself. Mr. Ryan obtained 14.41 per cent. and I 14.04 per cent. Mr. Ryan extracted his portions for many days; I extracted mine for eight hours. There seems to be a volatile portion, which gave Mr. Ryan trouble in determining the moisture.

AMOUNTS OF SEED COMMENDED FOR SOWING PER ACRE.

The practice followed by many intelligent farmers of selling the good seed and sowing the screenings, led us to make the following experiments, even though they digress from the main purpose of this bulletin.

The fresh seed has a light greenish yellow color which is sensitive to the light, eventually becoming reddish brown. The size of the seed varies; it is described as larger than clover seed. A sample gathered by hand from plants growing singly on a poorly irrigated piece of ground, had the following properties: bright greenish yellow color; more than twice as long as broad; and as a rule not as thick as broad; thicker at one end than at the other, giving the seed a slightly twisted appearance; length a little more than 3-32 of an inch. The pods were full, the seeds pressing one upon the other. The analysis of these seeds is given in the table. When well dried the seeds absorb moisture readily. Fifteen portions of one gram each were weighed off, after thoroughly shaking the sample, and counted. The average was found to be, 456 seeds to the gram ; lowest number per gram, 450 ; highest number 463 ; number of seeds per pound, 206,837.

Sample No. 2, purchased in the market, gave 458.6 seeds per gram ; 208,021 seeds to the pound. These seeds were not so even in size as the first sample. There were a few shrunken seeds. The sample was clean, containing less than one per cent. by number of foreign feed. Sample No. 3, also purchased in the market, was of a brownish yellow color; sample contained 8 per cent., by number, of foreign seed, mostly of an amaranthus. The average number of seeds to the gram of this sample was 504.46. The seeds were very even in size ; minimum number to the gram, 503 ; maximum, 505. The number of seeds to the pound was 228,818.

Sample No. 4, consisted of first quality screenings, furnished by J. E. Gauger, Rocky Ford, Colo., about 65 per cent. of which was immature when cut. The seed was shriveled and dark brown in color. The sample was quite free from grass seeds, weed seeds, and stems, and contained 259,340 seeds to the pound.

Sample No. 5, first quality screenings from the same source as No. 4, was dark and contained many shriveled seeds, in which by weight there was 23 per cent. of impurities—grass and weed seeds. This sample contained 344,123 seeds to the pound.

Sample No. 6, first quality screenings (J. E. Gauger) seed evidently well cured, many seeds green and immature, contained 266,233 to the pound.

Sample No. 7, second quality screenings (J. E. Gauger), containing more stems and weed seeds, especially of an amaranthus, than any other sample, contained 331,383 seeds per pound.

Sample No. 8, third quality screenings (J. E. Gauger), was quite clean. The seeds were large, but shriveled, numbering 312,385 to the pound.

We may assume that a pound of first-class seed contains 210,000 seeds; first quality screenings, 260,000 and occasionally many more on account of shriveled seeds ; and for second and third quality screenings, about 320,000 seeds to the pound.

THE QUESTION OF WHAT IS A GOOD STAND.

The amount of seed sown to the acre in this state varies exceedingly, the smallest that I know of as having been sown for a hay crop, being seven pounds per acre; and having examined the stand personally, I have no doubt but that it will produce as large a crop as a heavier seeding would, but whether there is the same certainty of getting an even stand is a question. In this case it was very even. The highest amount that I have seen given as sown to the acre is thirty pounds. Twenty and twenty-two pounds to the acre is common. This gives us, supposing prime seed to be used, from 1,470,000, with seven pounds, to 4,620,000 seeds when twenty-two pounds of seed are sowed to the acre. There is certainly a wide difference in practice, and it is claimed, with no difference in the result, either in quantity or quality of hay. The majority is unquestionably in favor of heavy seeding, but the minority seem to me to have more reason on their side.

The quantity of seed to be sown to the acre was touched upon by Miller (1807). "In sowing broadcast Rocque directs fourteen pounds to the acre; in Kent they sow twenty pounds, which is generally allowed to be the proper quantity; in France they allow near thirty pounds to an English acre. Some sow only ten pounds with six pounds of broad clover, to have a crop the first season, both with a thin crop of barley or oats." Again, he says: "The field was sown broadcast with Lucern seed. * * Twelve pounds to the acre sown at twice." And of another field of broadcast Lucern sown twenty years before with barley. "The plants were in patches or single, often two or three feet apart; yet it produced four tons of hay on an acre, at three cuttings. * * * It also shows what a large space plants of Lucern will fill."

Two reasons can be urged in favor of heavy seeding, and if they are founded on facts, they are sufficient to justify the practice. One is that a thick stand produces a more desirable hay than a thinner one; the second is that a large amount of seed is necessary to obtain such a stand. In the first proposition there is clearly a lack of definiteness in the term "a thick stand." Very few persons who use the term have any idea whether they mean by this one or twenty plants to a square foot, and I doubt whether there is any increase of crop or quality of hay gained in one field with 260,000 plants to the acre over another with one-half that number, assuming that the stand is equally even in the two fields and that other conditions are similar. This is six and three plants to the square foot respectively.

We have given ourselves some trouble to establish some thing definite regarding the terms stand, good stand, etc., in connection with the weight of stubble plowed under.

A piece of alfalfa, six months old, contained fifteen plants to the square foot, or 653,400 per acre (Prof. W. W. Cooke), which is one plant for every seven seed on the basis of twenty pounds of seed to the acre. A measured piece, twenty-five feet square, was plowed up and the plants picked out of each furrow in turn, the whole of the soil being turned over by hand, and the number of plants to the acre was found to be 526,793. Prof. A. E. Blount writes me that this field was seeded to alfalfa May 10, 1886, and was consequently ten years old. The roots were very small, not over one quarter of an inch thick at the crown, and were in a remarkably healthy condition. This portion of ground is as high as any other cultivated portion of the college farm and is a fine, loamy soil. The yield last year was rather over four tons (weighed) per acre.

Mr. Philo K. Blinn, Superintendent of the Rocky Ford Experiment Station, in Otero county, at my request, measured off a square twenty-five feet on the side and counted the plants. He found 139,392 to the acre. This is a most excellent piece of land, alluvial soil. The yield of alfalfa hay last year was 4.4 tons per acre. Mr. Blinn measured two small squares, 5x5 feet, obtaining 291,000 and 305,000 plants in these.

I selected an average plat 25x25 feet in a field one year old seeded with twenty-two pounds of seed to the acre, cross drilled 11 pounds each way. The soil is a fine loam, subsoil sandy clay succeeded by fine sand. This plat has been in cultivation a number of years. The stand would be designated as "very good." The cross drilling showed plainly at this date, April 29. Number of plants per acre, 331,122.

A piece 25x25 feet of another field, sowed to alfalfa May 17, 1884, twenty pounds of seed to the acre, (Prof. A. E. Blount), was plowed up. This field of alfalfa is in bad condition. The stand is very irregular, large patches of ground being entirely bare. The soil is a sandy loam, with clay subsoil; water plane four to eight feet from the surface. Number of plants per acre, 70,283. Nearly every plant has a hollow crown and root; yield per acre last year something over three tons. At three tons this is approximately 1 1-4 ounces of hay or less than 4 1-6 ounces green weight to the plant for the season. In the case of the 562,-793 plants and four tons yield, it is only 1-4 ounce of hay to the plant, or one ounce of green weight for the three cuttings. I sought out twenty plants growing singly, which had received no care whatever. They were in patches of volunteer plants. The weights were taken immediately upon cutting and averaged 14.4 ounces or 3.8 ounces of hay to the plant. The average number of stems was 39 to the plant; the highest number was 58. The lowest weight was about 1-3 of a pound, the highest 2 1-3 pounds. Any one familiar with alfalfa will recognize that these plants can be duplicated easily and are by no means unusually large. I found a plant standing quite by itself in the field of James Whedbee, the space in which the plant grew being about three and possibly as much as four square feet. There arose from the crown of this plant 161 stems. I dug up one other plant, which had 360 stems on it; the space covered by this crown was about three square feet. The weight of these I regret was not determined. Others have observed even larger plants. Miller says that he had a plant whose crown was eighteen inches in diameter, and from which he cut nearly four hundred stems at one time. M. Duhamel states that a flourishing plant will produce a pound of well dried hay. These facts seem to me very suggestive. I have noticed with some degree of attention the size of the stems on these large plants and I do not find them of noticeable coarseness. I believe that every advantage supposed to be obtained by crowding the plants, whether the claim be well founded or not, will be produced with an even stand of not more than four plants to the square foot, and of two or even one under favorable conditions. The importance of favorable conditions is admirably shown by the yields of the plat giving 526,793 plants per acre. In 1893 it yielded 2 2-5 tons at the first cutting; this year about one ton. Moisture is necessary to the production of a crop of alfalfa. I regret that we have no analyses of hays cut from crowded and from singly growing plants. Granting, however, that a stand of a half million plants to the acre is desirable, is so large a quantity of seed as twenty pounds, about 4,200,000 seeds, necessary to produce it? This will depend first of all upon the germinating power of the seed, and also upon the vitality of the plants produced.

VITALITY OF ALFALFA SEED.

It is claimed that alfalfa seed soon looses its germinating power, and that the young plants are very tender, though hardy enough when established and older. Concerning the former, Loudon says: "Great care should be had to procure it (Lucern seed) plump and perfectly new, as two years old seed does not come up freely." In North Carolina Bulletin No. 60, these seed are described as twice as large as red clover seed with a brownish yellow hue. "The vitality of Lucern seed is so low that seed over one year old is scarcely worth sowing." The author of that bulletin records two sprouting experiments made with presumbly two years old seed, showing only 6 and 12 per cent. of the seed capable of germinating. This is quite in accord with the statement of Loudon. Not finding myself able to unhesitatingly subscribe to these results, I collected the following samples of seed. I experienced difficulty in obtaining in our local markets seed two years old, even after explaining my desire and object.

1. Prime seed, two years old, gathered by myself.

2. Prime seed, two years old, obtained in market fresh and kept in laboratory.

3. Prime seed, obtained of P. Anderson & Co., probably two years old.

4. Prime seed, two years old, grown in Otero county, (J. E. Gauger).

5. Prime seed, three years old (J. E. Gauger).

6. Prime seed, six years old, obtained from Professor Crandall, whose record shows that this seed was obtained from P. Henderson & Co., of New York, through the Department of Agriculture at Washington, D. C., in the spring of 1891. This sample had been kept for most of this time in a 2-oz. bottle, exposed to the light in a show-case. The seeds were discolored, reddish brown, and emitted a rancid odor when poured out for the purpose of mixing. I, of course, have no record of the variations in temperature to which these seeds had been subjected, but they were certainly great. Their state of moisture varied, also, but probably less than any other external condition.

7. Screenings, first quality, one year old, (J. E. Gauger).

8. Screenings, first quality, two years old, (J. E. Gauger).

9. Screenings, first quality, three years old, (J. E. Gauger).

10. Screenings, second quality, two years old, (J. E. Gauger).

11. Screenings, third quality, one year old, (J. E. Gauger).

The following tests of these seeds were made with such facilities as are at the command of every farmer. A common tumbler was filled with crumpled paper to about half its hight and pressed down until it was quite even. On this were placed three disks of ordinary blotting paper; the seed were strewn upon the upper one of these disks and covered with two similar disks of blotting paper and one of cardboard. The crumpled paper was thoroughly wetted, the disks and seed put in place, and enough water added to fill the bottom of the tumbler to the depth of about half an inch, and placed on a box behind the sitting room stove. The water that evaporated had to be replaced, and required the addition of a tablespoonful night and morning. The tests were continued for fourteen days; the record is as follows:—

RESULTS OF SPROUTING EXPERIMENTS.

No. of Sample.	Quality.	Years Old.	Number of Seeds to the Pound.	Seeds Taken.	Seeds Rotted.	Seeds Left.	Seeds Sprouted.	Average per cent. Sprouted.
1	Prime seed	2	206,837	100	0	0	100	96.0
				100	0	8	92	
2	Prime seed	2	228,818	100	1	9	90	92.0
				100	0	6	94	
3	Prime seed	2	208,021	100	1	7	92	95.5
				100	1	0	99	
4	Prime seed	2	....	100	1	13	86	88.0
				100	5	5	90	
5	Prime seed	3	....	100	0	2	98	98.5
				100	0	1	99	
6	Prime seed	6	....	100	5	1	94	93.0
				100	5	3	92	
7	Screenings, first quality	1	259,340	100	23	11	66	66.5
				100	20	13	67	
8	Screenings, first quality	2	344,123	100	42	7	51	55.5
				100	29	11	60	
9	Screenings, first quality	3	266,233	100	24	1	75	79.0
				100	16	1	83	
10	Screenings, second quality	2	331,383	100	59	7	34	38.0
				100	53	5	42	
11	Screenings, third quality	1	312,385	100	66	1	33	38.5
				100	48	5	47	

The seed designated as "left" or hard seed, make from 1.5 to 9 per cent. of the samples of prime seed and from 1 to 12 per cent. of the screenings. These seem not to imbibe water for a long time, but eventually they do when they swell and sprout in large numbers. The hard seed remaining at the end of the sprouting tests were put together and the test continued for an addional twenty days, when 78 per cent. of them had sprouted, 13 percent. rotted, and 9 per cent. were still left. This explains, in part at least, the observations that some alfalfa seed seems to lie dormant for a time.

The sprouting tests were continued for from 13 to 16 days, but a sufficiently accurate estimate of the germinating power of the seed could have been formed by the end of the third day, as the following shows :—

THE NUMBER OF SEEDS WHICH HAD EITHER ROTTED OR SPROUTED AT THE END OF THE THIRD DAY.

	Per cent.
Prime seed, two years old	87.00
Prime seed, six years old	80.50
First quality screenings, one year old	84.00
" " " two " "	85.00
" " " three " "	85.00
Second " " two " "	85.00
Third " " one " "	93.00

There is a considerable difference in the readiness with which the different samples of the same age germinate, more even than between samples of different ages. The quickest of the eleven samples to germinate was the one six years old. The results are positive in showing that the age of the seed up to six years old does not effect their germinating power. In regard to the vitality of the plants produced, I have made no observations, but so far as I could judge from the vigor with which the seeds sprouted, I would say that it depended upon the seeds themselves rather than upon their age; the seeds of some samples being obviously stronger than those of others, and each sample showed this difference between the individual seeds.

These tests and observations also strengthen the claim made that in practice screenings produce as satisfactory results as prime seed. Taking it on the basis of the germinating power in the most unfavorable sample, second quality screenings two years old, with only 38 per cent. germinating, we have, where twenty pounds of seed are sown to the acre, 1,325,532 plants, and assuming that one-seventh of them live, there would be 189,361 plants to the acre, or over four to the square foot, a sufficient number surely to produce a maximum crop. It sometimes happens that it is necessary to re-sow a field the second year, even with twenty-two pounds of seed per acre. Such failures are not due to the quantity of seed nor to the germinating power. I do not believe that it would happen oftener with eleven pounds to the acre than it does with twenty. It is not my province to seek the causes of such failures, but I think I have adduced sufficient proof that it does not lie in the germinating power of the seed.

ROOTS OF ALFALFA.

That this plant is an exceptionally deep rooting one, has been recognized by every writer on the subject, as is evidenced by the statements to be found scattered through the literature on this subject ascribing a length of ten, fifteen, thirty-five, and even more feet to its roots. The popular estimation of their length has been and is equally appreciative of their power to penetrate to considerable depths. The size attained by the roots has also been stated to be large, but the writer does not recall having seen any figures given to convey a definite idea of the size actually attained under stated conditions of soil, age of plant, cultivation, etc., but rather that the root is a tap root, large and fleshy, "resembling a carrot" more or less, or is represented as forming a symmetrically formed but inverted cone, in which system the tap root is, as a matter of course, the longest and central portion or axis.

The size of alfalfa roots is not so great as the usual adjectives used in describing them would lead one to infer. It is a strong root, but is under one-half inch in diameter, rather than above it. This statement is true of the plants when grown in a deep, sandy loam, under favorable conditions as to irrigation and climate, including mild winters. Larger roots have been observed by the writer, but there have been special conditions obtaining wherever this has been the case and these roots represented the size which the alfalfa root may attain, and not the average size which they actually do attain when growing in ordinary soil, and standing thick enough to produce, say 3 1-2 tons of hay per acre, with three cuttings annually. The largest root measured by me, was 2.82 inches in diameter, being nearly circular in section, though not quite ; its largest diameter was rather more than three inches. An examination proved that this was an anomalous root. For some reason, not discovered, the tap or central root was short, not exceeding 1 1-2 feet, at which point it divided, giving rise to several rather small branches which were not followed as they spread out, running several feet almost horizontally. This dividing could not be attributed to the roots having encountered a hardpan or other obstacle, for the soil at this depth was uniform in hardness above and below the point of spreading. I have seen several very large roots, but have found upon digging them out, that they were in every case short and at variance with what seems to be the normal type.

The root system of this plant, growing in our soils, is exceedingly simple and is shown in the plates. The roots represented, are from three different counties, the soils varying from sandy loam to heavy clay. They show a marked permanency in type of development in a simple tap root, running down to from three to five feet and then sending off a few side roots, or rather dividing into a few branch roots about equal in size and length. These branches do not, as a rule, deviate more than a few inches from the course pursued by the tap root before division. I have in no case found a system of small roots starting out below and near the crown, extending laterally for several feet and then turning downward, forming a symmetrical conical system, whose broadest part was near the surface. The absence of such roots was a matter of note to me, but after having observed it in upwards of three hundred and fifty instances, I was satisfied that it was a habit of the plant. In cases where I found any root or roots setting out from the tap root immediately under or near the crown, they were large, usually as large as any of the roots formed by the branching of the tap root, and in every instance in which I was able to follow them to the end, they extended to almost or altogether as great a depth as the tap root itself or any of its divisions. When such side roots occured, we found but few of them, as a rule only one or two. This is well shown in one of the plates. The tap root, as well as all its divisions, are remarkably smooth and free from fibrous roots. The tap root is often perfectly smooth, save for the wart-like excressences on it, caused by its symbiotic micro-organisms ; so much so that it can be removed after having been properly exposed, leaving a perfect cast of the root in the undisturbed soil. Close investigation of the adjacent soil has failed to show small roots even a few inches in length, such as may be found practically possessing the ground for many inches—twenty or more—about the vetch, tomato, or almost any of our garden plants. It may be stated here that the plants studied had not been cultivated, that is, the soil about them had not been disturbed from the time the seed was planted until the plants were dug up, except in cases where the fact will be explicitly mentioned.

