PROCEEDINGS

OF THE

Iowa Academy of Science

FOR 1920

VOLUME XXVII

THIRTY-FOURTH ANNUAL SESSION, HELD AT
IOWA CITY, APRIL 23 AND 24, 1920

PUBLISHED BY
THE STATE OF IOWA
DES MOINES

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THE TORCH PRESS
CEDAR RAPIDS
IOWA

IOWA ACADEMY OF SCIENCE

OFFICERS OF THE ACADEMY

1920-1921

President, Nicholas Knight........................Cornell College
First Vice-President, D. W. Morehouse........................Drake University
Second Vice-President, Robert B. Wylie........................State University
Secretary, James H. Lees........................Iowa Geological Survey
Treasurer, A. O. Thomas........................State University

EXECUTIVE COMMITTEE

Ex-officio — Nicholas Knight, D. W. Morehouse, R. B. Wylie, James H. Lees, A. O. Thomas.

Elective—H. E. Jaques, Iowa Wesleyan College; L. D. Weld, Coe College; J. E. Guthrie, State College.

1919-1920

President, T. C. Stephens........................Morningside College
First Vice-President, Nicholas Knight........................Cornell College
Second Vice-President, D. W. Morehouse........................Drake University
Secretary, James H. Lees........................Iowa Geological Survey
Treasurer, A. O. Thomas........................State University

EXECUTIVE COMMITTEE

Ex-officio — T. C. Stephens, Nicholas Knight, D. W. Morehouse, James H. Lees, A. O. Thomas.

Elective — P. E. Brown, State College; Ira S. Condit, Teachers College; S. W. Stookey, Coe College.

PAST PRESIDENTS

Osborn, Herbert........................1887-1888
Todd, J. E........................1888-1889
Witter, F. M........................1889-1890
Nutting, C. C. (2 terms) 1890-1892
Pammel, L. H........................1892-1893
Andrews, L. W........................1893-1894
Norris, H. W. (1 term)....1894-1896
Hall, T. P........................1896
Franklin, W. S........................1896-1897
Macbride, T. H........................1897-1898
Hendrixson, W. S........................1898-1899
Norton, W. H........................1899-1900
Veblen, A. A........................1900-1901
Summers, H. E........................1901-1902
Fink, Bruce........................1902-1904
Shimek, B........................1904-1905
Arey, M. F........................1905-1906
Bates, C. O........................1906-1907
Tilton, John L........................1907-1908
Calvin, Samuel........................1908-1909
Almy, Frank F........................1909-1910
Houser, Gilbert L........................1910-1911
Begeman, L........................1911-1912
Bennett, A. A........................1912-1913
Kinney, C. N........................1913-1914
Conard, Henry S........................1914-1915
Kelly, Harry M........................1915-1916
Stewart, George W........................1916-1917
Ross, L. S........................1917-1918
Beyer, S. W........................1918-1919
Stephens, T. C........................1919-1920

MEMBERS OF THE IOWA ACADEMY OF SCIENCE*

HONORARY FELLOWS

*Arthur, J. C. .... Purdue University, Lafayette, Indiana
*Macbride, Thomas Huston .... State University, Iowa City, Iowa
*Osborn, Herbert .... State University, Columbus, Ohio
*Todd, J. E. .... State University, Lawrence, Kansas
*Trelease, William .... State University, Urbana, Illinois
*Udden, J. A. .... State University, Austin, Texas

LIFE FELLOWS

*Beyer, S. W. .... Iowa State College, Ames
Clarke, Dr. J. Fred .... Fairfield
Conard, Henry S. .... Grinnell College, Grinnell
Erwin, A. T. .... Iowa State College, Ames
Fitzpatrick, T. J. .... State University, Lincoln, Neb.
*Greene, Wesley .... Des Moines
*Houser, G. L. .... State University, Iowa City
*Kay, George F. .... State University, Iowa City
Kuntz, Albert .... St. Louis University, St. Louis, Mo.
*Lees, James H. .... Iowa Geological Survey, Des Moines
Norton, W. H. .... Cornell College, Mount Vernon
Pellett, Frank C. .... Hamilton, Ill.
Ricker, Maurice .... Bureau of Education, Washington, D. C.
*Ross, L. S. .... Drake University, Des Moines
*Seashore, C. E. .... State University, Iowa City
*Shimek, B. .... State University, Iowa City
Summers, H. E. .... Iowa State College, Ames
Sylvester, R. H. .... Public Health Center, Des Moines
Thomas, A. O. .... State University, Iowa City
*Tilton, John L. .... West Virginia University, Morgantown, W. Va.
*Williams, Mabel C. .... State University, Iowa City
*Wylie, R. B. .... State University, Iowa City