The absence of these small fibrous roots has been and still is perplexing, as it was anticipated that such a vigorously growing plant would be well supplied with such, each provided with its spongiole to provide the plant its necessary sustenance. While the number of spongioles found was in the aggregate large, it was much smaller than expected and the spongioles were at the extremities of the roots themselves and almost exclusively at a depth corresponding to that attained by the root. This observation is in perfect accord with the usual statement that alfalfa is a deep feeder and furnished a very convenient explanation for the observed effect of an alfalfa rotation upon an exhausted soil; but it is contrary to another fact which has also been observed, i. e., that alfalfa responds quickly to top dressings of fertilizers, barnyard compost and ashes being the fertilizers here referred to. Other fertilizers may produce equally quick and marked effects, but reliable observations have been made with these two. The spongioles were found mostly at or near the depth reached by the tap root. The form and size of it varied greatly. It was as a rule cylindrical, from one to one and a half inches long and terminated by a rather stiff hair-like projection. The root leaving it was much smaller than the spongiole for several inches behind it, and, consequently, was growing in a free space made by the extending spongiole. The amount of work done by the plant in this manner is very great. While the cylindrical form prevails, others also occur, a double cone shape being quite common. As already intimated, these were not found in large numbers near the upper part of the roots; and at no other point except where the softness of the ground and a greater abundance of food encouraged their development. Such conditions were found, for instance, in refilled prairie-dog holes which were always crowded with them and in places very thickly so.

THE DEPTH ATTAINED BY THE ROOTS.

The depth to which the roots penetrate and at which they feed varies, as a matter of course, with the soil; and in cases where the permanent water table lies within twelve feet of the surface, with this also, as the roots do not according to my observations enter the water for a greater distance than from four to eight inches. The popular notion that the roots cannot endure the water, but cease to grow and decay as soon as they reach it, is not substantiated by observation. They do cease to extend further downward, but all that I have had opportunity to observe were healthy and vigorous. I entered the permanent water plane at two localities where I dug out the roots. In one instance the water was alkaline (Jas. Whedbee's place, 1½ miles from Fort Collins); in the other (Rocky Ford, Otero County) the water, an analysis of which will be given later, was as bitter as a solution of Epsom salts. The roots, however, penetrating it were not dead. In the former case the water was only six feet seven inches and in the latter twelve feet from the surface. The roots do cease to descend, as would be expected, when they reach permanent water; but they do not on the other hand continue their downward growth under all circumstances until they reach permanent water. In choosing a place at which to dig up alfalfa roots, several things had to be considered, especially as my original plan was, after having found plants of some age, to make an excavation of sufficient size and depth and then to remove the plants by washing away the soil. I succeeded in finding the plants and water favorably located, but a little examination of the manner in which the soil had withstood the action of the waste water from an irrigating ditch suggested that it would be utterly impractical to wash out the roots; and this was the case. The site chosen was about twelve miles from Fort Collins, on the place of Mr. J. H. Walter, in Weld county, at a point where a ditch had been cut through a hill, making a cut at the deepest point of rather more than twelve feet with a flume crossing it at this point. The lake, or reservoir which the ditch had been cut to empty had not been filled, so I was informed, for several years and the soil at the bottom of this cut had had no other than rain and snow water to wet it in that time. I do not know at what depth the water plane lay at this point; but unless the water plane was somewhat above the level of the water in the lake near by, which, after making allowance for the damming back of the water in the soil, seemed to me very improbable, it must have been a good way below the bottom of the cut, so that the roots had most favorable conditions to seek it if they did not get enough moisture otherwise. These plants were either five or six years from the seed, were growing a few feet from the edge of the cut, were exceptionally vigorous, and were at that time in full seed, not having been cut that season. I do not know how much water they had received, but judging from the condition of the corn and alfalfa growing within a few feet of them, the supply had not been very liberal, and I inferred that they owed their luxuriant growth to the fact that it had probably been made during the time of early rains and to their advantage of position, in that they were growing in a little sag in the surface of the ground. A section of this soil was as follows: about three inches of blown dirt, leaves, dead stems, etc., from previous years; in other words, soil made about the plant subsequent to their establishment there; then followed twenty-one and a half inches of a black, compact soil which had not been disturbed by the plow except very superficially. This was so firm and tough that it had to be removed with a pick. Succeeding this was six inches of a white marl; next a calcareous clay, three feet; then a hard, tough clay of three inches, followed by a rather sandy clay of three feet thickness; and then a second band of tough, hard clay, three inches; and lastly a fine sand. This soil from top to bottom was only slightly damp, and the sand and sandy clay in the bottom of our excavation was as dry as any portion of it except the very top. These roots were the largest that I have ever seen anywhere and supported the most luxuriant growth of tops. The crowns were large and the stems were very tall, measuring five feet three inches. The streaks of hard clay had not caused the roots to spread out and seek the contact between it and the softer soil, but it had caused them to double upon themselves, to twist and knot, and then run horizontally for some inches when they changed their course and descended again. It was almost as difficult to get them out of this without cutting or breaking as it had evidently been for them to make their way through it. I did not observe a single instance in which the root had divided in penetrating these hard layers. These plants sent their roots down eleven feet nine inches, with their ends, for the most part, in a fine sand; but the deepest ones were in a sandy clay where they would have had comparatively little work in penetrating to a greater depth, and it was not the abundance of moisture which caused them to cease growing.

The next place where I undertook to dig up roots was between an irrigating ditch and a railroad cut. Quite a large quantity of clay had, at a previous time, been taken from this point for the manufacture of brick. The character of the soil was almost the same from the top to the bottom; here the roots, were not gnarled as in the preceding instance, and they attained a length of twelve feet three inches, with their ends in soil just as dry as that through which they had passed. Though these roots were longer by about six inches than those from Mr. Walter's place, they were much smaller, their diameter being not more than two-thirds of that of the former; but they were still above the average. The age of these plants was either six or seven years. These are all the observations that we have had opportunity of making upon the effect of the depth of the water plane upon the length of the alfalfa roots. We are convinced that, when it is encountered by the roots, it practically determines their length; but when it is not actually encountered, its effect is problematical. If for any reason the depth of the water plane should be permanently lessened, as is the case when the higher land about a basin-shaped area is brought under irrigation, or irrigation water is increased, it would undoubtedly have a very serious effect upon the alfalfa, even to the killing of it if it should rise nearly or quite to the surface, especially if stagnant.

The water under the Whedbee field had a very strong flow; that under the field at Rocky Ford did not appear to have any; it was so far from the surface, however, that its effect would not be that of water filling up a basin-shaped area, and immersing the roots, in which case they would die out and rot.

EFFECT OF AGE UPON THE SIZE OF ROOTS.

There is no other point on which our observations are so at variance with one another as they are on this point. While we have not seen any young plant having a root so large as those mentioned from Weld county, we have seen many roots of six-year-old plants smaller than roots of other plants which we knew to be only nine months old. It can be stated in a very general way only, that one may expect larger roots among older plants than in a young stand. One of the chief causes of this is the fact that there is a natural process of thinning out, and the remaining plants have more room to grow and perhaps can avail themselves of the remains of the dead plants as a fertilizer.

DEATH RATE.

How fast this thinning out process takes place is difficut to answer. If there is any rule I have failed to observe it. In one instance I compared the casts of dead roots with the living ones in a piece of alfalfa five years from seeding, and the ratio of two to one seemed to hold good for the dead to the living plants. This is evidently open to question as to whether I could recognize the remains of plants that had been dead for several years, three or more; second, as to whether this ratio would hold for other soils as the death rate will vary under different conditions. The productiveness of this piece of alfalfa had not deteriorated very much and the variation in its tonnage may have been due to other causes than the dying out of a portion of the plants. This loss in number of plants is compensated for in part or wholly by the increased size attained by the remaining crowns. In the case of young plants or those crowded on account of the thickness of the stand twelve or fifteen stems may arise from a single crown, while crowns standing alone, i. e., occupying from six to eight or more square feet of surface, will throw out almost any number of shoots. I have counted as many as one hundred and sixty-one, and seen others two years old which had thrown out many more. For this reason I do not consider it of much importance whether the rate of dying is slow or rapid within reasonable limits and provided the dying out is not confined to certain spots. There are two ways in which these plants perish: one is, that for some reason or other, the root just below the crown rots off, leaving the lower portion of the root perfect in every respect, so far as is evident to the naked eye. This is not apparently due to age or exhaustion of the vitality of the plant. The second manner in which they perish is due to age and other causes. If the stubble of the second year be examined by splitting it open down to the crown, there will be observed at the node above the crown a blackening of the tissue and also that it gradually extends downward into the root itself. It begins in this manner and continues until the whole center of the crown has been destroyed. The new shoots come out from the outside of the crown under the old growth and are in communication with the outer portion of the root and not with the interior vascular bundle. The central portion of the crown and interior of the root may be entirely destroyed to a depth of eighteen inches or more. This cavity serves as a nesting place for a variety of larvæ, but they have no direct part in causing it. The decay finally extends to such an extent that it involves the whole neck of the root and the plant perishes. This condition can be found in alfalfa of different ages. I have in mind one field, about seven years old, where the roots are large and nearly all of them are more or less affected in this way. I know of another six years old where the stand is extraordinarily thick and the roots small, and so few of them show this that one may say the roots are perfectly healthy. The former piece is on land which is rather low, with the water table about seven feet from the surface; the latter is on high land. The distance of the water table from the surface does not seem to be the sole cause of this dying, for I have observed it in plants growing in ground where the water table was probably not less than twelve feet from the surface, as this was its depth on a neighboring farm. This condition of the roots is illustrated in plates XV, XVI and XVII. The crown does not generally perish all at once, but is broken up into parts which die successively. The field from which the plants represented were taken yielded about three tons to the acre last year, and is, according to the best information I could obtain, over ten years old. The stand in this field is not much over one crown to the square foot, and the remains of many plants which have died within the past few years are still easily recognized.

The alfalfa root when destroyed below the crown does not throw out new buds and re-establish the plant, as many other plants do, and its ability to repair an injury to its roots by throwing out adventitious roots seems to be very moderate. I have seen but few roots that have been eaten off by the pocket gopher or cut by the plow where it has calloused and thrown out roots which would be efficient in sustaining the plant if it had to depend upon them. I did not observe many with any roots produced in this way, but I have seen a few.

ALFALFA ROOTS CUT BY GOPHERS.

In a piece of bottom land near the Cache-a-la-Poudre river, I found a piece of alfalfa which was infested by these animals, and an examination of these roots showed that eighty per cent. of the plants had their roots eaten off, and this was doubtlessly the cause of the death of some of the plants, but they endured this severe root pruning to a surprising degree.

NODULES ON THE ROOTS.

Nodules appear on the roots in three forms: as warthy excressences mostly near the neck; as single nodules on small roots, and united into large colonies. The first form appears at shallow depths and whether these are identical with the others or not, they cease to appear on the roots at greater depths; while the third was found most abundant from three to five feet from the surface, and the second at all depths up to eleven and a half feet. There was a very great difference in the number of these on the roots at different localities though the plants seemed to be equally vigorous, and the proteids in the hay did not vary materially. They were found much more abundant on the plants grown in a garden soil, and also much nearer the surface than in the fields. The development of the colonies illustrated most vividly the influence of the alfalfa roots as mechanical agents for opening up the soil and admitting the air. I frequently found the passage left by the decayed root entirely filled by a colony or group of these nodules, whose axis agreed with the axis of the hole left by the root. Groups were almost invariably found occupying such passages or other cavities or clefts in the soil; while the single nodule was found scattered anywhere along the course of the root from the surface of the soil to the end of the root. Plate No. XI. shows some of the nodules as they occur near the extremity of the roots; these roots were about seven feet long. Plate No. XIV. shows large groups of them as found at a depth of from two and a half to five feet from the surface, and it also gives an idea of the size and character of the smaller roots of this plant. The largest nodules were nearly spherical and were from an inch to an inch and a half in diameter. Some were irregularly hemispherical and nearly two inches long. Others resembled the antlers of a stag, some of the individual portions having a length of more than half an inch. Compared with the nodules on the vetch and red clovers, as they grow in our soils, the alfalfa is but poorly supplied with them ; this is particularly true with some of the vetches, but the groups of these nodules are incomparably larger on the alfalfa. The branched groups occur on the vetches as well as on the alfalfa.

Some of these groups were submitted to a partial analysis. The samples were obtained from plants growing in a rich, dark loamy soil. The groups were found about three and one-half feet from the surface and rather more than this from the permanent water below. They were washed to remove the sand and dried between filter paper. The nodules contained 61.67 per cent. of moisture and the dried material 5.725 per cent. of nitrogen ; while the bark of the roots contained 2.25 per cent. nitrogen. This included any nodules which chanced to be on the bark. No attempt was made to avoid them. The washing of both the roots and the nodules was quite unavoidable. There is no doubt that the composition of each was altered by the process ; not enough, however,to materially detract from the significance of the results. The effect of washing the roots is described elsewhere.

RATIO OF THE ROOTS TO THE TOP.

The largest root which I dug up, was twelve feet six and one-half inches long, and the average diameter of all the roots measured (150) is one-half inch at the crown, and one-third of an inch, six and a half to seven inches below the crown, or at the average depth of plowing. The tops on the other hand at a period of their growth vary even more than the roots do, varying exceedingly as to the number of individual stems, and these vary even more in their thickness, leafiness and hight. In a plant of one season's growth, having but few stems and these slender, the root may be several times heavier than the top; and on the other hand the top of a favorably located plant may attain a weight of from four to seven and even more pounds, green weight, while the root will seldom exceed a pound. Our heaviest root weighed 418 grams, equal to about thirteen ounces, and was nine feet nine inches long Taking the average of all the plants which we have weighed, we find the ratio of roots to tops to be 1 : 1.3.

This at best can only be considered an approximation; first, for the reason stated above; second, because it is almost impossible to remove plants of the size of the ones with which we had to deal without loosing some leaves and stems, and still more difficult to get their original weight; for, do the best we could, evaporation from both roots and tops took place, though they did not show wilting to any extent. We weighed thirty-two plants, and the difficulty of the task may be appreciated in some measure when it is considered that the shortest plant handled, counting root and top, measured nine feet nine inches. The weight obtained for the roots is very nearly correct; while the weight of the tops is far too low, for the plants were already in seed when they were dug, and the loss by breakage and falling off of leaves was large, and to this is to be added the loss due to evaporation, which was unavoidable, as many of the plants which we weighed were secured twelve miles from the laboratory. There was no way of determining this loss, and we have no basis on which to estimate it. The closest approximation that we can make is on the following basis: first, assuming that the roots which we weighed were representative, we find their average weight to be 106.5 grams, green weight; second, we are justified by actual count in assuming that a good stand of five-year old alfalfa has about 140,000 plants to the acre; third, experiment indicates that the stubble is equal to about one-sixth of the green crop; fourth, five-year-old alfalfa referred to cut two and one-quarter tons of hay to the first cutting last year (1895), or 5,000 pounds, adding a loss of about twenty per cent. Seventy per cent. of the green crop is water, and thirty per cent. hay. All these data are based upon determinations made with as much accuracy as the subject will permit. Before proceeding with this calculation, it should be observed that the weight of the roots of the smaller plants exceeds the weight of the tops, sometimes being over three and one-fourth times as heavy. If the smaller ones are nearer the average, as is probably the case, the weight of the roots will exceed that of the tops of any single cutting.

Basing our calculations on these results, we have the two and one-half tons of hay, corresponding to 16,666 pounds of green crop; now adding one-sixth for stubble, gives us 19,443 pounds, or 9.72 tons. With 140,000 roots, each weighing 106.5 grams, we have, taking one pound as equal to 453.4 grams, which is near enough for our purpose, a total of 16.44 tons of roots, or a ratio of 1.69:1 for the roots to the total tops produced at this cutting, which means that it is more than the average alfalfa plant on which the top equals or exceeds the root in weight.

STUBBLE.

Two efforts were made to determine the ratio of the stubble to the crop removed where the stubble includes the roots to the depth that they would be cut by the plow and the stems to the hight left by the mowing machine. In the first attempt the ratio of the stubble to the tops was determined by cutting off the plants at the depth of six or seven inches below the crown, weighing the whole plant, and then removing the top about as a mowing machine would cut it and weighing each. In this manner we would detect any loss if it occurred. The result of this method was that we found the ratio of 1:1.4 for the stubble to the green crop as cut for hay making. The second method was by plowing up a small piece of alfalfa five days after it had been cut, picking out the roots, and weighing them. The result of this was, allowing two and one-half tons for the total dry matter cut off of one acre at first cutting, that we obtained the ratio of 1:1.69. The agreement here is better than we expected, as the plants in the first case were all large, and, growing singly, and had larger than average crowns; while the second observation was made upon a field with a good stand in which the plants were crowded compared with the others. We are not far from the truth when we assume that the stubble turned under after the first cutting bears the ratio of 1:1.5 to the green crop removed, or is equal to two-thirds of the green alfalfa which has been cut, assuming that there has been no loss by falling off of leaves, breaking off of stems, etc., to which subject reference has already been made.