FELLOWS

Aitchison, Miss Allison E. .... State Teachers College, Cedar Falls
Albert, Henry .... State University, Iowa City
*Almy, Frank F. .... Grinnell College, Grinnell
Anderson, J. P. .... Juneau, Alaska
Andrews, Launcelot W. .... Williamstown, Mass.
*Arey, Melvin F. .... Iowa State Teachers College, Cedar Falls
Baker, J. A. .... Simpson College, Indianola
*Baker, Richard P. .... State University, Iowa City
*Bakke, A. L. .... Iowa State College, Ames
*Baldwin, Bird T. .... State University, Iowa City
*Baldwin, F. M. .... Iowa State College, Ames
*Ball, E. D. .... U. S. Dept. Agriculture, Washington, D. C.
*Bartsch, Paul .... U. S. National Museum, Washington, D. C.
*Begeman, Louis .... Iowa State Teachers College, Cedar Falls
*Bond, Perry A. .... State University, Iowa City
*Boyd, Mark F. .... University of Texas, Galveston, Texas
*Brown, F. C. .... Bureau of Standards, Washington, D. C.
*Brown, Percy E. .... Iowa State College, Ames
Bruner, H. L. .... Butler College, Indianapolis, Indiana
*Buchanan, R. E. .... Iowa State College, Ames
Cable, E. J. .... Iowa State Teachers College, Cedar Falls
Carter, Charles .... Parsons College, Fairfield
Chaney, R. W. .... State University, Iowa City

* Starred names are also members of the American Association for the Advancement of Science.

FELLOWS—Continued

Chittenden, E. W.....State University, Iowa City
Condit, Ira S.....Iowa State Teachers College, Cedar Falls
Conklin, R. E.....Drake University, Des Moines
Cook, A. N.....State University, Vermilion, South Dakota
Coover, W. F.....Chemistry Dept., Iowa State College, Ames
Cratty, R. I.....Iowa State College, Ames
Daniels, Miss Amy.....State University, Iowa City
*Davis, W. H.....2017 Kendall Ave., Madison, Wisconsin
Dieterich, Ernest O.....The B. B. Goodrich Co. Phys. Lab., Akron, Ohio
Dodd, Lawrence E.....Physics Dept, State University, Iowa City
*Dole, J. Wilbur.....Parsons College, Fairfield
Doty, H. S.....Simpson College, Indianola
*Dox, A. W.....Parke, Davis & Co., Detroit, Michigan
*Evvard, John M.....Iowa State College, Ames
*Ewing, H. E.....Iowa State College, Ames
Faris, Ellsworth.....University of Chicago, Chicago, Illinois
Farr, Clifford H.....State University, Iowa City
Fay, Oliver J.....1212 Equitable Bldg, Des Moines
Finch, Grant E.....Normal School, Dillon, Montana
Fortsch, Arthur R.....215-7th St. S. W., Mason City
Fraser, C. McClean.....Nanaimo, British Columbia
Gabrielson, Ira N.....515 P. O. Building, Portland, Oregon
Gaessler, William G.....Iowa State College, Ames
Galpin, Sidney L.....Iowa State College, Ames
Geauque, H. A.....Simpson College, Indianola
*Geiser, Samuel W.....Zoology Lab., Johns Hopkins Univ., Baltimore, Md.
Getchell, R. W.....Iowa State Teachers College, Cedar Falls
*Gillette, C. P.....Agricultural College, Fort Collins, Colorado
Glomset, Daniel J.....518 Iowa Building, Des Moines
*Goodell, F. E.....West High School, Des Moines
*Graber, M. E.....Morningside College, Sioux City
*Guthrie, Joseph E.....Iowa State College, Ames
Hadden, David E.....Alta, Iowa
*Hance, James H.....Assistant State Geologist, Urbana, Illinois
*Hansen, N. E.....South Dakota State College, Brookings, South Dakota
Hartzell, Albert.....Iowa State College, Ames
Hawk, Grover C.....Penn College, Oskaloosa
Haworth, Erasmus.....Lawrence, Kansas
*Hayden, Miss Ada.....Iowa State College, Ames
Hendrixson, W. S.....Grinnell College, Grinnell
Hersey, S. F.....Iowa State Teachers College, Cedar Falls
Helmick, Paul S.....Physics Dept., State University, Iowa City
Hewlett, C. W.....State University, Iowa City
Higbee, Frederick G.....State University, Iowa City
*Hinman, Jack J.....Medical Laboratories, State University, Iowa City
Hoersch, Victor A.....Oklahoma University, Norman, Oklahoma
Horsfall, John L.....Field Station, State College, Bustleton, Pennsylvania
*Jaques, H. E.....Iowa Wesleyan College, Mount Pleasant
*Jeffs, Royal E.....Okahoma University, Norman, Oklahoma
Jewell, Miss Susan Grace.....Tabor College, Tabor
*Job, Thesle T.....Loyola Medical College, Chicago, Illinois
Kelly, H. M.....Cornell College, Mount Vernon
Keyes, Charles Reuben.....Cornell College, Mount Vernon
*Keyes, Charles Rollin.....944 Fifth Ave., Des Moines
*King, Miss Charlotte M.....Iowa State College, Ames
Knight, Nicholas.....Cornell College, Mount Vernon
Kunerth, William.....Iowa State College, Ames
*Lamb, Alvin R.....Iowa State College, Ames
Lazell, Fred J.....Cedar Rapids
Learn, Clarence D. Colorado Agricultural College, Ft. Collins, Colorado
Leighton, Morris M.....State University, Champaign, Illinois