Three plats of 675 square feet each were plowed up at the end of April (April 28-29-30), and the stubble carefully picked out and weighed. On May 26, after having been kept for upwards of three weeks in the laboratory, the results obtained were, for Plat No. 1, 526,793 plants to the acre, ten years old, and 3.34 tons stubble. Plat No. 2, 333,514 plants to the acre, one year old, .81 tons. Plat No. 3, 70,238 plants to the acre, ten years old, 2.55 tons of stubble per acre. Omitting the one-year-old plat—no one would plow up a good stand of one-year-old alfalfa under ordinary circumstances—we have an average of 2.94 tons of air-dried substance per acre. On a subsequent page, under the manurial value of the stubble, it will be seen that we assume the amount to be 2.86 tons for plants five years old. This quantity was arrived at by accurately weighing a small number of plants and estimating the total quantity. The agreement of the results by the two methods leaves nothing to be desired. The increase in the amount of stubble after the first year seems to be large, but it is not always so pronouced as appears from the above figures. I have seen one and five-year-old roots nearly equal in size, but the crowns of the plants five years old were much the larger.

COMPOSITION OF THE STUBBLE.

The stubble, of which an anslysis is herewith given, was obtained in the first effort to determine the ratio of stubble to the tops, already referred to. The plants were in seed at the time of cutting.

	Moisture.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Total Nitrogen.
Air dried	5.16	4.24	.516	11.56	36.48	42.04	1.869
Water free	....	4.47	.518	12.16	38.19	45.00	1.945
Air dried	5.39	4.27	.577	11.15	35.50	43.05	1.788
Water free	....	4.51	.610	11.75	37.40	45.73	1.880

ASH CONSTITUENTS IN 1,000 POUNDS AIR-DRIED STUBBLE.

The following table gives the pounds of the various components of the ash in each one thousand pounds of air-dried stubble on the basis of 4.24 per cent. of ash :

Silica.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Potash.	Soda.	Lime.	Magnesia.	Oxide of Iron.	Alumina.	Oxide of Manganese	Total.
1.104	4.155	1.261	1.156	7.762	2.307	8.831	2.681	.434	.289	.110	30.09

COMPOSITION OF THE ROOTS.

It was hoped that we would find time to submit the roots to a chemical investigation, but no other than the fodder analyses and analyses of the ashes of the bark, the inner portion of the root, and the whole root have been made. Trouble was met in preparing a sample of the roots. At first we endeavored to clean them by washing and wiping. This method proved inapplicable, for, as was noticed, the roots when moistened became sticky, absorbed water greedily, and yielded a large portion to the wash water. Wiping with a wet cloth was also tried and finally rubbing with a brush was resorted to. This was the only practicable method, though it left much to be desired.

The green roots dried to a constant weight in the air gave 60.41 per cent. moisture and 39.59 per cent. of dry matter. The roots in sample No. 17 were from Weld county; No. 17-a Larimer county.

	Water.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.
No. 17, air dried	4.55	3.79	.71	10.81	25.13	54.98
Water free	....	3.97	.72	11.35	26.33	57.63
No. 17—a, air dried	5.04	3.69	1.07	10.07	24.18	55.95
Water free	....	3.88	1.15	10.66	25.46	58.85

The difficulty in preparing our samples suggested the following experiment: The roots were exhausted with hot water, the solution filtered, and evaporated to dryness. The residue, dried at 100 degrees C., amounted to 36.2 per cent. of the weight of sample No. 17 and to 45.3 per cent. in sample No. 17-a. A similar experiment with another sample showed that 44.23 per cent. of the total ash constituents were taken into solution. These facts show why washing the roots is inadmissable; also the extent to which the dead roots will give up their mineral as well as a portion of their organic matter to the soil waters, whose action is probably still greater than that of distilled water. Nothing was done owards determining the nature of the dissolved subtances except that their reducing power was determined by Fehling's solution. It corresponded to 12 per cent of sugar n the dried extract. This amount was not increased by oiling with sulphuric acid, with the usual precautions taken n the conversion of starch into sugar. The filtered extract eems not to have contained starch. The aqueous extract f the roots is acid toward litmus. It is possible that the ugar was produced by the action of the acid solution on the arch. I have expressed this reducing power in terms of ugar because it is convenient, not because it is known to e due to sugar. The taste of the roots in early spring is rst sweet and afterwards bitter; the bitter taste is much ore marked when the plant is more active. Cattle and ogs are fond of the roots, and I am informed, that horses so, readily acquire a liking for them.

ASH CONSTITUENTS IN 1,000 POUNDS OF AIR DRIED ROOTS.

	Silica.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Potash.	Soda.	Lime.	Magnesia.	Oxide of Iron.	Alumina.	Oxide of Manganese	Total
No. 17, washed	1.443	3.512	1.268	.295	8.879	.976	7.207	3.308	.453	533	.141	28.015
No. 17—2, not washed	1.267	4.554	2.266	.741	10.925	.944	8.540	4.245	.378	.325	.067	34.252
No. 17—a, washed..........	1.405	2.229	.706	.219	7.126	.396	7.430	1.921	.592	.418	.203	22.645
No. 17—a—2, not washed...	1.323	4.048	1.829	.471	10.201	1.831	4.777	2.300	.437	.406	.224	27.874

It is unfortunate that samples No. 17 and 17-2 are not portions of the same larger sample. They are roots obtained at the same place, but not at the same time. The same is true of No. 17-a, and 17-a-2. A comparison of the results indicates that the acids and the alkalies are removed from the roots in large quantities by washing them. This operation did not last more than ten or fifteen minutes at the longest and consisted in immersing them in water with gentle rubbing, until the dirt was loosened and then wiping them with a towel. The result in regard to lime is doubtful, as sample No. 17-a-2 contains less of this substance than the washed roots from the same place. Because of this doubt, a portion of sample No. 17-2, although it had lain in the laboratory about five months and the solubility of its ash constituents had possibly changed, was treated with tepid water, the extract evaporated to dryness and incinerated with the same precautions which had been taken in the preparation of ash from other samples. A partial analysis of this ash was made with the object of corroborating the results of the preceding analyses. The results are calculated on 1,000 pounds air-dried matter as before; on the basis of 1.6 per cent. ash dissolved out, 1,000 pounds yield to water sixteen pounds ash, containing 11.99 pounds fixed ash ingredients.

ASH OF AQUEOUS EXTRACT.

	Silica.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Potash.	Soda.	Lime.	Magnesia.	Oxide of Iron.	Alumina.	Manganese	Total.
No. 17—2, air dried..	.850	2.050	1.252	—*	5.166	.554	.660	1.270	.118	......	.070	12.0

* Not determined.

Showing that even a larger proportion of the phosphoric acid, sulphuric acid, and particularly of the potash went into solution under these conditions than the preceding analyses indicate as probable.

MANURIAL VALUE OF THE STUBBLE.

Others have shown the fertilizing value of alfalfa hay, as grown in the east without fertilizers, to be $9 per ton, and when grown with fertilizers, $10.84 per ton.—Mass. State Rep. 1888, p. 165. Our farmers can not afford to turn under a crop of alfalfa preparatory to seeding to wheat or planting to potatoes, even if they get only from two to six dollars per ton for the hay as fodder, but they can afford, (and it would be good practice) to break up their alfalfa, say every six years, for at this age the average field has passed its maximum yield, and put in some other crop. To break up a field of alfalfa is a different task from breaking up one of clover or a timothy sod. In the case of clover it may be allowed to make a considerable growth in the spring before being turned under. This is not the case with alfalfa, for if the plant is allowed to stand late enough to make a growth sufficient to be of value as a green manure, or in fact any considerable growth, the toughness of the roots makes it difficult to break up; therefore, any attempt to estimate the manurial value of alfalfa in a field from a practical standpoint ought to be made on the basis of the stubble and roots taken while the plant is dormant. Our stubble was taken when the plant was active, and perhaps at the height of its activity, and our results are correct only for this period. We find the amount of stubble taken to a depth of about six and one-half inches to be 11,812 pounds per acre, and the moisture which this gives up in drying in the air to be 51.57 per cent. This moisture is undoubtedly rather low, and consequently, the air-dried material too high, due to the fact that our sample had lost water before it was possible for us to begin the determination. According to the preceding we obtain 5,720.8 pounds, or 2.86 tons air-dried matter per acre. Each ton of 2,000 pounds contains 8.31 pounds of phosphoric acid, 15.52 pounds of potash, and 6.37 pounds of nitrogen which, at fifteen cents per pound for the nitrogen, five and one-fourth cents per pound for the potash, and five cents per pound for the phosphoric acid, give the total value of the stubble at $19.28 per acre, $6.75 per ton for the stubble. The three substances mentioned are the ones to which it is customary to assign a money value. These are not the only elements which are returned or added to the soil by this manner of green manuring, nor have we in the preceding estimate the whole of these. We have stated that we included only the first six and one-half inches of the roots, the rest of th roots corresponding to 5.14 tons of air-dried matter per acre, is left below the assumed depth of six and one-half inches.

MANURIAL VALUE OF THE ROOTS.

The manurial value of this portion is not equal pound for pound to the stubble, still it is by no means a negligible quantity. The nitrogen is equal to 14.98, practically 15 pounds per ton of 2,000 pounds; the phosphoric acid 4.45 pounds, and the potash 14.25 pounds; or stated differently, there is less than one-half as much nitrogen, one-half as much phosphoric acid, and about the same amount of potash in the roots as in the stubble, the first six inches of the roots being taken with it. On the other hand, while there is 2.86 tons of air-dried matter in the stubble, there is 5.14 tons in the rest of the roots, making them about equal to the stubble in the total nitrogen and phosphoric acid contained, and twice as rich in potash; or expressed in dollars and cents, the value of the roots below six and one-half inches, and to an average depth of ten feet, is phosphoric acid, $1.14; potash, $3.84, and nitrogen $11.60, a total of $16.58 against $19.32 for the stubble, making a total value per acre for the portion left after removing all the crop above ground of $35.90. In estimating this value all the other constituents of the ash and the organic matter have no value signed to them; whereas we know that the organic matter, particularly for our soils, has a comparatively high value, and the other ash constituents presumably in a more favorable condition for absorption by other plants than they are in the soil, can not be indifferent, though it is not usual to place any value upon them.

It may be questioned whether a large portion of the plant food stored in these roots does not lie so deep that it is beyond the reach of ordinary crops, such as potatoes and wheat. Whatever the answer of this question may be it is a well attested fact, that the yield of wheat on alfalfa ground is often doubled and always greatly increased; and while the alfalfa is an exceptionally deep-rooting plant, no violence is done to observe facts in assuming that the roots of the wheat stimulated by the presence of plant food in certain channels left open by the decaying of the alfalfa roots, may penetrate to greater depths than they do when the food is disseminated evenly through the soil. The roots, of the wheat plant, however, have been observed to penetrate to the depth of seven feet—Schubart cited by Johnson, "How Crops Grow," page 264—which is as deep as a large percentage of the alfalfa roots penetrate into our soils.

It is necessary in this connection to distinguish between the roots and the soil in which they have grown, for while the roots contain, as we have seen, a large amount of plant food, particularly nitrogen, it does not follow that the soil itself contains as much of this element as it did before the alfalfa was grown in it; in other words, if the alfalfa roots were removed, the soil might be poorer in nitrogen as it certainly would be in other elements of plant food. If the amount of nitrates in cropped soils be taken as the measure of available nitrogen in a soil, alfalfa exhausts a soil faster than many other crops. Aikman, in "Manures and Manuring," page 157, quotes the amount of nitrates found in cropped soils per acre (Rothamsted soils), from which it appears that there is the following amount of nitrogen as nitrates in each acre of soil taken to the depth of nine feet: In soil cropped to white clover, 102.8 pounds; to vetches, 54.6 pounds; to wheat, after fallow, 18.4 pounds, and to alfalfa, 17.0 pounds. It is further shown for the soil cropped to alfalfa, that while the first nine inches of soil contains 8.9 pounds per acre, the last nine inches taken, that is, from eight feet three inches to nine feet, contain only 0.4 pounds; while in the soil cropped to white clover there is at the same depth (eight feet three inches to nine feet), 10.0 pounds, showing how great a draft the alfalfa had made upon this form of nitrogen in the soil.

There is a suggestive fact shown by the figures of the table as quoted, i. e., the first nine inches of soil contain after vetches a trifle less than one-fifth of the total taken to the depth of nine feet, and more than one-half of the total after alfalfa. The dimunition of the nitrogen after the alfalfa is almost continuous to the depth of eight feet three inches; where, as given above, the amount of nitric nitrogen is only 0.4 pounds per acre; while in the other cases, the dimunition reaches its maximum at a depth of between two and three feet, from which point on the nitric nitrogen increases somewhat, being present in the largest quantity after white clover at a depth of four and one-half to six feet.

The figures given in this connection show more clearly than any others with what avidity and also the depth to which alfalfa feeds. I do not think that the movement of the nitric nitrogen (nitrates) in the soil can operate to produce this marked result in the case of the alfalfa, but that the nitrogen is appropriated by the plant.

LEAVES AND STEMS AS A TOP DRESSING.

It has been repeatedly stated that the mechanical loss in making alfalfa hay is very considerable, and while I have no figures established by experiment—the reason has been given elsewhere—I estimate the minimum to be between fifteen and twenty per cent. of the total dry matter, including all the leaves that fall during the growth of the plant and the making of the hay. I believe twenty per cent. of the dry matter to be a reasonable estimate. The amount of matter added to the soil in the form of a top dressing on this basis of loss is more considerable than at first appears. The actual amount ranges from .95 ton for a 3-ton yield of hay to one ton for a 5-ton yield. It is not only twenty per cent. of the total dry matter, it is about one ton of the richest portion of the crop, equivalent to the addition of 70.4 pounds of nitrogen and 168.8 pounds of ashes. Some of the nitrogen may be lost, but the whole of the ashes is available. The table quoted by Prof. Aikman shows that the first nine inches of the cropped soils are rich in nitric nitrogen, and in the case of the alfalfa they contained more than one-half of the total found to the depth of nine feet, 8.9 pounds out of a total of 17.0 pounds.

These facts may be more directly related than at first appears. The ashes contain seven pounds of phosphoric acid and 28.6 pounds of potash, which have been brought up from below. A portion of this is, doubtlessly, taken up by the plant and utilized in making the next year's crop; but there is a remainder each year which accumulates to the enrichment of the surface portion of the soil. The accumulation of nitrogen is probably less in Colorado than it would be were our conditions more favorable to the formation of humus in the soil. There is no series of analyses showing how great the changes in the surface soil are in respect to humus, nitrogen, or ash constituents; we have only the general results as measured by the increase in wheat produced, and this only in general terms. I have presented the composition of the plant and its parts; the amount of plant debris added year by year; the stubble added to the soil at the end of one, five, and ten years; also the amount of roots not included with the stubble; and I have also intimated another source of addition to the soil during a part of the life of an alfalfa field, i. e., by the perishing of the inner portion of the roots. The composition of the plant debris has been given and the following tables contain the analyses of stubble and roots and the fixed ash constituents for each thousand pounds of air-dried material:—

	Moisture.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Total Nitrogen.	Amide Nitrogen.
Stubble	5.16	4.24	.546	11.56	36.48	42.01	1.849	.202
Stubble	5.39	4.27	.577	11.15	35.50	43.04	1.788	....
Roots, Weld County	4.64	3.72	.72	10.99	25.30	54.63	1.840	.281
" Weld County	4.46	3.86	.66	10.73	24.96	55.33	1.794	....
" Larimer County	5.03	3.69	1.04	9.96	24 15	56.13	1.590	.257
" Larimer County	5.04	3.69	1.13	10.17	24.21	55.76	1.630	.....
" outside portion	4.38	5.21	2.06	14.08	21.75	52.52	2.253	......
" inside portion	3.77	3.50	2.81	7.70	29.19	53.03	1.231	......

ASH CONSTITUENTS IN 1,000 POUNDS AIR DRIED SUBSTANCE.

	Silica.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Lime.	Magnesia.	Iron Oxide	Alumina.	Manganese Oxide.	Potash.	Soda.	Total.	Nitrogen.
Stubble	1.104	4.155	1.261	1.156	8.831	2.681	.434	.289	.110	7.762	2.307	30.090	18.186
Roots, Weld Co	1.267	4.554	2.266	.741	8.540	4.245	.378	.325	.067	10.925	.944	34.252	18.400
" " washed.	1.443	3.512	1.268	.295	7.207	3.308	.453	.533	.141	8.879	.976	28.015	17.94
" Larimer Co	1.323	4.048	1.829	.471	4.777	2.300	.437	.406	.224	10.201	1.831	27.847	16.30
" " washed.	1.405	2.229	.706	.219	7.439	1.921	.592	.418	.203	7.126	.396	22.645	......
" bark	3.075	4.768	3.206	1.086	7.298	3.337	.728	.824	136	13.277	2.998	40.733	22.53
" bark	2.386	4.285	3.190	1.218	8.225	5.558	.507	.738	.205	11.469	1.118	38.899	......
" inside	.403	3.937	1.776	.434	5.060	4.197	.242	.053	.078	8.204	2.574	27.008	12.31
" inside	.361	5.389	1.642	.477	7.070	4.085	.174	.079	.098	6.282	.815	26.472	......

The work on the soils from our standpoint is quite unsatisfactory, but either someone else or ourselves may be able to make a systematic study of this subject which is of some importance as well as of interest to the West.

The soil in which the Weld county samples were growing was sampled to the depth of eleven and one-half feet in three parts, corresponding to the large variations in the character of the soil; at the same time a sample of soil was taken a few feet distant from a field planted to corn, but owing to lack of water it was practically fallow at the time. The corn plants had made no growth during the season; subsequently a fifth sample was taken of the blown soil which gathers about the large crowns of alfalfa containing a great many leaves and plant refuse. This enables us to present the composition of the plant, the root, the soil accumulation about its crown, the soil proper, the subsoil in two sections, and that of a sample of the soil not in alfalfa. The alfalfa was six years old. The plants were very large, some of the stems being over five and one-quarter feet high, and the largest of the roots one and one-half inches in diameter, with abnormal roots, i. e., such as had short tap roots two to three feet long attaining a diameter of two and seven-eighth inches. The soil is a very fine clayey loam, almost black in color and 21½ inches deep. It had never been broken by the plow to any depth and was so compact that we were compelled to use a pick in working a part of it. This is succeeded by six feet of marly clay and fine sand, the upper four to six inches of which was a white marl and the next three and a half feet fine clayey sand. The sample from the cornfield corresponds to the 21½ inches of black soil. For fodder analysis of plant see page 31, first cutting, analysis No. 12.