FELLOWS—Continued

*Leonard, Arthur G.........University, near Grand Forks, North Dakota
*Leverett, Frank.........U. S. Geological Survey, Ann Arbor, Michigan
*McClintock, John T.........State University, Iowa City
McGaw, F. M.........Cornell College, Mount Vernon
*McKenzie, R. Monroe.........Parsons College, Fairfield
Martin, John W.........Dept. Botany, Iowa State College, Ames
Maxwell, H. L.........Chemistry Dept., Iowa State College, Ames
*Melhus, I. E.........Iowa State College, Ames
Merrill, Dayton E.........Guthrie Center
Miller, A. A.........214 College St., Davenport
*Miller, B. L.........Lehigh University, Bethlehem, Pennsylvania
Morehouse, D. W.........Drake University, Des Moines
*Mounts, Mrs. Beryl Taylor.........Ballard Normal School, Macon, Georgia
Mueller, Herman A.........St. Charles
*Newell, Wilmon.........State Plant Board, Gainesville, Florida
*Norris, H. W.........Grinnell College, Grinnell
*Nutting, Charles C.........State University, Iowa City
Oleson, O. M.........Fort Dodge
Orr, Ellison.........Waukon
Overn, O. B.........1222-St. Anthony Ave., St. Paul, Minnesota
*Palmer, E. L.........804 E. Seneca St., Ithaca, New York
Pammel, L. H.........Iowa State College, Ames
*Pearce, James Newton.........State University, Iowa City
*Pearson, Pres. R. A.........Iowa State College, Ames
Peck, Morton E.........Willamette University, Salem, Oregon
*Plagge, Herbert J.........Iowa State College, Ames
Reed, O. B.........Iowa State Teachers College, Cedar Falls
Reed, C. D.........U. S. Weather Bureau, Des Moines
*Reilly, John Franklin.........State University, Iowa City
*Reynolds, Bruce D.........603 N. Dubuque St., Iowa City
*Rietz, H. L.........State University, Iowa City
Roberts, Miss Maria M.........Iowa State College, Ames
Rockwood, E. W.........State University, Iowa City
Rogers, Walter E.........Lawrence College, Appleton, Wisconsin
Runner, Joseph J.........State University, Iowa City
*Sanders, W. E.........615 Equitable Building, Des Moines
Savage, T. E.........University of Illinois, Urbana, Illinois
*Schoewe, Walter H.........University of Kansas, Lawrence, Kansas
*Sherman, Miss Althea R.........National, *via* McGregor
*Sherman, L. P.........Grinnell College, Grinnell
*Shipton, Washburne D.........Washington University, St. Louis, Missouri
*Sieg, Lee Paul.........State University, Iowa City
Smith, George L.........Shenandoah
*Smith, John E.........Iowa State College, Ames
Smith, Orrin H.........Cornell College, Mount Vernon
*Somes, Melvin P.........815-3rd Ave. E., Kalispell, Montana
*Spencer, Miss Clementina S.........Coe College, Cedar Rapids
*Spinney, L. B.........Iowa State College, Ames
Stanley, Forrester C.........Penn College, Oskaloosa
*Stephens, T. C.........Morningside College, Sioux City
*Stewart, George W.........State University, Iowa City
*Stiles, Harold.........Iowa State College, Ames
Stoner, Dayton.........State University, Iowa City
*Stromsten, Frank A.........State University, Iowa City
Suydam, V. A.........Grinnell College, Grinnell
Thompson, George E.........Iowa State College, Ames
*Trowbridge, Arthur C.........State University, Iowa City
*Van Tuyl, Francis M.........School of Mines, Golden, Colorado
*Walter, Otto T.........State University, Iowa City
Walters, G. W.........Iowa State Teachers College, Cedar Falls
Watson, Emery E.........Parsons College, Fairfield