The total fixed ash constituents removed by 1,000 pounds of hay, on a basis of 8.87 per cent. moisture and 9.94 per cent. crude ash, is 75.32 pounds, distributed as follows:—

Silicia	1.49
Phosphoric acid	4.43
Sulphuric "	5.59
Chlorine	7.92
Lime	23.65
Magnesia	5.89
Oxide of iron	.40
Alumina	.25
Oxide of manganese	.19
Potash	23.69
Soda	1.82
	75.32
Nitrogen	22.31

ANALYSES OF THE ASHES.

Plants.	Per cent.
Sand	1.765
Silicic acid	1.513
Phosphoric acid	4.459
Sulphuric "	5.636
Chlorine	6.776
Calcic oxide	23.905
Magnesic oxide	5.951
Ferric "	.397
Aluminic "	.253
Manganic " (brown)	.188
Potash	23.934
Soda	1.840
Carbonic acid	25.151
	101.768
Less O equivalent to Cl	1.523
	100.245

Roots.

	Per cent.
Sand	2.380
Silicic acid	2.875
Phosphoric acid	10.270
Sulphuric "	5.093
Chlorine	1.322
Calcic oxide	19.008
Magnesic oxide	9.492
Ferric "	.844
Aluminic "	.729
Manganic " (brown)	.149
Potash	24.443
Soda	2.110
Carbonic acid	21.742
	100.457
Less O equivalent to Cl	.299
	100.158

ANALYSES OF THE SOIL.*

	Soil Blown about Roots.	Black Soil to Depth of 21½ Inches.	Marly Soil fr'm 1 Ft. 9 In. to 7 Ft. 9½ In.	Fine Clay and Sand from 7 Ft. 9½ In. to 11 Ft. 3½ In.	Soil fron Corn Field, Corresponding to Black Soil.
Insoluble Matter	78.472	66.700	55.032	68.145	63.258
Soluble Silicic Acid	9.174	15.110	12.921	10.082	16.086
Potassic Oxide	.327	.610	.531	.416	.409
Sodic Oxide	.093	.235	.368	.250	.152
Calcic Oxide	.562	.570	9.182	4.775	.755
Magnesic Oxide	.551	.852	2.016	1.185	1.251
Manganic Oxide (brown)	.....	.....	.....	.....	.....
Ferric and Aluminic Oxides	5.835	8.931	7.937	7.005	9.780
Phosphoric Acid	.143	.186	.195	.132	.148
Sulphuric Acid	.065	.070	.102	.057	Trace.
Chlorine	.004	.005	.007	.003	.003
Carbonic Acid	Trace.	.017	7.842	3.606	.293
Moisture	1.400	1.797	1.629	1.431	2.052
Volatile and Organic Matter	not det.	3.338	2.050	3.291	5.534
Total	......	98.421	99.812	100.378	99.721
Nitrogen	.085	.076	.035	.025	.062
Humus	......	.400	......	.200	......

* Analyses by Mr. Chas. Ryan.

In the mechanical analyses of the soils we followed as closely as we could the method of Osborne, but we had no sieve corresponding to .1 mm., and but one portion is made between .25 mm. and silt. There is a large quantity of calcic carbonate and silicate, particularly in sample B., which is distributed between the three last portions. Imperfect as the analyses are, they serve the purpose for which they are used.

	.5 mm.	.25 mm.	.10 mm. and Sand.	Silt.	Clay.	Dust.
Soil A	6.888	8.820	72.450	3.433	.410	7.999
Soil B	4.416	11.130	73.745	3.213	2.247	5.249
Soil C	6.011	15.200	68.650	5.090	.120	.493

Analyses by Mr. Chas. Ryan.

The physical condition of this soil is excellent when it has been mellowed by tillage, but is compact when it retains the natural firmness acquired by its long-settling and the firming of its particles. The degree of flocculation is small. The particles are fine and puddle easily. The amount of alumina and iron—we may say alumina, for their is very little ferric oxide in the soils—together with the soluble silica convey a fair idea of the exceedingly fine state of division prevailing in them. The amounts of potash, phosphoric acid, and nitrogen are abundant. We used hydrochloric acid sp. gr. 1.115 in extracting the soil, and with the large amount of calcic carbonate present in some of the samples, the action of the solvent was propably not excessive; so that, after entertaining every misgiving as to the value of the results obtained by a chemical analysis, we may accept the amount of plant food taken into solution as representing approximately the amount available in this soil. Here it should be noted that no attempt was made to determine the extent of this soil, but as it is common to find it, we assume that it is not an exceptional soil, though it is by no means so common that it can fairly be claimed to represent the general soil of the county.

In estimating the amount of ash ingredients removed by the crop of alfalfa from this soil, the basis of 9,000 pounds of hay per acre may be assumed as a convenient estimate. The amount of ash ingredients removed for each 1,000 pounds of hay has been given for this particular case as 75.32 pounds, or for the 9,000 pounds—four and one-half tons—677.88 pounds distributed as follows :

	Pounds.
Silicic acid	13.41
Phosphoric acid	39.87
Sulphuric acid	50.31
Chlorine	71.28
Lime	212.85
Magnesia	53.01
Oxide of iron	3.60
Alumina	2.25
Brown oxide of manganese	1.71
Potash	213.21
Soda	16.38
	677.88

The nitrogen in the hay amounts to 200.79 pounds. The amount of plant food in the soil, however, is so large that it is scarcely possible but that a very large excess over that required by the crop was obtainable at all times throughout the season. The total plant food present in the soil penetrated by the roots in this case is so large that it seems to have no object in trying to express the quantity in figures. The quantity of phosphoric acid present in one acre of this soil and its subsoils taken to the depth of eleven and one-quarter feet is approximately thirty-four and one-quarter tons, and about three times as much potash, or one hundred and two tons. It would seem probable that,under these conditions, the plant would contain as large a quantity of ash ingredients as it could take up,but the average ash content of alfalfa hay,including all cuttings and varieties of alfalfa grown in Europe and different parts of this country, is 7.44 per cent., or nearly as great as the average of the samples collected by ourselves, including this particular one, 9.08 per cent., for the first cutting and rather higher for the second and third cuttings. Our averages are something higher than that given by Mayer and others. This difference is reduced a little when the lower water content of our hay is taken into consideration; but there still remains an excess over the average ash content. This may correspond to the amount which is taken from our soils in excess of the normal amount due to an excessive supply. It is to be remembered that the alfalfa in our case is practically growing in a virgin soil, even if the upper soil has previously been sown to wheat, for the wheat roots, whatever depth they may attain in loose open soils, can not attain great depths in our prairie soils unless they have been opened by some preparatory crop or process. It is probable that the amount of ash constituents taken up by our alfalfa does not exceed ten, or at most, fifteen pounds per hundred, indicating an amount necessary for the perfect maturing of this plant, which only a rich soil can furnish or a most vigorous root system collect.

We have no other series of soil samples so complete with the hay produced upon the same, but we have one sample from Rocky Ford, Otero county. The hay is a sample of the third cutting; the yield for the year, three cuttings, was five tons. An analysis of the hay gave the following: water, 6.06 per cent.; ash, 9.87 per cent.; fat, 1.29 per cent.; crude fiber, 32.69 per cent.; protein, 13.69 per cent., and nitrogen free extract, 36.40 per cent. The fixed ash constituents amounted to 73.788 pounds for each 1,000 pounds of hay, as follows: silicic acid, .828 pound; phosphoric acid, 3.258 pounds; sulphuric acid, 5.280 pounds; chlorine, 7.444 pounds; lime, 23.684 pounds; magnesia, 3.033 pounds; oxide of iron and alumina, .662 pound; brown oxide of manganese, .153 pound; potash, 27.197 pounds; soda, 1.976 pounds; or the total removed from the soil by the five-ton crop, supposing it all to have been as rich in ash as the third cutting was 737.88 pounds.

The Weld county sample, already given, shows 677.88 pounds ash constituents, based upon the first cutting and a yield of four and one-half tons. If we assume a five-ton yield, to make them more easily comparable, we have 737.88 pounds of ash in Otero county, third cutting, as against 753.2 pounds in Weld county, first cutting; a difference of about 15 pounds, only three pounds for each ton, or only about two per cent. of the total ash constituents considered. This difference is less than that usually found between two samples cut at different times from the same plat.

We fortunately have an analysis of the Otero county soil, also made by Mr. Ryan. The point at which this sample of soil was taken is not, as in the case of the Weld county sample, the one at which the hay sample was gathered; but, after examining the soil, I am satisfied that, owing to its uniformity, no error is introduced by the fact that the sample is not the identical soil in which the plants had grown and there can be no doubt but that its value is as great as that of any chemical analysis which might be made of this soil.

ANALYSIS OF SOIL FROM OTERO COUNTY.

	Per cent.
Insoluble	77.72
Potash	.25
Soda	.11
Lime	1.55
Magnesia	.11
Ferric oxide	2.93
Alumina	4.70
Phosphoric acid	.90
Sulphuric acid	.45
Chlorine	.04
Carbonic acid	1.01
Moisture, at 110 degrees	1.66
Loss by ignition	3.70
	100.45

This sample does not represent the soil to a greater depth than four and a half feet; while the preceding ones, together, represent the Weld county soil to a depth of eleven and a quarter feet. The twenty-one inches of Weld county soil contain 11,208 pounds of phosphoric acid to the acre; while the Otero county soil, calculated to the same depth, contains 55,125 pounds of this acid, or nearly five times as much. The ratio of the potash in the two soils is markedly in favor of the Weld county soil, it containing in the first twenty-one inches 37,362.5 pounds; while the Otero county sample contains 15,312.5 pounds. The amounts of these substances removed by the respective crops bear no such relation to each other as the total amounts of them bear to one another. The amount of phosphoric acid removed by one thousand pounds of hay from the Weld county soil is 4.43 pounds; while the amount removed from the Otero county soil, by an equal weight of hay, was 3.58 pounds. With a total quantity of phosphoric acid, five times greater than that present in the Weld county soil, the plants have taken up a little more than three-quarters as much of it. The potash removed by a thousand pounds of hay from the Weld county soil was found to be 23.69 pounds; while from the Otero county soil, with less than one-half as much total potash, this weight of hay removed 27.197 pounds. The magnesia, it was hoped, might give a clue as to the amount of food brought up from the lower portion of the soil, as we have the ground water quite heavily laden with salts of this base; but an examination of the results obtained failed to show any such relation as might even be suggestive that these solutions had anything whatever to do with the nourishment of the plants. The Weld county sample contains for each 1,000 pounds of hay, 5.89 pounds magnesia; the Otero county sample only 3.033 pounds. The Weld county soil contains about one per cent. of magnesia and the Otero county soil only a little over 0.1 per cent., but in the latter case the roots penetrate the ground waters, which are rich in magnesia salts, as the following table illustrates:

COMPOSITION OF GROUND WATER.

Calcic sulphate	155.650
Sodic "	341.771
Magnesic "	51.880
" chloride	29.027
" carbonate	16.026
Insoluble	2.412
	596.766

The total solids per gallon was 596.766 grains.

Examination failed to reveal the presence of phosphoric acid or potash, despite the large amount of the former in the upper portion of the soil and a fair abundance of the latter. The condition of the roots was good, although they were very different from those in Weld county, and also from others in Larimer county, which had penetrated into flowing water near the level of the Cache-a-la-Poudre river. These roots were neither "rotten" nor dead, but living, and were doubtlessly discharging their functions. I, of course, cannot tell to what extent their action had been modified; but it is evident that, so far as the magnesia is concerned, they had not taken enough of it into the plant system to make its amount equal to that taken from the Weld county soil. We are in this case debarred from trying to explain the difference in the amount of magnesia appropriated by the plant by the less amount of lime in the Weld county soil, for the fact is, that the Weld county soil is very much the richer of the two in lime; and moreover, the amount of lime in 1,000 pounds of the samples is almost identical, i. e., 23.65 pounds in the Weld county sample and 23.69 pounds in the Otero county sample; nor yet is it probable that the potash taken up influenced the amount of magnesia so far as the analyses indicate; the Weld county sample has 23.69 pounds and the Otero county sample 27.20 pounds of potash for each 1,000 pounds of hay. There is here an excess of potash in favor of the Otero county sample, about equal to the deficit of magnesia, which fact alone would have but little significance; but it acquires some weight when it is observed that the sum of the lime and potash, including magnesia with the former and soda with the latter, is constant within comparatively narrow limits, i. e., they are equal to from 55.5 to 59 or 60 per cent. of the total ash constituents of the plant above ground; but this is not true of the roots to the same extent, nor of the leaves and stems taken separately. The magnesia in the roots is as a rule higher than in other parts of the plant; while the nearly constant sum of these four constituents—the two, potash and soda, rising as the lime and magnesia fall, or contrariwise—might be interpreted as indicating an intimate relation between their relative quantities and a partial interchange of functions. The varying relation of their quantities in the ash of the leaves, stems, and roots, obscures this to such an extent that we can say nothing definite about it; and for this reason we believe it improbable that the four per cent. more of potash in the Otero county sample has any direct bearing upon the lower percentage of magnesia in it than in the Weld county sample. There was an abundance of magnesic salts presented to the absorptive action of the roots of the Otero county plants, but the fact is the salts were not taken up, nor is the amount of soda present in this sample apparently influenced by the soda salts present in the soil waters, for in the Weld county hay we find 1.82 pounds of soda for each 1,000 pounds of hay, and in the Otero county 1.98 pounds. In other samples, grown in alkali soils, we have from two to three times as much soda present as we find in either of these samples. We have omitted some essential condition or we are justified in concluding that the supply of plant foods is so excessive in both of these soils that the plants in each case have taken up as much of the various ash constituents as they could appropriate, or that the available supply in the two soils was about the same and that the ground waters exercised no decided influence upon the character or amounts of these constituents taken up. Such a conclusion, if established, would be in harmony with the suggestion already made, that the alfalfa plant may feed at greater depths, but it does not necessarily do so, and that it can dispense with its long tap root and still flourish.

The ground water met with in the above instance is rather a "bitter water" than an alkaline water, even though there is a large portion of sodic sulphate present. Combining the bases with the acids in the following order: sodium, calcium, magnesium, we have the following percentage composition of the thoroughly dry residue:—

	Per cent.
Silicic acid	0.5
Sodic sulphate	57.3
Calcic sulphate	26.0
Magnesic sulphate	8.7
Magnesic chloride	4.8
Magnesic carbonate	2.7
	100.0

The composition of the water accounts for its nauseating, bitter taste. It was clear and almost sparkling. We give the following analysis of a seepage water collected late in the season from a newly opened drain running through an alkalized and somewhat marshy swale. The larger quantity of salts held in solution and their difference in character, distinguish the ground water from the seepage water. The magnesic salts in the seepage water have evidently been taken up from the soil. The water used for irrigating was practically snow water. I have no analyses of the Arkansas river water at my command. I have no doubt but that it is quite as different from the ground water as the seepage water is, and resembles the latter much more than it does the former.

Ground Water.

Total grs. per gal.	596.766
Sodic sulphate	341.771
Calcic "	155.650
Magnesic sulphate	51.880
" chloride	29.027
" carbonate	16.026
Insoluble	2.412
	596.766
Total magnesic salts	96.933

Seepage Water.

Total grs. per gal.,	97.85
Sodic sulphate	54.38
Calcic "	29.47
Magnesic chloride	7.50
" carbonate	5.27
Insoluble	1.23
	97.85
Total magnesic salts	12.77

This seepage water is from Larimer county, and the different conditions of soil and the different waters used for irrigation influence the character of the salts taken into solution or left by evaporation and consequent concentration. The writer does not know the history of the land from which this drain water was taken; but there is no doubt that it is a seepage water which had collected in the lower portions of the farms and was drawn off by the laying of this drain. The water used for irrigating was taken from the Cache-a-la-Poudre river. The water supply for the city of Fort Collins is taken from the same source, and as delivered for domestic use contains in the month of February, when the water is low, rather less than ten grains of solid matter to the gallon. This gives us a general, though somewhat indefinite, idea of the amount of salts due to concentration and solution from the soil.

The Arkansas river water may contain more solids when taken out for irrigating purposes, but there is little doubt that the magnesic salts, in both cases, are taken into solution as the result of chemical changes between the salts of the soil and those taken into solution by the water. The ground water is not so different from the seepage water, but that it may be considered as a product of the concentration of seepage waters. This is not the place to discuss the manner in which this concentration has been effected. We have intimated an answer to the most patent inquiry, i. e., whence the magnesic salts contained in both the samples, the ground as well as the seepage waters, especially as the irrigating water used is river water, supplied by melting snows and flowing for the greater part of its course over gneissic or granitic rocks. This is more literally true of irrigation water used in parts of this county (Larimer) than it is of that used in Otero county, which is farther removed from the mountains. The analyses of drain waters taken in European soils are not closely comparable with our seepage waters, for these soils have been washed out and ours, in this semi-arid climate, have not been; still even the European drain waters show a relatively large amount of magnesic carbonate present in them ranging from one-third to one-twelfth of the total lime salts.

This subject may form the basis of some future work by the department, though the subject has already been approached in Bulletin No. 9, of this Station.

The relation of soil water to the salts taken up by plants is apparently not the same as that sustained by solutions in water culture. Our alfalfa roots have not taken it up from this depth. We have given analyses of the soils and of the ground water and we place the analyses of the ashes of the hays side by side for easier comparison.