FELLOWS—Continued

*WEBSTER, R. L. ....115 Cook St., Ithaca, New York
WEIGLE, O. M. ....Westminster College, Fulton, Missouri
WELD, L. D. ....Coe College, Cedar Rapids
*WENTWORTH, E. N. ....6320 Kenwood Ave., Chicago, Illinois
*WESTER, C. W. ....Iowa State Teachers College, Cedar Falls
*WICKHAM, HENRY F. ....State University, Iowa City
WIFVAT, SAMUEL J. A. ....1104 W. 25th St., Des Moines
WILSON, GUY WEST ....Upper Iowa University, Fayette
*WOODWARD, SHERMAN M. ....State University, Iowa City

ASSOCIATES

ABEL, ARTHUR R. ....Sioux City
ADAMS, MISS MILDRED, Iowa City
*AINSLEE, C. N. ....Sioux City
ANDERSON, A. J. ....Sioux City
BELANSKI, C. HERBERT ....Mankato, Minnesota
BENNETT, GEORGE ....Iowa City
BENNETT, WALTER W. ....Geddes, South Dakota
BERNINGHAUSEN, FRED W., Geneva
BERRY, E. M., Lafayette, Indiana
BIRD, K. ....Des Moines
BOOT, DAVID H. ....Iowa City
BRIGGS, LEO ....Indianola
BROWN, F. E. ....Ames
BROWN, HOWARD C. ....Geneva, Illinois
BUCHANAN, L. L. ....Washington, D. C.
*CAMPBELL, H. G. ....Sioux City
CARTER, MISS EDNA M., Dubuque
CASE, CHAUNCEY, Salineville, Ohio
CAVANAGH, JOHN A., Des Moines
CAVANAGH, MISS LUCY M. ....Iowa City
COSS, JAMES A. ....Sioux City
COX, FREDERICK G. ....Laurel, Mississippi
CROFUTT, CHARLES B., Iowa City
*DEWEY, ARTHUR H. ....State College, Pennsylvania
*DILL, HOMER R. ....Iowa City
ELLIS, MISS MARJORIE, Iowa City
ELLYSON, C. W. ....Waterloo
EMERSON, F. W. ....Oskaloosa
ENSIGN, DWIGHT C. ....Iowa City
ENSIGN, MISS EVELYN, Des Moines
ERICKSON, THERON, Mount Vernon
*FENTON, FREDERICK A. ....Ames
FILLMAN, MISS LOUISE, Iowa City
FISH, DON E. ....Mount Pleasant
FLINT, PRES. C. W., Mount Vernon
FOFT, SAMUEL F. ....Waukee
FOSTER, MISS ALICE, Chicago, Ill.
FOSTER, CLARENCE L. ....Chengtu, Szechuan Province, China
FRENCH, RAYMOND A., Dubuque
*GILMAN, HENRY ....Ames
GIDDINGS, LEVI A. ....Salt Lake City, Utah
*GLOCK, WALDO S. ....Iowa City
GOSE, BERT ....Indianola
*HADLEY, S. M. ....Oskaloosa
HANNAH, DOROTHY M., Davenport
HARBERT, A. N. ....Iowa City
HARPER, FLOYD S. ....Iowa City
HARRISON, BRUCE M. ....Ames
HASLAM, THOMAS P., Sioux City
*HAYWARD, W. J. ....Sioux City
HEATON, VINCENT E. ....Ames
HEHNER, NELSON E. ....Indianapolis, Indiana
HEITKAMP, G. W. ....Dubuque
HEMMINGS, WM. A., Mt. Pleasant
HICKMAN, EDWIN ....Bronson
*HIMMEL, W. J. ....Radcliffe
HOFFMAN, WM. A. ....Brownwood, Texas
HOLBROOK, ROYAL H., Cedar Rapids
HORNICK, EDWARD J. ....Dubuque
*HOWELL, JESSE V., Lawton, Okla.
HOWELL, J. W. ....Dubuque
JESSUP, PRES. WALTER A., Iowa City
*JOHNS, ERWIN W. ....Northfield, Minnesota
JORDAN, RUDOLPH H. ....Iowa City
KINGMAN, ROBERT H., Storm Lake
KNOLL, WILLIAM V. ....Ackley
KRALL, J. A. ....Manchester
KRETH, DANIEL ....Wellman
LANE, C. E. ....Iowa City
LARSON, G. A. ....Des Moines
LAWSON, DONALD F. ....Waterloo
LINDEMANN, MISS MARCELLA, Adel
LINDLY, JOHN M. ....Winfield
*LINDSEY, ARTHUR W. ....Decatur, Illinois
LOCKE, A. P. ....Sioux City
LOCKHART, W. O. ....Knoxville, Tennessee
LONSDALE, JOHN T. ....Iowa City
LORENC, F. A. ....Loma, Nebraska
LOWMAN, O. E. ....Fayette
MARSH, REV. HERBERT ....Dolliver
MILLS, WEIR R. ....Pierson
MOCK, PRES. CHARLES A., Le Mars
MOON, MISS HELEN ....Vinton
MOORE, WILLIAM A., Mt. Vernon
*MULLIN, MISS CATHARINE ....Iowa City

ASSOCIATES—Continued

Nicholson, Miss Helen............ ....Iowa City
North, Lloyd.................................... ....Maracaibo, Venezuela
Olivier, Arthur.........Gilmore City
Overholt, Sigel ....Carson
Paige, F. W..................Fort Dodge
Parker, Ralph L.........................Ames
*Patterson, T. L.............Iowa City
*Patton, Leroy.................................. ....New Concord, Ohio
Paul, Miss Matilda, Iowa City
Plagge, Homer H....................Ames
Prottsman, W. G......................... ....La Crosse, Wisconsin
Quigley, T. H.................................. ....Gainesville, Florida
Ralston, Paul ....Lacona
*Ressler, I. L...............................Ames
Ries, Victor H.............Cedar Falls
Robinson, C. L....................Norwalk
Rohret, Miss Marguerite............ ....Des Moines
Rowe, Paul ....Glenwood
*Sawyer, Miss M. Louise............ ....Galesburg, Illinois
Schriever, William...................... ....Norman, Oklahoma
Scott, Winfield............Cedar Falls
Shippee, Vernon C....................... ....Prineville, Oregon
Shumaker, John B................Ames
Simpson, Miss Margery.............. ....Greencastle, Indiana
Smith, Donald M..................Ames
Snider, Frank J....................Kalona
Snyder, Charles E.....Sioux City
Spiker, Charles J., New Hampton
Stainbrook, Merrill A., Iowa City
Stecher, Miss Lorle I., Iowa City
Stolt, Miss Margaret.................. ....Fairfax, South Dakota
Stuhlman, Otto, Jr.................... ....Morgantown, West Virginia
Takkenberg, Henry G., Davenport
Torrance, D. Merrill, Van Horne
Treganza, J. A..........................Britt
Trieschmann, Jacob E............... ....Ellsworth, Kansas
*Tuttle, Mrs. F. May..........Osage
Van Wagenen, Miss Gertrude ....Pacific Grove, California
Wait, G. R..........................Iowa City
Webster, C. L.............Charles City
Wehman, H. J................................ ....New York City, New York
Weeks, Carl................Des Moines
*Weida, F. M...................Iowa City
Whipple, Mrs. Elizabeth S..... .... Wapello
Whittaker, J. S.................Corydon
Willey, Miss Florence S., Ames
*Williams, Noel J., Arnolds Park
Wilson, Ben H., Mount Pleasant

TITLES OF PAPERS PRESENTED

Botany

Chemistry

Geology

Mathematics

Physics

Psychology

Zoology

Archeology

PROCEEDINGS OF THE THIRTY-FOURTH ANNUAL SESSION

Held at Iowa City, April 23 and 24, 1920

The meetings of the thirty-fourth annual session of the Academy were held in Physics Hall at the State University. The session was called to order by President Stephens at one o'clock Friday afternoon. After the preliminary business meeting the exercises in connection with the presentation of the Calvin Memorial Portrait were held and the president then gave the Annual Address, on the subject of The Taxonomic Unit. Following the presentation of papers the Academy adjourned to the Englert Theatre where Professor Nutting showed the motion pictures of the University Barbados-Antigua expedition of 1918. Dr. Farr then exhibited a film showing the penetration of potatoes by the fungus Pythium De Baryanum. At 9:00 o'clock, after the usual dinners and a short program, the Academy attended a reception given by President and Mrs. Jessup at their home.