	Weld Co. Per cent.	Otero Co. Per cent.
Carbon	.000	.020
Sand	1.765	1.261
Silica	1.513	.858
Phosphoric acid	4.459	3.714
Sulphuric acid	5.636	5.477
Chlorine	6.776	7.721
Lime	23.905	24.524
Magnesia	5.951	3.141
Ferric oxide	.397	.683
Aluminic oxide	.253	
Brown oxide of manganese	.188	.156
Potash	23.934	28.209
Soda	1.840	2.055
Carbonic acid	25.151	24.053
	101.768	101.777
Less O equivalent to Cl	1.523	1.739
	100.245	100.038

The results of our study and observations as to the effect of alfalfa growing upon our soils are briefly stated as follows :

The biological relations of the soil are probably materially improved by the maintenance of a more uniform tempature during the heat of the summer days, by the maintenance of greater uniformity of moisture, and by a supply of organic matter. The shade and moisture furnished or conserved by a growth of alfalfa must evidently exert a pronounced influence upon the soil conditions, and not only improve the biological conditions, but also favor chemical changes, particularly humification processes.

There is added yearly to the surface portions of the soil a large amount of mineral matter by the falling portions of the plant, leaves, stems, etc., which, with the shade and moisture furnished to facilitate their decay, amounts to an excellent top dressing. The slowness with which straw, leaves, etc., decay in our soils with the ordinary supply of moisture, almost prevents such material from serving any good purpose as manure or as a means of forming humus in the soil, and anything which facilitates this process is of a decided advantage ; for the physical condition of our soils, while good, can be improved in this direction.

There is no doubt but that the return of the plant food appropriated and deposited in the leaves and stems which fall upon the surface may be slower than it would be under humid atmospheric conditions; still it goes forward somewhat faster under the influence of the shade and conserved moisture of a thick growth of alfalfa than it would otherwise do, and the surface soil must have a very considerable amount of mineral ash constituents added to it in the course of six or more years. Some may be flooded off by irrigating, some may be blown away, and a large amount may be taken up in the production of subsequent alfalfa crops ; still there can scarcely fail to be a large residual amount of available plant food collected in the first few inches of the soil. I am satisfied that this factor in the improvement of the soil has not received the consideration it deserves. It is one of those factors, however, that is just as potent without as with recognition, for the leaves fall and can not be prevented. I have elsewhere, in speaking of the loss in hay making, stated that from fifteen to twenty per cent. is about the minimum, and taking it at twenty per cent., and this is scarcely too high, we have a top dressing of leaves weighing one ton for every five tons of hay taken off, and as this amount of hay may be cut from an acre in one season, though it is too high for the average, we may calculate the annual dressing of leaves, etc., at one ton per acre. The total ash in this is 269 pounds, taking the ash of the leaves at 13.45 per cent., which is the average of four determinations. The 269 pounds of ash contain 11.83 pounds of phosphoric acid and 49.22 pounds of potash, equal to 25.79 pounds bone phosphate and 77.73 pounds chemically pure muriate of potash. To these are, of course, to be added the ash ingredients, for instance, the lime equal to 76 pounds caustic lime and upwards of 30 pounds sulphuric acid ($S\ O_3$); also nitrogen, equal to 74 pounds. It would require 449 pounds of sodic nitrate to furnish this amount of nitrogen. The yearly top dressing from this source alone is equal to 25.79 pounds pure calcic phosphate (bone phosphate), 77.73 pounds pure muriate of potash, and nitrogen equal to 449 pounds pure sodic nitrate. We take into consideration the facts that the organic nitrogen is not worth as much as the nitric nitrogen ; that some of these constituents may be lost ; also that much of it will be used by the growing plants, and still, as I have before said, the residual manurial elements must be large.

The value of the stubble and roots in the soil has been shown to be about $35 per acre, for the nitrogen, p hcsphoric acid, and potash, attributing neither influence nor value to the other fertilizing elements, which is justifiable only on the ground that we have neither a commercial nor a conventional measure of value for them, particularly the easily decomposable organic matter which has more value in our soils than it would have in many others. The humus in our soils is not high—in the samples given 0.4 and 0.2 per cent. respectively—and they produce good crops, but the addition of this form of organic matter would better their mechanical condition and very probably their productiveness. As the increase of humus in these prairie soils is not easy, I believe that we ought to value highly the easily decaying alfalfa roots.

There is still another manner in which the growing of this plant benefits our lands for cultivation: it opens up channels through compact substrata to a considerable depth, allowing the entrance of water and air. The writer unfortunately does not know whether hardpan streaks are frequently met with or not, but, so far as his observation goes, they are not; compact layers are met with, but the alfalfa roots have penetrated all of these which he has examined with this point in view. The size and length of the average roots in this country are not at all consonant with popular estimate, nor yet with the descriptions given of them as found elsewhere; but their power to penetrate tough clays and hard streaks is great enough to make them most excellent subsoilers. The soil of a field which has been to alfalfa has practically been deepened for a subsequent sowing to wheat. I have not seen, nor do I know of any observations having been made upon the root development of wheat in our prairie soils or as to the depth to which they penetrate in virgin soil, where there is a very fine, compact, and tough substratum, the result of the settling and compacting of ages To plant such a soil to alfalfa is to perforate this compact subsoil with numerous channels for the passage of water and air and for the entrance of other roots when those of the alfalfa have rotted. The work done by the alfalfa roots in accomplishing this is very great, but this work is to the benefit of the soil, the advantage of the succeeding crops, and to the profit of the owner, being the cheapest labor as well as the best directed and most efficient of any which he can employ.

A very common practice among our ranchmen ought to be particularly mentioned here, though it is only incidental to the object of this bulletin and is self-evident, needing only that attention should be directed to it. The great benefit accruing to worn out wheat soils by being sown to alfalfa is so marked that it is a matter assumed to be a fundamental fact of our Colorado farming. Alfalfa hay does not, at present prices, bear transportation; except it can be converted into some more markatable form ; and this has been the case for years. Until recently the fattening of steers was profitable, and, consequently, a favorite manner of marketing alfalfa hay. The crop was fed in the field, the animals pasturing and feeding on the ground upon which the crop grew; this was practically equal to returning the crop to the soil from which it was taken. Of course, the practice is not without some drawbacks; still the crowns were not tramped to death and the voidings of the animals were equivalent to manuring the surface soil with the crop grown upon it. There is no question but that this is not an economical way of treating the manure; but, in spite of the losses, a large amount of the manurial elements of the crop were returned to the soil. This does not hold for sheep feeding, and unless our farmers pay more attention to the manure of the sheep-fold, some of the beneficent effects of alfalfa growing observed in the past will be wanting in the future. The care of this manure is an important question to the people of this community. The alfalfa is a heavy feeder and lays a tax upon the soil for every benefit it bestows. The apparently wasteful methods of the past have tended to gain all the advantages from growing this plant and to obviate any disadvantages. If the same good results are to be maintained under a changing system of feeding, care must be exercised, and the manurial equivalent of the crop must be returned to the soil.

APPENDIX.

In the preceding pages I have given the general results of our study of the development of the alfalfa plant, mostly in numbers based upon hay, because this is the condition with which the average reader is most familiar, and the details of the preparation of samples, so far as there is any need of their being given at all, have been given ; but there are some details deserving of mention and yet of less interest to the public than the general discussion Some of these may find place here, together with the tabulated results based upon thoroughly dry material.

PREPARATION OF THE SAMPLES.

The samples of hay were prepared with the utmost care in order that the samples should represent the best grade of hay possible to be prepared from plants in that stage of development. They were protected from undue exposure to sun, wind and rain ; in fact, they were cured in muslin sacks and brought into the laboratory whenever there was any rain and during the night; so that they were not exposed to the effects of dew or moisture other than the hygroscopic changes in the atmosphere itself. We found that the protection from blowing sand and from loss of leaves due to the wind and drying of the plants was absolutely necessary in order to have our samples represent the plant as it actually was at the time of cutting. The sand found in the analyses of plant ashe is partly accounted for, in our cases, by its being blow upon the plant during the preparation of the sample ; som of it, however, is lodged in the axils of the leaves an stems, or even driven into their tissues by the winds. Thi method was very tedious, requiring as many as ten days even in this climate, to get some samples to a constan weight. A few experiments were made to determine th effect, if there was any, of drying the sample at 100 degrees C. and then exposing the dried hay to the air until it had saturated itself with moisture under the usual atmospheric conditions. We found this much more convenient and without effect upon the analytical results. The samples, however they might have been prepared, had to be sealed, and every precaution taken to prevent their absorbing more moisture, which in the closed bottle, they did not so readily give up.

PREPARATION OF THE ASH.

The method pursued in preparing the ash was, to heat a large platinum dish over the flame of a small Argand burner so strongly that the bottom, the room being partially darkened, began to show a dull redness over an area from one to one and a half inches in diameter; the weighed sample was introduced in separate portions until the charred mass filled the dish to rather more than two-thirds full, when it was allowed to continue heating until the volatile matter was nearly or quite expelled; the bulky mass was then transferred to a porcelain casserole and allowed to burn of its own accord so long as it would. The mass was stirred frequently and new portions of the sample were treated in like manner until the whole of it was brought into the casserole. When it had burned out and cooled sufficiently the still highly carbonaceous ash was extracted with water and washed so long as the wash water showed the presence of chlorine. The insoluble portion free from chlorine was then burned to whiteness at as low a heat as was feasible. This often proved to be a tedious operation. The solution containing the alkalies was evaporated to dryness in a platinum dish after the addition of the insoluble portion and enough ammonic carbonate to convert the calcic oxide formed into calcic carbonate. The ash was eventually dried at 200 degrees C., at last with addition of solid ammonic carbonate and bottled while still hot and carefully corked. If the ash thus prepared has to be kept for any length of time, it is necessary that it should be sealed. This degree of care was taken to avoid loss of chlorine and also possibly of sulphur. During the course of the preparation, however, we became convinced that the precautions taken were inadequate, because the loss of chlorine was not due to the volatilization of the sodic or potassic chlorides, but due to the formation of ammonic chloride. The odor of ammonia was very marked at certain stages of the process and was present in sufficient quantities to react upon red litmus paper, and a glass cylinder, placed over the already charred mass became coated with a white film whose solution in distilled water reacted strongly for chlorine. The temperature of the mass was at this time very low, and the escape of the potassic and sodic chlorides from the mass, whose surface was covered with a layer of already cooled ash, even if the temperature at the glowing points was high enough to volatilize them, is difficult to believe. But one proof has already been adduced, that with this highly nitrogenous plant, chlorine did escape, whatever may be the facts relative to the sodium and potassium. The loss of chlorine was also noted by direct observations in the incineration of a sample of seed, but the conditions were not similar and the film of chloride, collected on the cool platinum foil used in this instance, may have been the chloride of one of the fixed alkalies, or perhaps of both. No less care had to be exercise to avoid the formation of the alkaline sulphides either directly or by reduction of the sulphates, principally, if not exclusively, by the latter process. Close observation shows that, if the combustion is slow enough to avoid a high temperature in any part of the mass, there will be no sulphides formed, but otherwise yellow points may be detected in the mass by careful examination before it has been stirred too much. In burning large quantities it is almost impossible to avoid its formation because of our inability to control the rate of combustion in all parts of the mass.

The time consumed in preparing the samples of ash was very great, and, as we shall subsequently see, did not produce results commensurate with the care bestowed upon it. The only point in which satisfactory results were obtained was in producing an ash practically free from carbon and one in which we had no free bases, either lime or alkalies. The evaporation of the ammonic carbonate solution to dryness and heating to 200 degrees C., with the addition of the insoluble, was probably without any other effect than to assure the conversion of any caustic lime into the carbonate. That it may have been the cause of the loss of any chlorine ors ulphuric acid, particularly the latter, is verydoubtful. This question suggested itself, and calcic sulplate was repeatedly heated in this manner without change in weight.

THE METHODS OF ANALYSES.

As the methods adopted in this work are not identical with those commended by the Association of Official Agricultural Chemists, we deem it just to give the methods used, which, in our hands, are convenient and very satisfactory. The general method was to dissolve 4-5 grams of the ash in hydrochloric acid and to separate the silicic acid by evaporating to dryness and heating in an air bath at 115 to 120 degrees for two hours, after which the mass was wet with strong hydrochloric acid and evaporated to dryness again on the water-bath, taken up with water and as little hydrocholoric acid as possible, and the solution made up to 250 c. c. The soluble silicic acid was separated from the sand and carbon by means of caustic potash solution. The sand, etc., was washed from the filter into a platinum dish, a solution of caustic potash, corresponding to three grams of the solid salt, was added, and the whole evaporated to dryness on the water-bath. This gives us fixed conditions for all the analyses. Fresenius and Will have shown that sand is not attacked under these conditions. There was not carbon enough in any sample of ash analyzed to give any trouble and the solutions were clear and colorless. The residue, insoluble in caustic potash, was washed with hydrochloric acid and subsequently with water until free from chlorine and weighed on a tared filter. The carbon was burned off and the sand weighed. The silicic acid was separated from the potash solution as usual and weighed as silica. One portion of the solution, corresponding to about one gram of ash, was taken from the determination of the sulphuric acid, oxide of iron, and alumina. A second portion, equal to the first, was taken for the phosphoric acid, manganic oxide, lime and magnesia, and a third one for the determination of the alkalies. The sulphuric acid was thrown down as baric sulphate from the boiling solution by hot dilute baric chloride solution; this precipitate was filtered off, washed until no chlorine could be detected in the wash water, ignited, and as a precaution, weighed. It was then fused with sodic carbonate or sodic-potassic carbonate—the solution of the sulphate must be complete—whereby the excess of barium and any iron and alumina is separated, the solution was acidulated with hydrochloric acid and after standing until the excess of carbonic oxide had escaped, was heated to boiling, and the sulphuric acid again precipitated by a hot dilute solution of baric chloride; this precipitate was washed and weighed, then dissolved in concentrated sulphuric acid, and the baric sulphate cystallized by evaporation to dryness and washed with boiling water. The fusion, with the alkaline carbonates, is advisable to remove excessive baric salts, iron and alumina, the solution in sulphuric acid to remove alkaline salts from the baric sulphate. These operations lengthen the analyses, but the results are very different from the first weights obtained in the determinations.

The ferric and aluminic phosphates were thrown down from the filtrate by means of ammonia, and acetic acid added to dissolve the other phosphates. This precipitation had to be repeated at least three times to get rid of baric and calcic phosphates. There was not maganese enough in any sample analyzed to come down with ferric and aluminic phosphates in sufficient quantity to be detected. The ferric oxide was separated by means of citric acid ammonia and ammonic sulphide. If the precipitate of phosphates is not heated too strongly, even partial fusion must be avoided, their solution in hydrochloric acid is easily effected, and the separation is easily performed.

PHOSPHORIC ACID, MANGANESE, LIME AND MAGNESIA.

A quantity of pure ferric chloride, sufficient to combine with all the phosphoric acid, was added and then, if the solution was not too acid, solid sodic acetate sufficient to convert all the bases into acetates, and the whole evaporated to dryness on the water-bath. If the solution was too acid, it was partly neutralized with sodic carbonate before the addition of the acetate. The dry mass was moistened with acetic acid and boiled out with water. As a rule, I do not wash this precipitate thoroughly, but dissolve it in hydrochloric acid and evaporate the second time with the addition of sodic acetate. The precipitate contains neither manganese, lime nor magnesia and the solution is free from iron and alumina, from which no trouble is experienced in precipitating even traces of maganese by bromine water, and has the further advantage of being small in volume. The lime was precipitated as oxalate, with the ordinary precautions, to obtain its complete precipitation. I allowed it to stand as long as at all convenient, washed and dried it partially and ignited it in a platinum crucible or dish until all the oxalate was destroyed; it was then brought into solution and reprecipitated as oxalate. This precipitate was free from magnesia. The filtrates containing the magnesia were evaporated to a convenient volume and the magnesia thrown down by ammonic phosphate ; this precipitate was purified by solution and reprecipitation. A nitric acid solution of the precipitate of ferric oxide, containing the phosphoric acid, was obtained either by dissolving it in nitric acid directly, or by first dissolving it in hydrochloric acid, precipitating by ammonia, washing and then dissolving it in nitric acid. The latter method will be found the shorter, as a rule, and more satisfactory. The phosphoric acid was thrown down from this solution by ammonic molybdate, the precipitate washed with dilute nitric acid, dissolved in ammonia, and precipitated with magnesia mixture. The precipitate was allowed to stand, though precipitated hot with the aid of violent stirring, for twelve hours, and then, after washing, dissolved and precipitated, often with the addition of a little citric acid if there was any suggestion of the presence of ferric phosphate in the phospho-molybdic acid. The third portion of the solution was used for the determination of the alkalies. I added to the boiling solution baric chloride, enough to precipitate the sulphuric acid, and ferric chloride to combine all of the phosphoric acid and then washed milk of lime to alkaline reaction, washing the precipitate free from chlorine. If too much milk of lime is added this is rendered much more difficult. I prefer to add no more milk of lime than is necessary to precipitate the ferric salts and render the solution alkaline, filter and wash out the precipitate, add lime water to filtrate and evaporate down to a small volume, filtering off the magnesic and calcic salts which separate before precipitating with ammonic carbonate ; by which, together with a little oxlate of ammonia, the lime was removed. The last portions of the lime are removed as usual. The addition of baric salts makes this portion of the operation more difficult, but if more than traces or only small quantities of sulphuric acid are present, the addition of baric chloride is advisable. The potassic-platinic chloride was uniformly dissolved in boiling dilute hydrochloric acid and crystallized by evaporation on the water-bath. If enough hydrochloric acid is added, there will be no trouble experienced by the formation of a crystalline film to prevent evaporation ; on the contrary, the salt will crystalize in large, well defined crystals, as good as free from water, if not entirely so. The potassic-platinic salt was weighed on a tared filter after drying in the water-oven for not less than two and one-half hours.

CHLORINE AND SULPHUR.