On Saturday morning following the sectional programs the final business session was held. Provision was made for the selection of an editorial committee, for the details necessary to complete affiliation with the American Association for the Advancement of Science and for the revision of the constitution.

REPORT OF THE SECRETARY

Members of the Iowa Academy of Science:

The past year has been one of steady growth for the Academy, as is witnessed both by the new members who have joined our society and by the continued high quality of our programs. The Academy is to be congratulated on the widespread interest which is taken in it by its membership, and it is probably not too much to say that this interest is responsible for the enviable position which our Academy holds among similar organizations of the United States and for the excellent reputation which it enjoys. Some of you read the article in Science (N. S., Vol. L, Dec. 5, 1919) on State Academies of Science by President David D. Whitney of the Nebraska Academy. You will recall that the tables there presented showed that among the strictly state Academies Iowa ranked first both in membership and in publications. They also showed that all of the sciences were well represented in our Academy. For convenience of reference the information contained in these tables is given below retabulated.

Name of academy	Classification of Members									Dues	Pages of publications	Annual state appropriation	Salary of officers	Interest
	Botany	Chemistry	Geology	Mathematics	Medicine	Physics	Zoology	Unclassified	Total					
California									300±	$ 6.00		No data given		
Colorado		20	75	11	5	15		20	146	10.00	110±	None	$600	Apathetic during war, but now interest is reviving
Connecticut	4	4	12	2	12	4	7	128	172	5.00	450	From private funds, $1,530	None	Lively interest in publications, but a decided lack of interest in the meetings
Florida									88	1.00	None	None	None	Dead
Illinois	63	45	28	9	29	29	56	55	314	1.00	345±	$1000	None	More lively than apathetic
Indiana	51	24	16	10	22	23	55	30	231	1.00	475	$700	None	Good and getting better
Iowa	60	30	40	18	12	30	60	100	350	1.00	550-650	Printing	None	Lively
Kansas	20	30	10	10	12	12	10	79	173	1.00	400	$1300	$1000	Rather apathetic
Kentucky	13	24	12	9	4	13	12	9	96	1.00	None	None	None	Fairly lively
Michigan	55		30		21		45	33	208	1.00	300-400	Printing	$75	Interest reviving
Nebraska	13	8	5	4	9	5	10	19	73	1.00	75	$150	None	Lively interest at the annual meeting, but apathetic the remainder of year
New Mexico	3	3	3	5		3	2	6	25	.50	None	None	None	
North Carolina	13	13	4	4	1	6	15	24	80	1.00	125-150	None	None	Very lively
Ohio	66	6	40	4	16	29	79	18	258	1.50		From private funds, $250	None	Fair
Tennesse	5	14	6	4		8	1	37	75	2.00	50±	None	None	Sixty percent alive
Utah	11	6	4	1	5	10	14	41	92	1.00	244	None	None	Rather apathetic
Wisconsin									350	1.00	500	$1500	$200	About fifty-fifty
Total	377	227	285	91	148	187	366	599	3031					

It is evident that so far as Iowa scientists are concerned the state Academy holds a place of large usefulness. The various national societies fill a need that nothing else can supply but for most of us the state Academy occupies a position of great value. It seems that what is perhaps an ideal condition is being attained in the affiliation of these two classes of organizations such as is now progressing in the case of the American Association for the Advancement of Science and the state and local academies of the Union. This matter was discussed by this Academy at its last meeting and the Executive Committee was authorized to perfect affiliation provided such union did not affect the internal organization of the Academy. At the time of the meeting of the American Association in St. Louis several conferences were held between representatives of the Association and of the academies. At these conferences the following plan of affiliation was tentatively decided upon, and was then accepted by the Council of the American Association and was to be presented to the various academies. Immediately following the meeting our Executive Committee was apprized of the action taken at St. Louis and unanimously ratified the proposal. The outline of the plan follows:

1. The Academy upon acceptance of the plan becomes thereby an affiliated Academy.
2. Membership in the Association is entirely optional with members of the Academies.
3. The combined annual dues of the two bodies amount to one dollar less than the sum of the two separate dues. In our case these dues would be five dollars for members of both bodies. This sum is to be collected by the treasurers of the academies and four dollars is to be forwarded to the secretary of the American Association for each member who is also a member of that body. For the current year one dollar each will be remitted to the Academy members who have already paid the Association dues when the secretary of the Association is informed that the Academy has accepted affiliation.
4. Affiliation has no effect upon the internal affairs of the academies. They remain entirely autonomous.
5. The academies are urged to assist in increasing the membership of the Association in order thereby to overcome the decrease in its income through the remission of a part of its dues, as well as to stimulate interest in its work and aims.
6. Each affiliated Academy is to be represented in the Council of the Association by one person to be chosen by the Academy itself.
7. Six months time is allowed for the Academies to consider and act on this question. All the Academies will hold meetings within that period.

Probably the chief value of this scheme of affiliation will be the resultant tying up of all the scientific organizations of the country into a more unified body. The probable outcome of the plan will be the formation of a Central States Division of the American Association similar to the Pacific Coast Division and the Southwestern Division.

It may be necessary to change our fiscal year to agree with that of the Association so that dues will be collected before the first of each year. Other details will have to be worked out as occasion arises. This proposition will be submitted for your formal ratification at the closing business session.

There are sundry matters of policy to which the attention of the Academy is directed. It has been the custom of the Academy to pay for the extra cost of the binding in buckram of three hundred copies of the proceedings for distribution to its own members. This year the State Document Editor, Mr. Ora Williams, has kindly assumed that item and thus has relieved our treasury of a heavy burden. Mr. Williams has also assumed the cost of cutting up and stitching the separates which the Academy furnishes to the authors of papers and will doubtless continue the policy thus inaugurated. For several years past the authors of papers in the Proceedings have been supplied with separates by cutting up one hundred of the one thousand copies of the Proceedings allowed us by law. This reduced the cost of separates to the Academy very much but it also reduced the number of bound copies available. It is believed that very few authors really care for more than fifty separates of their papers and that if the other fifty copies are thus released to be bound they will serve a better purpose. The few members who need more than fifty separates usually have an additional number printed and so will not be put to any greater inconvenience.

It has seemed to the secretary that it would be well for the Academy to adopt as a fixed policy some plan whereby papers should be submitted to an editorial committee for approval before being published. The secretary has no means of adjudging the correctness or value of any paper and it might be that the plan suggested would still further enhance the quality of our publications. Such a plan is followed by some of the national societies and might be adopted advantageously by our Academy. In this connection may I not urge authors to give common names to the objects described in addition to the scientific names. I know of nothing more dreary or stultifying to interest than to struggle through page upon page of technical names without being able to get the least comprehension of the content of the paper. And yet that represents the situation with regard to some papers presented for publication. I suspect that the botanists are the greatest offenders in this matter. Our Proceedings go into most of the libraries of the state and can do much to make or mar our reputation. If they consist largely of unintelligible Latin words the common estimate of scientific people will be accentuated rather than corrected. Another suggestion in this connection: It seems to the secretary that the Academy would do well to encourage research and publication by noncollegians — that is persons interested in science who are not now connected with our educational system. From time to time such papers have appeared and the intent of this suggestion is to incite members of this class to increased activity.

The affiliation of the Academy with the American Association will tend to greatly increase the duties of the Treasurer, which are already onerous. It would seem only fair that some compensation should be given him to repay him for this added labor. We have never granted the treasurer any honorarium and it appears that now is an opportune occasion to establish the custom. Incidentally I may add that the Treasurer informs me that very few service men accepted the remission of their dues which was granted them by the Academy. Even after being notified of the action of the Academy most of these men forwarded their dues as usual.

May I be permitted to offer the suggestion that there seems to be no further use for the two classes of membership known as Corresponding Fellow and Corresponding Associate. This division of membership is merely a residence distinction and seems to serve no valid purpose. Why not modify the constitution by omitting those parts which relate to these classes of nonresident members and then group all active members under the classes of Life Fellows, Fellows and Associates, with the designation of Honorary Fellow reserved for special distinction?

In closing let me congratulate the members of the Academy upon the auspicious circumstances surrounding this gathering and wish for them the success which is due their interest and activity.

Respectfully submitted,

James H. Lees,
Secretary.

TREASURER'S REPORT

RECEIPTS

Cash on hand April 25, 1919	$ 31.58
Transfer and entrance fees	34.10
Annual dues from members	211.00
Sale of Proceedings	8.08
Total	$284.76

EXPENDITURES

Programs for 33rd Annual Meeting	$ 9.00
Stationery and supplies for secretary	9.00
Stationery and supplies for treasurer	7.60
Honorarium to secretary	50.00
To Miss Newman, sending out vol. XXV	10.00
Postage and clerical work for treasurer	17.50
Telephone service	1.10
Cash on hand, April 23, 1920	182.81
Total	$287.01
Less Ck. No. 12 in transit	2.25
	$284.76

A. O. Thomas,
Treasurer.

April 23, 1920.

Report approved by Auditing Committee, Messrs Bond and Jaques.