The chlorine was determined in two ways ; first, from the ash and second from the plant. I was induced to do this by two observations, the first of which has already been given, i. e., an observed loss of chlorine; and the second was the fact that I obtained such unusually high percentages of chlorine in the different ashes that I at first felt that probably I had made some mistake, particularly so as there was not even an approximate agreement between the results obtained from what would be considered comparable samples. The first method was, to dissolve a weighed portion of ash in cold dilute nitric acid with immediate addition of argentic nitrate, and sometimes I used a mixture of argentic nitrate and nitric acid as the solvent. The argentic chloride was dissolved in ammonic hydrate, filtered and thrown down by nitric acid and eventually weighed on a tared filter. The very highest result that I could find given for chlorine in the ash of this plant was a little over eight per cent., and the usual quantity given was about two per cent. or less; and still finding from five to six and even eight per cent., although I knew that chlorine had been lost in preparing the ash, I concluded that I was in error and resolved to determine the chlorine in the plant or dried sample. To this end from ten to thirty grams was taken, from two and one-half to eight grams of pure sodic carbonate was dissolved in water and made up to a volume sufficient to wet the sample thoroughly. The sample was then placed over a free flame and thoroughly charred, the mass being extracted with hot water; the filtrate was usually slightly colored, especially in cases where a larger portion had been taken, but when the charring had been successfully done, the solution was colorless. The carbon was washed free from chlorine and then burned until the ash was white. As the organic matter is an unpleasant material to have in the solution, I evaporated the same to dryness and ignited it to complete the carbonization. This was easily effected at a temperature which would produce no volatization of the sodic chloride from the mixed salts. The solution was filtered off and added to the nitric acid solution of that portion of the ash insoluble in water. As a matter of course, care was taken to avoid loss from effervescence, escape of hydrochloric acid, etc. From this point on the two processes were the same, but the results were much higher than before. This induced me to treat the whole series in this manner. It has been stated that a loss of chlorine can scarcely be avoided in incinerating the plants; but either the loss has been considered insignificant or the determination of chlorine has been deemed of so little importance to our study of the plant's requirements that the determination of chlorine in the ash has been accepted, perhaps with good reason, as quite sufficient for our purposes. Be this as it may, we have made the series of determinations in which our results approximate closely to the chlorine in the plants at the time they were cut; and, while the loss is very varying, it is observable in every case and shows that the amount of care bestowed upon the preparation of the ash was not sufficient to give us more than a relative idea of the amount of this element in the plant. The results are expressed in the percentage of ash found in the air-dried samples, and contain a small error which may, in this case, be neglected. The results are grouped so as to show the chlorine in different parts of the plant, as well as the differences in the results of the two methods of analysis. The samples from the same locality are brought together as far as convenient.

The first column gives the percentage of chlorine found in the ash, and the second the amount corresponding to that obtained from the plant, calculated on the basis of the per cent. of ash found in the air-dried samples.

Hay Samples.

Coming in bloom, 2nd cut	7.758	8.670
Full bloom	8.500	10.880
Half bloom, 2nd cut	7.919	9.637
More than half bloom, 1st cut	7.010	8.888
With seed formed, 1st cut	8.150	9.609
With seed formed, 1st cut	5.760	7.166
Stubble	1.598	2.762
Not in full bloom, 1st cut	4.036	5.665
Half bloom, 1st cut	3.358	4.201
Full bloom, 1st cut	6.020	6.531
Red clover	2.500	2.527
Not in bloom	8.311	9.457
Third cutting	4.753	5.161
Third cutting	7.727	8.180
Some seed formed, 1st cut	6.776	7.966

Parts of Plant.

Whole roots, washed	.523	.746
Whole roots, washed	.318	.609
Whole roots, not washed	.985	1.357
Whole roots, not washed	1.322	1.615
Outside portion of roots	1.226	2.000
Outside portion of roots	1.771	2.333
Inside portion of roots	.756	1.151
Inside portion of roots	.603	1.375
Stems		5.988
Stems	8.510	9.923
Stems	8.180	9.667
Leaves	4.835	.....
Leaves	6.463	7.388
Leaves	6.246	6.773
Leaves	4.822	5.941
Flowers	4.881	.....
Seed	.767	1.453

The ash of the stems appears to contain the highest percentage of chlorine, but that of the leaves by far the largest quantity, as they have an average ash content of about 13.5 per cent., against 5 per cent. in the stems; the roots and seed have but little, both the percentage of ash and its content of chlorine being small.

I have one sample of red clover grown under conditions identical with those under which one of the alfalfa samples was grown, and is therefore comparable with it. The clover contains 10.07 per cent. ash, with only 2.5 per cent. chlorine; while the alfalfa hay grown under the same conditions has 10.42 per cent. of ash with 6.53 per cent. of chlorine.

According to E. Wolff as quoted by Mayer in his Agrikulturchemie, red clover ash contains 3.95 per cent., and alfalfa ash 3.48 per cent. of chlorine; while E. Wolff, in his ash analyses, gives 2.57 for the percentage of chlorine in alfalfa ash from plants in bloom. The difference between these determinations may be accidental and I regret that I have not enough of the sample to either establish the fact, for instance, that alfalfa does require more chlorine for its proper maturing than clover does, or that this result is an accident. As it is the result is suggestive only. It ought to be remarked here that alfalfa does better throughout this country than clover does, although good crops of clover can be grown here. I never saw a finer specimen of red clover than the one used in this determination. The chlorine may have a very important function in the development of alfalfa, and hence its large amount, this may or may not be the proper explanation, but it is evident that the ordinary method of preparing the ash gives too low results and, after allowing for differences due to differences of soils, we have differences due to the degree of maturity; but in all the samples the percentage is high. I have found but few analyses that are nearly as high. Wolff gives three with 6.97, 7.00 and 8.05 per cent. chlorine. Harrington, in Texas bulletin No. 20, also gives three, with 5.07, 6.90 and 8.57; while the average percentage in the ash of alfalfa hay, as we have found it, is 7.85 per cent., with 10.88 per cent. as a maximum and 4.20 per cent. as a minimum.

The sulphur was determined and estimated as sulphuric acid. That some of the sulphur may escape as sulphuretted hydrogen on dissolving the ash in hydrochloric acid, is a well-known and an almost hackneyed observation. As the albuminoids which may contain sulphur are abundant, and also as the alfalfa is a lime loving plant (its leaves containing an abundance of calcic sulphate), the sulphur seems to promise as great a loss as the chlorine. As my time did not permit of an extended series of experiments in this line; and further because of the tedious character of the operations, only a few samples were chosen in which to attempt the more accurate determination of these components, sulphuric and phosphoric acids. Two samples of roots and one of leaves were chosen for this work; the leaves because of the large amount of sulphuric acid, and the roots because of their relative richness in phosphoric acid as well as low percentage of ash.

In the following table, the first column gives the percentage of sulphuric and phosphoric acids found in the ash, and the second column gives the percentage which the ash should contain to correspond to the percentage found in the plant.

Leaves:—		
Sulphuric acid	10.841	12.843
Phosphoric acid	3.459	3.600
Inside portion of roots:—		
Sulphuric acid	4.881	8.091
Phosphoric acid	16.032	15.982
Whole roots:—		
Sulphuric acid	5.093	7.653
Phosphoric acid	10.270	10.048

Here we observe a loss of 2.001, 3.210, and 2.561 per cent. of sulphuric acid; while the phosphoric acid determinations agree as well as could be expected. The preparation of the ash samples has been given. The determination directly from the air-dried samples was made as follows: from ten to thirty grams of the sample, according to the amount of ash it had yielded, was placed in a silver dish and thoroughly saturated with a solution of a mixture of ten grams potassic hydrate to two and one-half grams of nitre and ignited with subsequent addition of weighed portions of nitre until the mass had become white. The sulphuric acid in the potassic hydrate and nitrate was determined and deducted from the total found. Every precaution heretofore given was exercised in these determinations of sulphuric acid, and equally so in the case of the phosphoric acid, which was thrown down from the filtrate from the baric sulphate as ferric phosphate and then by ammonic molybdate as usual.

These results make evident the error in the sulphuric acid determinations by the method of direct incineration as given for these samples; but show no loss for the phosphoric acid. These were the primary objects of the determination, but the samples were chosen with the purpose of giving duplicate determinations of these constituents, particularly of the sulphuric acid in the ash of the leaves and of the phosphoric acid in that of the roots, which seemed anomalously high, but the correctness of the other determinations was more than fully established in this far, that the ash of the leaves contains large quantities of sulphuric acid, and that that of the roots is next to that of the seed in richness in phosphoric acid. The leaves are rich in albuminoids, chlorine, and sulphuric acid. We have no where made any distinction between sulphur and sulphuric acid, and, though it is probable that a large proportion of the sulphur is present in the leaves as sulphate of lime, it is certainly not all present as such. There are two ways of explaining this that suggest themselves to the ordinary mind: either they are simply accumulated there, being brought here more rapidly than they can be disposed of by the plant, or they are gathered there for some functional purpose. The decision of this matter we leave to the physiological botanist; but until we learn better we shall continue to think it more probable that it is for the functional purpose rather than the result of simple accumulation.

Reference has been made in the bulletin proper to the attempt to determine the nitric nitrogen in alfalfa hay. The reducing agent used was neither of those recommended for this purpose; but was metallic iron in conjunction with precipitated copper. I have found this a most convenient and efficient reducing agent for converting nitric acid into ammonia and have given it preference in this work. I am not aware that this has been recommended by any one previous to this time. I added two grams of crystallized cupric sulphate and one and one-half to two grams of reduced iron. As this will give from 13.78 per cent. to 13.83 per cent. of nitrogen in potassic nitrate, I deemed it of sufficient delicacy to give reliable indications in this investigation and have already given the results obtained.

All methods not given in this appendix were the conventional methods.

The fodder analyses were made by Mr. Ryan; also the soil analyses. All others were made by myself.

We have brought together in the following tables our own analyses of alfalfa hay and separate parts of the plant, calculated on the basis of dry matter; also all the analyses of other stations so far as we have been able to find them. Many of these are given in the original publications as analyses of hay; others as analyses of the green plant; and still others in the form here adopted. Of course, all of the first two classes appear here in different percentages from those in the originals.

The writer is not familiar with the conditions in California, Texas, etc., but the results of the analyses show in some cases most remarkable differences. With us in Colorado, the youngest plants analyzed (cut while very immature--May 5th—from three to four weeks before blooming), show 25.72 and 31.52 per cent. of crude fiber for two different types of plants. These are the lowest percentages obtained by us for crude fiber from any Colorado sample; but none of the New Jersey samples reach 25 per cent. The Texas samples vary greatly, and the Kentucky samples are all below 25.2 per cent. The fat in these samples is from two to four fold that found in our samples, and the nitrogen free extract is as a rule higher, though in some cases it is lower. Those of all the samples which approach nearest to Colorado alfalfa are given by the Massachusetts Experiment Station. There are two points in which all the analyses agree, i. e., in showing high percentages of ash and proteids, the latter reaching its maximum in the Texas samples, followed closely by the Kentucky and Georgia samples; while the Colorado samples are very low in the series, the single samples from California and Vermont being the only ones below them in this respect.

It is futile for a person unacquainted with the soil conditions, the climate, the cultivation, and every detail of the conditions under which the plants were grown, the stage of development of the plants at the time of cutting, treatment of samples, etc., and even to these are to be added other very imperfectly understood factors, to attempt to explain the causes of the differences in the samples. The distance between Cape Ann and New Brunswick, N. J., is nearly the same as that between Fort Collins and Rocky Ford, and from New Brunswick to Raleigh, N. C., is about twice as far, while the latitude of New Brunswick and Fort Collins differs by only about one degree. Yet, the samples from Massachusetts and North Carolina are nearly identical with the Colorado samples; while the New Jersey samples differ very materially from them. We have four samples grown in different climates and soils; three of them agree in composition and the fourth one differs. The differences are not so marked in the other samples. I have found no complete analyses of alfalfa ash in any of the Station bulletins; the only ones that I have noted being four partial analyses given in Texas Bulletin No. 20, and two in Massachusetts State Experiment Station Report for 1888. These analyses were made with reference to the fertilizing value of the mineral constituents contained in them and not to determine all of the ash components.

FODDER ANALYSES.

	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Total Nitrogen.
FIRST CUTTING.						
Cut very young....	......	......	22.890	25.720	......	3.318
Cut very young....	.....	......	21 030	31.520	......	3.365
Not in bloom....	10.66	2.020	16.270	36.700	34.345	2.604
Not in bloom....	10.54	2.011	16.275	37.180	33.895	2.604
Not in bloom....	9.92	1.650	17.120	40.580	30.730	2.740
Not in bloom....	9.82	1.740	17.120	40.920	30.400	2.740
In half bloom....	9.89	1.260	15.370	38.880	34.600	2.549
In half bloom....	10.06	1.610	15.370	38.530	34 430	2.549
In full bloom....	9.68	2.300	15.304	......	......	2.420
In full bloom....	9.88	2.240	15.304	38.500	34.760	2.420
In full bloom....	10.53	1.250	15.027	42.880	30.313	2.404
In full bloom....	10.43	1.360	15.027	42.670	30.513	2.404
In full bloom....	10.71	1.530	15.660	36.110	35.990	2.506
In full bloom....	10.81	1.730	15.840	36.390	35.230	2.534
In full bloom....	11.01	1.664	16.020	35.380	35.930	2.566
In full bloom....	11.19	1.622	15.490	34.590	37.110	2.478
In full bloom....	11.41	1.450	15.840	36.900	34.400	2.534
In full bloom....	11.55	1.510	16.190	36.520	34.230	2.590
In full bloom....	12.27	1.810	17.240	34.590	34.070	2.758
In full bloom....	12.20	1.640	16.360	33.900	34.900	2.618
In full seed....	7.11	1.080	12.812	48.390	30.610	2.050
In full seed....	7.41	.960	12.656	48.380	30.590	2.025
In full seed....	10.24	2.060	14.690	40.800	32.210	2.350
In full seed....	10.44	2.210	15.310	39.450	32.590	2.450
SECOND CUTTING.						
Not in bloom....	11.23	1.340	17.560	30.860	38 810	2.810
Not in bloom....	10.91	1.610	16.670	30.920	39.890	2.670
Coming in bloom....	12.50	1.190	18.820	33.950	33.540	3.011
Coming in bloom....	12.44	1.190	18.850	34.320	33.200	3.018
Half bloom....	11.31	1.260	16.080	39.880	31.470	2.572
Full bloom....	10.01	1.600	13.781	39.480	35.129	2.205
Full bloom....	9.90	1.430	13.781	38.910	35.979	2.205
Full bloom....	11.47	1.840	13.240	39.770	33.680	2.119
Full bloom....	11.50	1.860	13.630	39.570	33.490	2.180
Early seed....	9.56	1.220	12.580	33.200	43.440	2.013
Early seed....	9.68	1.220	12.580	33.520	43.000	2.013
THIRD CUTTING.						
Hay from College farm....	9.09	1.710	13.000	39.550	36.650	2.080
Hay from College farm....	8.66	1.710	13.060	39 160	37.410	1.930
Hay from Rocky Ford....	10.47	1.380	12.910	34.670	40.570	2.064
Hay from Rocky Ford....	10.08	1.410	12.680	33.880	41.950	2.029
PARTS OF PLANT.						
Seed....	3.15	15.230	31.340	22.540	27.640	5.014
Seed....	3.19	15.400	31.700	22.570	27.170	5.072
Flowers....	9.85	2.210	22.350	20.850	44.740	3.576
Flowers....	10.20	.....	22.350	21.090	......	3.576
Leaves....	15.19	3.020	20.730	16.920	44.140	3.319
Leaves....	15.19	3.190	20.730	16.720	44.170	3.319
Leaves....	12.48	4.690	24.300	13.650	44.880	3.892
Leaves....	12.48	4.690	25.290	13.650	44.090	4.046
Leaves....	14.84	4.770	24.240	11.370	44.780	3.878

FODDER ANALYSES—CONCLUDED.

	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Total Nitrogen.
Leaves..........	14.61	3.750	24.690	11.650	44.300	3.950
Leaves..........................	15.03	3.078	25.500	13.760	42.630	4.088
Leaves..........................	15.54	3.109	24.500	13.830	43.420	3.920
Stems	5.19	.953	6.480	57.510	29.870	1.035
Stems	5.30	.900	6.470	57.610	29.720	1.035
Stubble, includes 6½ in. of the roots..	4.47	.518	12.160	38.190	45.000	1.945
Stubble, includes 6½ in. of the roots..	4.51	.610	11.750	37.400	45.730	1.880
Roots..........................	3.90	.760	11.500	26.580	57.310	1.758
Roots,.........	4.04	.680	11.210	26.120	57.950	1.717
Roots..........................	3.88	1.090	10.690	25.430	58.910	1.710
Roots..........................	3.89	1.190	10.640	25.490	58.790	1.703
Barks of roots..................	5.40	2.160	14.750	22.790	54.850	2.360
Inside portion of roots	3.64	2.920	8.000	30.330	55.140	1.280

COMPILED ANALYSES.

	Ash.	Ether Extract	Crude Protein	Crude Fiber.	Nitrogen Free Extract	Total Nitrogen.	
Fertilized	7.97	1.12	16.27	34.39	40.25	2.603	Mass. State Expt. Sta.
Not fertilized..............	7.10	1.04	14.41	32.41	45.04	2.306	Mass.Rep. 1888, p. 165.
No description given	8 25	4.47	12.60	32.94	41.74	2.020	Vt. Rep., 1891, p. 49.
Drilled, 1st cut...........	9.88	4.34	20.30	24.34	41.14	3.240	New Jersey Rep., 1888
" 2nd cut..........	7.89	3.73	15.24	18.36	54.78	2.438	" " " "
" 3rd cut	9.19	4.22	17.72	18.24	50.63	2.835	" " " "
" 4th cut	10.55	5.14	21.72	21.06	41.53	3.475	" " " "
Broadcast, 1st cut.........	10.52	4.07	20.73	23.11	41.57	3.316	" " " "
" 2nd cut........	8.22	3.24	16.76	23.70	48.08	2.681	" " " "
" 3rd cut	9.80	0.69	17.64	21.60	50.27	2.822	" " " "
" 4th cut	10.42	5.81	19.64	21.58	42.55	3.142	" " " "
Cut April 20, irrigated....	12.91	6.14	18.13	27.56	35.27	2.900	Texas Bul. No. 20, 1892
" " 29, irrigated....	12.30	5.18	19.93	29.87	32.72	3.190	" " " "
" May 11, irrigated....	10.34	4.87	19.18	33.61	31.98	3.070	" " " "
" " 30, irrigated....	8.00	3.61	15.31	34.23	38.85	2.450	" " " "
" " 30, 2nd cut......	15.26	3.10	23.56	25.20	32.88	3.770	" " " "
" April 3, not irrigated	10.94	6.30	25.75	16.64	40.37	4.120	" " " "
" " 21, not irrigated	10.59	7.25	25.68	22.98	33.50	4.110	" " " "
" May 11, not irrigated.	8.04	6.60	17.37	30.25	37.70	2.780	" " " "
Flowers begin to appear..	11.85	4.48	23.38	19.76	40.53	3.140	Ky. Rep., 1889-90, p. 19
In bloom..................	7.72	3.00	16.86	25.15	47.27	2.698	" " " "
Pods formed..............	9.67	2.07	14.83	25.19	48.22	2.405	" " " "
* No description given....	7.93	2.49	17.42	33.54	38.62	2.787	N. C. Rep., 1889, p. 82
† Sample inferior hay. ...	5.79	1.66	9.06	39.97	43.52	1.450	Cala. Rep., '91-2, p. 125
No description given... :.	4.28	2.22	21.86	29.55	42.09	3.498	Ga. Bul. No 7., 1890.
No description given......	7.87	2.66	16.24	31.08	42.15	2 569	N. Y. State Rep. 1889
Beginning to bloom	10.5	2.5	16 3	25.4	45.3		Mass. State Expt. Rep. '85, p 70
First cut (b)	9.3	2.6	20.1	28.3	39.7		N. J. Exp. Sta. Rep, 1886, p. 160
Second cut (b)...........	6.9	1.9	18.6	35.0	37.6		" " " " " "
Third cut (b)..............	6.6	2.1	16.0	33.5	41.8		" " " " " "
In bloom, 1st cut fertiliz'd	7.2	1.5	11.1	28.5	51.7		Mass. St. Exp. Rep. '87, p. 131
" " " not fert'z'd	7.8	2.0	13.0	27.9	49.3		" " " " " "
Coming into bloom......	8.8	2.2	18.8	30.1	40.1		Vt. Expt. Sta. Rep. 1887, p. 130
Seed in dough.............	8.6	2 4	16.1	32.8	40.1		" " " " " "
Time of cutting unknown	8.1	3.2	16.6	24.2	27.9		Colorado Expt. Sta. Bul. 8, 1889
‡Third cut, not irrigated..	11.5	3.0	21.9	18.6	45.0		" " " " "
Cut for seed, Sept. 25.....	7.9	4.2	12.3	24.5	51.1		" " " " "
Third cut, very coarse.....	9 1	2.4	12.2	26.3	50.0		" " " " "
Cut July 15, in bloom.....	11.2	2.5	11.6	15.4	59.3		" " " " "
" June 6, not irrigated .	9.8	2.8	13.5	21.0	52.9		" " " " "
" July 25, irrigat'd twice	7.9	2.0	12.4	25.0	52.7		" " " " "
" July 25, irrigated once	8.5	2.9	11.3	24.1	53.2		" " " " "
Second cut..........	8.8	2.7	12.9	22.2	53.4		" " " " "

* The analysis of the North Carolina sample, as it appears in their report, contains a typographical error, as the analysis shows an excess of 5 per cent. I have assumed that the error was in the nitrogen free extract, and have re-calculated the analysis giving the percentages on the basis of dry matter.

† The writer of the article in the California report states that the sample was mostly stems and that it was not a fair sample of California alfalfa hay. ‡ 26 days from time of previous cutting.

ANALYSES OF ALFALFA ASH.*

	Carbon.	Sand.	SiO_2.	P_2O_5.	SO_3.	Cl.	CaO.	MgO.	Fe_2O_3.	Al_2O_3.	Mn_3O_4.	K_2O.	Na_2O.	CO_2.	Sum.	Less O = Cl.	Total.
FIRST CUTTING.																	
Not in bloom	.031	1.087	1.181	5.028	4.440	8.311	22.833	3.223	.378	.162	.166	30.346	1.199	23.559	101.944	1.872	100.072
Not in bloom	trace	.781	1.150	4.630	4.965	4.063	24.750	3.806	.440	.166	.123	29.712	1.423	24.513	100.529	.915	99.614
Half bloom	"	.656	1.065	4.713	5.068	3.358	24.880	3.833	.337	.187	.123	29.892	1.652	25.361	101.125	.766	100.359
Full bloom	.112	.829	.881	5.234	5.608	8.500	27.620	3.798	.269	.089	.168	24.240	.943	23.730	102.220	1.920	100.300
Full bloom	.110	1.370	1.810	4.050	3.440	6.020	25.870	3.810	.090	....	.060	28.380	.860	25.200	101.070	1.350	99.720
In full seed	trace	2.142	1.083	5.404	4.216	5.760	20.146	4.462	.407	.241	.239	28.017	4.039	25.134	101.290	1.289	99.992
In full seed	"	1.765	1.503	4.459	5.635	6.776	23.905	5.951	.397	.253	.188	23.934	1.840	25.151	101.768	1.523	100.245
SECOND CUTTING.																	
Coming in bloom	"	.982	.776	3.941	6.114	7.758	25.973	3.373	.301	.055	.193	25.376	1.860	24.766	101.468	1.749	99.719
Half bloom	"	.907	.584	4.633	7.073	7.919	25.610	3.678	.249	.104	.149	26.865	1.756	22.606	102.133	2.003	100.130
Full bloom	.070	1.590	1.600	4.600	4.530	7.010	29.810	4.500	.140	.300	.080	21 340	1.020	24.410	101.030	1.580	99.450
Full bloom	.090	1.580	1.300	4.590	4.710	7.010	29.670	4.440	.100	.300	.110	21.250	1.050	24.440	100.640	1.580	99.060
Full bloom	.080	1.590	1.450	4.600	4.620	7.010	29.740	4.440	.021	.300	.090	21.300	1.040	24.440	100.850	1.580	99.270
Full bloom	.286	1.761	.850	4.519	6.640	8.150	26.273	4.033	.335	.171	.188	24.112	.991	23.625	101.934	1.836	100.098
THIRD CUTTING.																	
Hay	.011	.608	.431	3.903	3.551	4.753	21.497	4.142	.195	.092	.122	28.395	4.890	28.413	101.003	1.070	99.923
Hay	.020	1.216	.858	3.714	5.477	7.721	24.524	3.141	.397	.189	.156	28.209	2.055	24.003	101.680	1.739	99.941
PARTS OF PLANT.																	
Seed	trace	1.470	.640	38.863	1.370	.767	5.379	9.542	.485	.095	.209	35.213	1.547	4.536	100.116	.172	99.944
Flowers	"	9.187	3.157	7.702	6.256	4.881	16.949	3.953	1.013	1.179	.203	25.586	4.024	.....	......	.	......
Leaves	.023	4.104	1.844	3.013	11.520	4.835	31.327	5.259	.562	.594	.218	9.101	3.722	.....	......	....	......
Leaves	trace	.498	.866	4.399	11.241	6.463	28.435	4.642	.294	.208	trace	18.310	3.797	22.327	101.480	1.456	100.024
Leaves	"	.728	.767	3.407	6.246	6.697	38.370	4.266	.440	.103	.194	11.585	.777	28.113	101.693	1.509	100.184
Leaves	"	.524	.818	3.459	10.841	4.822	35.643	4.536	.430	.098	.315	10.905	3.641	24.031	100.064	1.086	98.978
Stems	"	1.727	1.604	4.437	3.492	5.988	14.260	5.261	479	.488	.163	26.851	8.335	.....	.....	....	.....
Stems	"	1.227	1 171	6.060	2.085	8.511	14.660	4.688	.545	.290	.157	33.487	4.522	24.368	101.771	1.915	99.856
Stems	"	.754	1.541	4.961	1.904	8.180	17.713	4.360	.362	.369	.145	36.688	1.093	23.858	101.928	1.802	100.124
Stubble	"	4.540	2.673	10.010	3 040	1.598	21.280	6.471	1.044	.697	.262	18.705	5.550	23.895	99.765	.360	99.405
Roots	"	5.907	3.561	8.888	3.208	.523	18.241	8.374	1.147	1.348	.357	22.474	2.469	23.567	100.154	.119	100.037
Roots	"	9.277	4.011	6.359	2.014	.318	21.208	5.481	1.689	1.188	.573	20.331	1.127	26.567	100.143	.038	100.105
Roots	"	2.058	3.865	11.821	5.337	.985	13.949	6.716	1.275	1.182	.681	29.784	5.355	17.630	100.638	.221	100.417
Roots	"	2.380	2.875	10.270	5.093	1.322	19.008	9.492	.844	.729	.149	24.443	2.110	21.742	100.457	.299	100.158
Bark of roots	"	5.119	6.045	9.375	6.318	1.226	14.357	6.563	1.430	1.619	.267	26.122	5.896	16.001	100.338	.276	100.062
Bark of roots	"	5.527	4.670	8.389	6.244	1.771	16.012	10.885	.993	1.444	.400	22.447	2.187	18.268	99.327	.398	98.929
Inside of roots	"	.860	1.125	11.144	4.973	.751	14.159	11.757	.675	1.148	.218	23.037	7.214	23.065	99.126	.169	98.957
Inside of roots	"	1.163	1.072	16.032	4.881	.603	21.021	12.148	.525	.235	.290	18.675	2.424	21.177	100.246	.135	100.111
Red clover	.120	1.730	1.950	2.890	1.330	2.500	25.330	5.550	.100	.....	.210	26.800	.230	30.640	100.380	.360	100.020

* Lithia was not detected in any sample, but strontia was present in all of them.

PLATE I.

The plant represented in this plate grew in a rich, loose soil, with a heavy clay subsoil and an abundant supply of water, the water level ranging from 4 to 8 feet from the surface at different seasons of the year. The diameter of the top was 18 inches, and the number of stems 360. The plate shows how these crowns gather soil around them, for the length of the underground stems is seen to be several inches, and this represents the accumulation of nearly this much material about it.

This is one of the largest plants that I have yet found. The specimen, as photographed, was dug April 30th, 1896.

PLATE II.

This photograph represents the face of an opening made to the depth of rather more than 13 feet in an alfalfa field on the Experiment Station Farm, at Rocky Ford, Otero County, Colorado. The soil is a fine alluvium. The roots penetrated to a depth of 12 feet 6 inches, and the simplicity of the root system is well shown, the roots being shown in their natural position. The upper margin of the photograph represents the surface of the ground, which lacks sufficient sharpness to show the crowns and stubble in the picture.

This alfalfa was four years old and cut from four to five tons of hay a year. The diameter of these roots, just below the crown, averaged a little less than ½ inch.

PLATES III. AND IV.

The two succeeding plates represent the largest alfalfa roots that I have seen. The root system and the tap roots are exceedingly large; they were of very nearly the same length—11 feet 9 inches—measuring from the crown of the root to the deepest point to which the roots had penetrated. They were not dug at the same time and are different types of roots. The tops of these plants measured over 5 feet 3 inches. They were obtained on the place of Mr. J. H. Walter, in Weld County, Colorado.

PLATES V. AND VI.

The two succeeding plates represent typical roots, grown on the place of Mr. J. H. Walter, in Weld County, Colorado. The smaller roots have been placed as nearly in the relative position which they had when taken from the soil as possible. These roots were very large, having a diameter below the crown of 1 inch. Unfortunately it was impossible to have the plants photographed immediately after digging them, and the leaves have fallen from the stems.

PLATE VII.

This cut represents an unusual form for an alfalfa root. It has not arisen from the tap root having received an injury at some time, for it is present, as may be seen upon close inspection, in perfect condition. It is difficult to distinguish between the branches of this root; they have about the same size and length, and one of them would serve as well for the tap root as any other. The root seems to have divided into five roots a little below the crown, each division going down separately, as an independent root, instead of going down as a single tap root. The length of this root was nearly 11 feet.

PLATE VIII.

This plate shows a root with more than the usual amount of branching, also the crown as dead on one side and developing on the other. The particular and anomalous feature about it is the throwing out of the two small roots at the crown. This is one of the very few instances of this which I have seen. In this case, as in all others which I have seen, these roots, although small in diameter, are as long as the larger roots.

PLATE IX.

Yearling plants grown on a highly cultivated soil; the maximum depth to which any of them had penetrated was 3 feet 9 inches. The soil was a fine prairie loam, with a clayey subsoil, succeeded by a fine yellow sand. This soil offered no resistance to the growth of the roots. The black spot on one of the roots is the remnant of a dead root, which, having died and decayed, left an open channel which the alfalfa root had followed. I have traced alfalfa roots for four and five feet where they have followed the course of decayed willow roots.

PLATE X.

These roots had a length of 9 feet 4¾ inches and were nine months old. The field had been sown to alfalfa with oats in the spring, and one cutting of alfalfa hay was made in the fall. The yield was about three-fourths of a ton.

The difference in the development of these young roots is no greater than is often found, and I see no satisfactory explanation for the facts. The yield from fields in which the roots are small is just as good as from those in which the roots are larger, without any perceptible difference in the quality of the hay. Some of these seedling roots were almost as large as any of the roots of the plants four years old, growing in an adjacent land. I do not know how soon an alfalfa root may acquire its full growth.

PLATE XI.

It was not possible to get the details of the small roots in photographs of plants whose roots were from 7 to 11½ feet long. We present in this plate the terminal portions of two roots, 7½ feet from the surface, each showing nodules, which appear as round or irregular black spots on the roots.

The extremities of the tap roots, I regret, were broken off.

PLATE XII.

This plate represents the terminal portion of a tap root, 11 feet 9 inches long. There was a fair degree of moisture, but no water at this point. There are a few nodules observable in the plate, but they are few in number and small. This root was in a perfectly healthy condition and was apparently growing vigorously. The spongioles were long, bright, and had every appearance of health and vigor.

PLATE XIII.

This is a mat of roots as it was exposed near the bottom of an excavation by the removal of a part of a layer of coarse gravel, leaving the roots in a cavity. It was due to the looseness and size of the gravel that we were able to obtain the fibrous roots intact. This gravel bed was filled to its upper margin with water, into which these roots penetrated for about 6 inches.

PLATE XIV.

Root nodules are often small and present in large numbers, being strung along the root as small, more or less round or cylindrical bodies, as may be seen to great advantage by digging up a plant of some of the small growing vetches or red clover, although on the latter the nodules are less abundant and larger. They usually occur on the roots of the alfalfa, isolated or grouped together, often forming colonies of considerable size, as shown in the accompanying plate, the largest of which were over 2½ inches across. These groups were of all shapes; some were globular, others flat and irregular in outline. The figures show this plainly. Some of them were broken and shrivelled; others were white and solid. The nodules represented were found at the depths of from 2½ to 5 feet.

PLATES XV., XVI., AND XVII.

The following series of three plates, with six plants, is intended to show the progress of the decaying of the roots at the crown, mentioned elsewhere in this bulletin.

In the first plate one part of the plant has been pulled to the side to show the cavity, which would otherwise have scarcely been seen. In the second one the root has been split down to show a more advanced stage of decay, and also the manner and depth to which it penetrates into the interior of the roots. The rest show different stages in its advance and the manner in which it affects the crown, finally killing it.

PLATE XVIII.

It is stated in the text, under the head of Roots, that it is difficult to explain the fact that alfalfa plants whose roots have been cut by gophers or mice continue to grow. As we believe the long roots to be necessary to the feeding of the plant, the statement is made in this connection that the alfalfa root does not, when eaten off, throw out adventitious roots, which are sufficient to supply so heavy a feeder as this plant is. The following plate is intended to show this and is of plants said to be ten years old. The plants were very much crowded and were all small. They were plowed up on April 29th, and the one with the smallest roots had as large a growth of top as any of the other plants. I cannot judge how long it was since the injury to the roots occurred

Plate I.

Plate II.

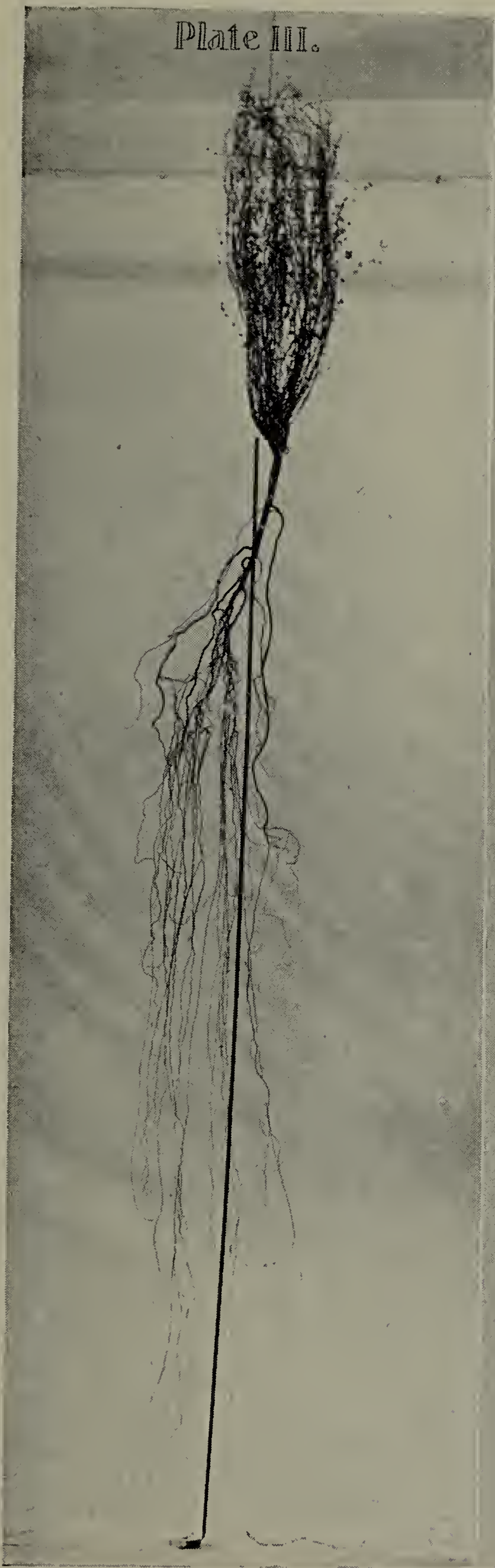

Plate III.

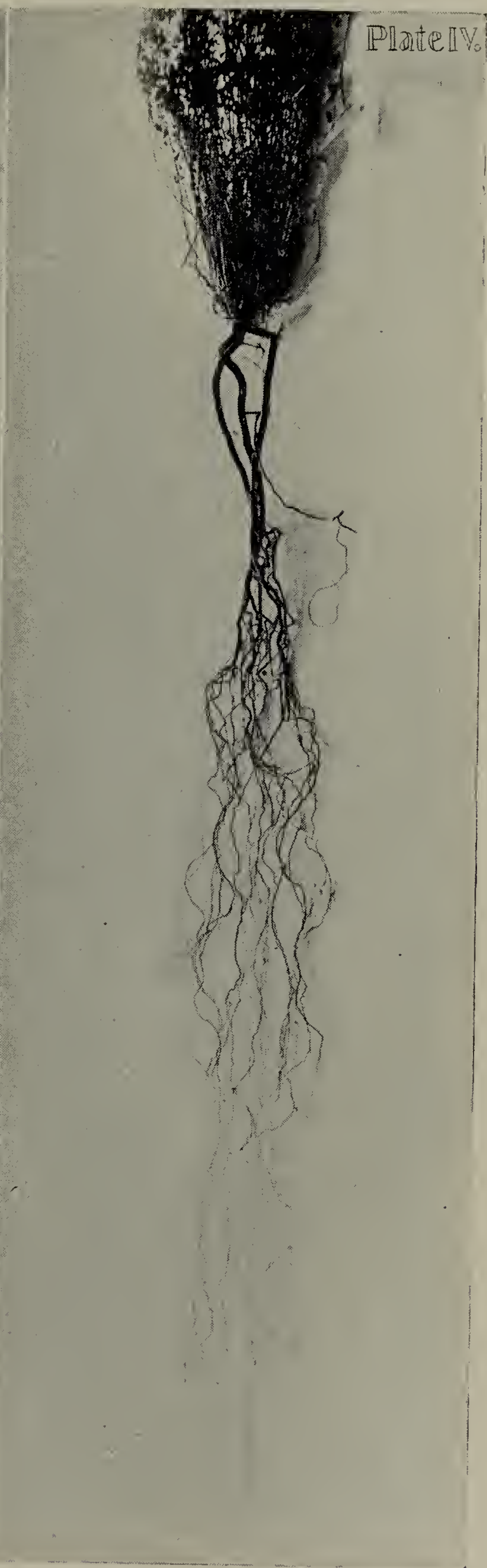

Plate IV.

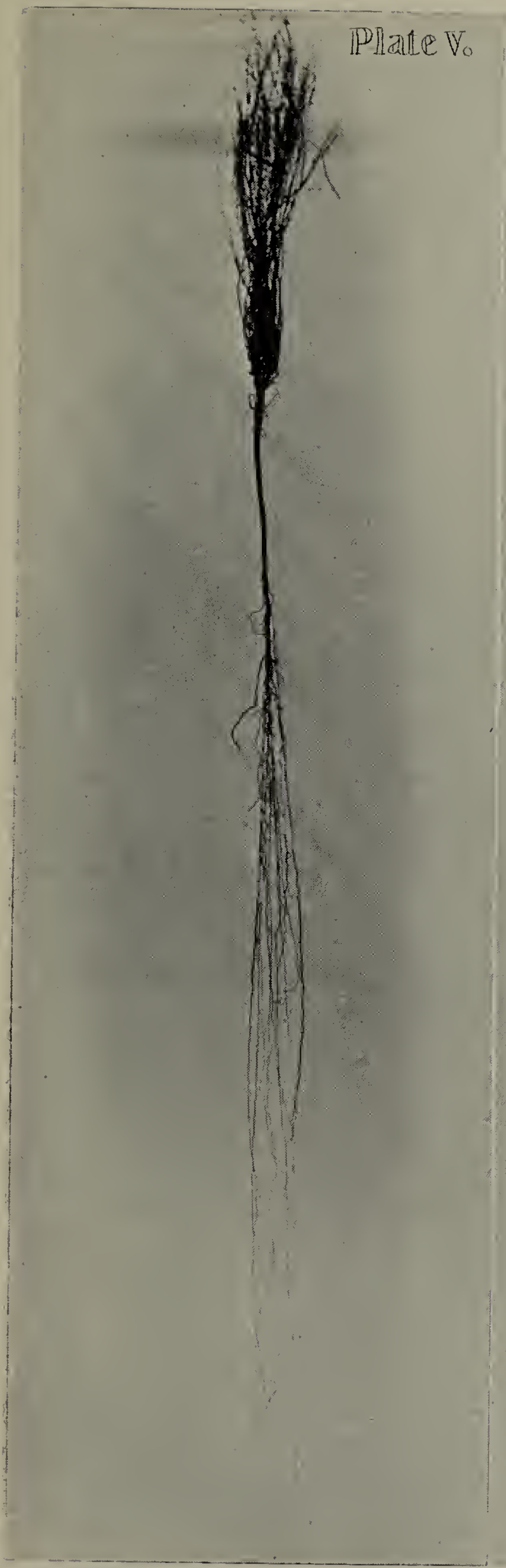

Plate V.

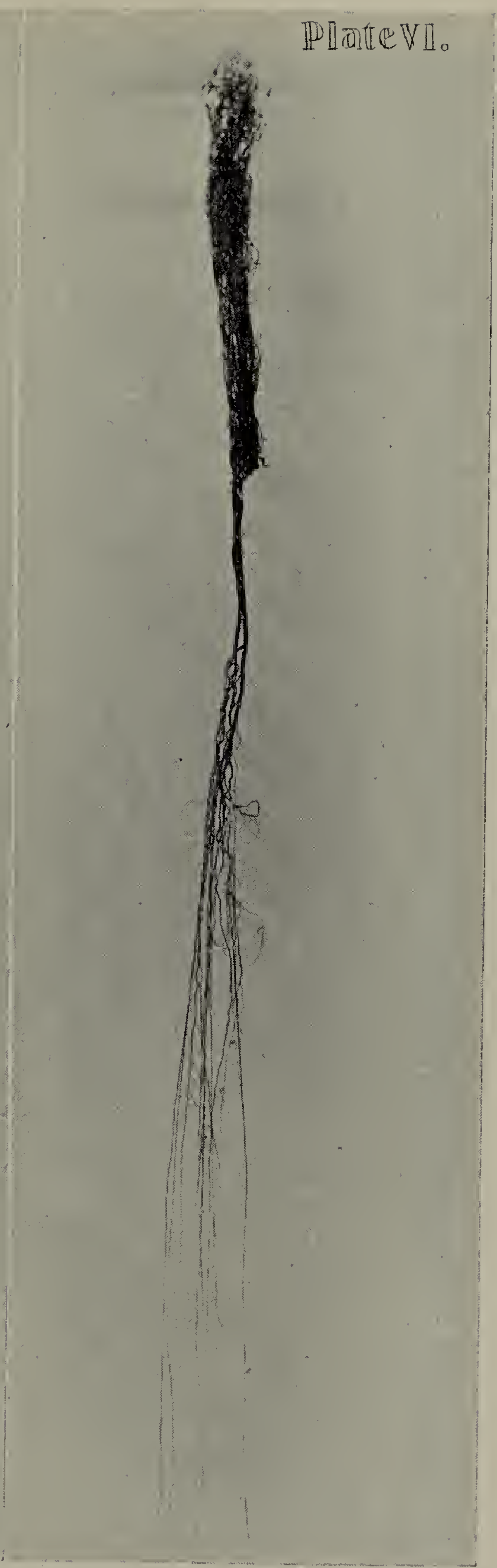

Plate VI.

Plate VII.

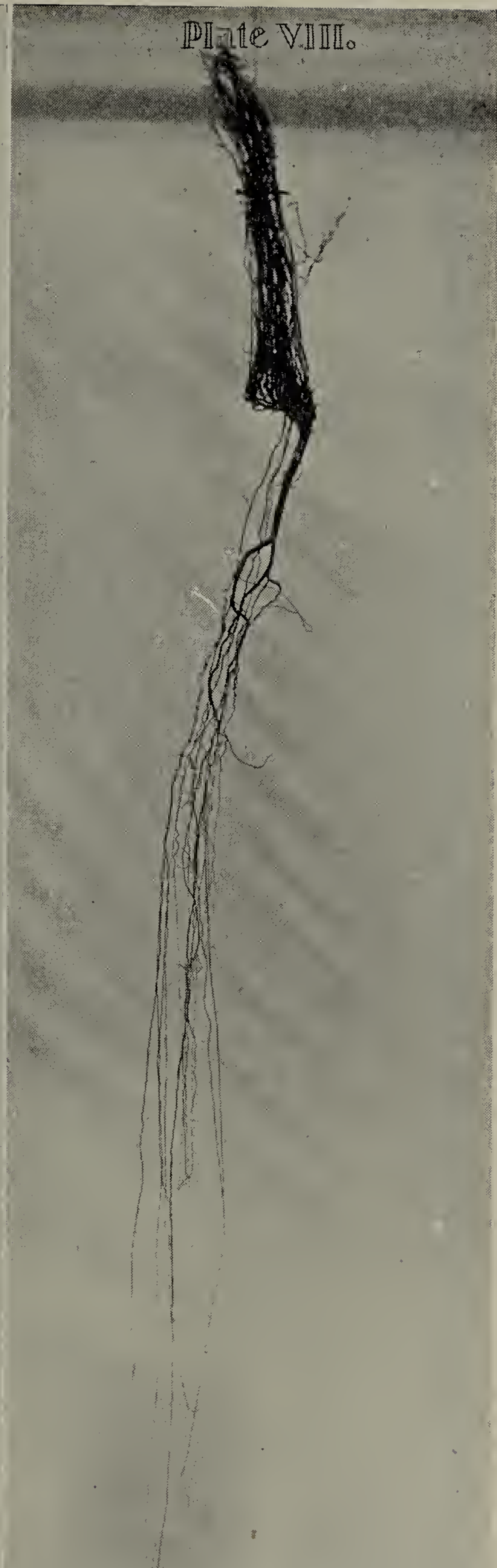

Plate VIII.

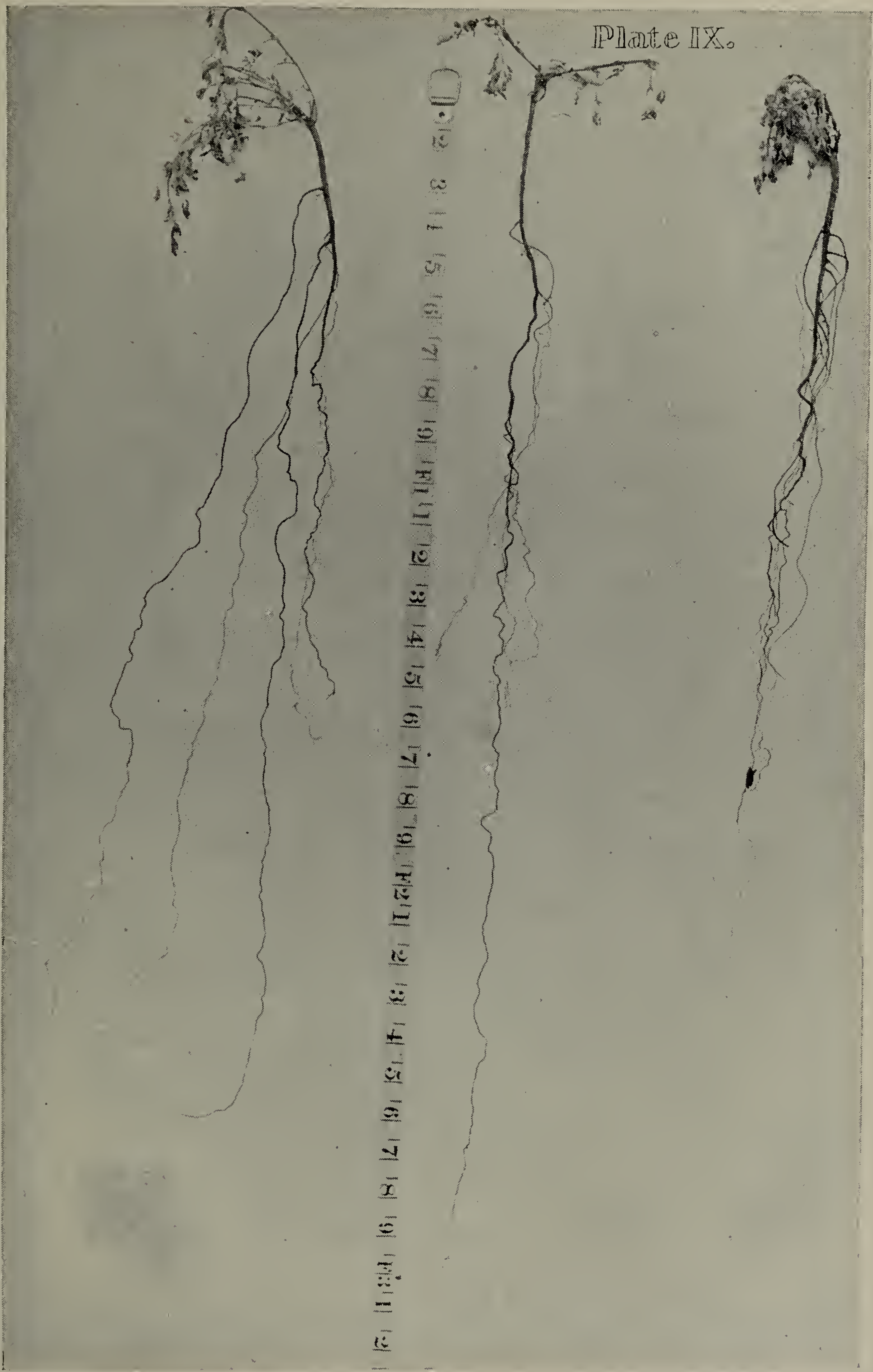

Plate IX.

Plate X.

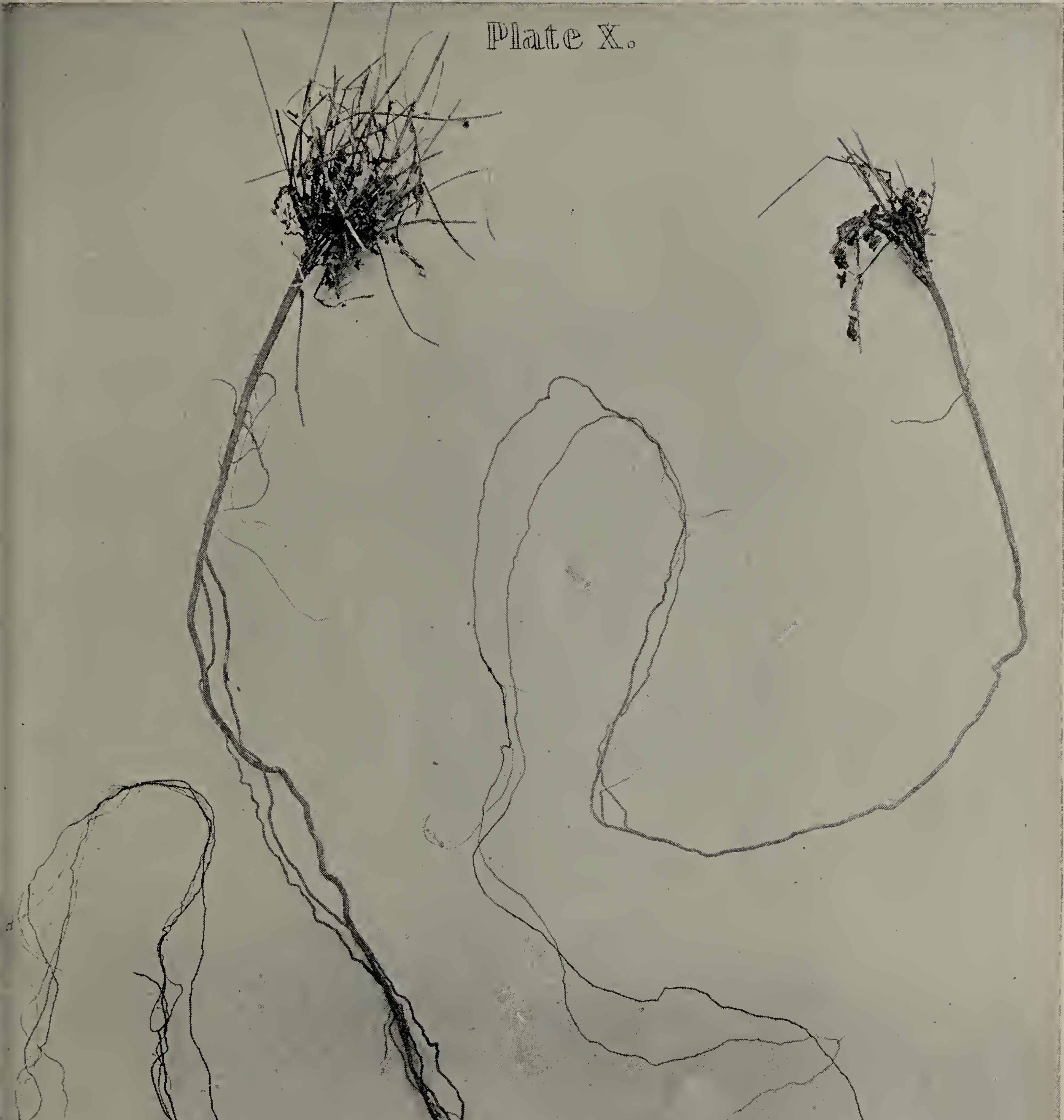

Plate XI.


Plate XII.


Plate XIII.

Plate XIV

Plate XV.

Plate XVI.

Plate XVII.


Plate XVIII