REPORT OF THE COMMITTEE ON THE SECRETARY'S REPORT

Your committee having read with care the excellent report of the Secretary of the Academy and having agreed unanimously on its various provisions, beg leave to present the following recommendations for appropriate action by the Academy:

1. Having been instructed to leave to another committee a critical study of the question of affiliation with the American Association for the Advancement of Science, which was recommended by the Secretary in his report, our instructions were followed. However, this committee in general favors the plan.

2. It is recommended that the Secretary be instructed to convey to Mr. Ora Williams, State Document Editor, the thanks of the Academy for his valuable coöperation in the matter of publication of the proceedings and that hereafter, but fifty copies of the proceedings, instead of one hundred, be cut up for the purpose of providing separates.

3. It is recommended that an Editorial Committee be established, to consist of one member for each science represented in the Academy, these members to be nominated by the Nominating Committee at each annual meeting, and each member having it as his especial duty to pass on, and edit all papers submitted for publication in the Science he represents.

4. Your committee recommends that beginning with the present fiscal year, the Treasurer be paid an honorarium of $25 per annum.

5. It is recommended that in conformity with the suggestion of the Secretary, the Constitution be amended, according to the regulations governing constitutional amendments, to omit the classes of Corresponding Fellow and Corresponding Associate and to provide that membership shall consist of Honorary Fellows, Life Fellows, Fellows and Associates.

BEGEMAN, TROWBRIDGE, ALMY,
Committee.

REPORT OF THE COMMITTEE ON AFFILIATION WITH THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

PROPOSED AMENDMENTS TO THE CONSTITUTION IOWA ACADEMY OF SCIENCE

Under the plan of coöperation between the Iowa Academy of Science and the American Association for the Advancement of Science, which plan was approved by the Academy at the annual meeting in 1919, it becomes necessary to modify the statement of the constitution of the Academy relating to fees:

Accordingly it is proposed that Sec. 4 of the constitution of the Academy be amended so as to read, by adding to clauses relating to fees as it now stands:

> Fellows and Associates who desire to avail themselves of the joint membership in the Iowa Academy of Science and the American Association for the Advancement of Science shall pay to the Treasurer of the Academy $5.00 annually, $4.00 of which sum shall be transmitted by the Academy to the American Association for the

Advancement of Science. For life fellows of the Academy the joint fee shall be $4.00.

In consideration of the fact that the fiscal year of the American Association for the Advancement of Science begins October first and that the treasurer of the Academy must get the fees of all joint members to the national organization before the end of the calendar year:

Accordingly it is proposed that the constitution of the Academy be amended by adding to Sec. 4 the following:

The fiscal year of the Iowa Academy of Science shall end September thirtieth.

In consideration of the fact that the Iowa Academy of Science is entitled, through the proposed plan of coöperation, to one member on the council of the American Association for the Advancement of Science:

Accordingly it is recommended that Sec. 5 of the Constitution of the Academy be amended by the introduction of the following clause:

The fellow of the Iowa Academy of Science to represent the Academy on the Council of the American Association for the Advancement of Science shall be chosen annually by the Academy.

This year the representative is to be chosen by the Executive Committee.

LEES, THOMAS, WYLIE,
Committee.

REPORT OF THE COMMITTEE ON RESOLUTIONS

Your committee offers the following resolution: —

Resolved, *First* that the Secretary of the Iowa Academy of Science extend to the faculty and friends at Iowa City our expression of appreciation of the opportunities that have been so amply provided for the successful conduct of this the Thirty-fourth Annual Meeting, and of our appreciation of the cordial hospitality manifest in the reception by President and Mrs. Jessup and in all provision by the local fellows for our enjoyment and profit.

Second, That we especially recognize the two leading features that have rendered this meeting memorable; the presentation of the portrait of Professor Samuel Calvin to the State Historical Department, and the exhibition of moving pictures of the University of Iowa Barbados-Antigua expedition, exhibited by Professor Nutting.

Third, That the Secretary of the Academy express to Professor Charles A. Cumming our recognition of his remarkable skill of portrayal in the lifelike representation of our beloved and honored Professor Samuel Calvin.

JOHN L. TILTON.
Committee B. SHIMEK.
H. W. NORRIS.

Resolutions of Mr. Bennett —

In view of the fact, that a government bounty law is in operation in the Territory of Alaska, whereby a continuous slaughter of our national bird, the American Bald Eagle, is going forward, which, in a brief period of time may make the species practically extinct.

Be It Resolved, that the Secretary be authorized to communicate with the Territorial Government of Alaska and the U.S. Federal Government, protesting against the unwise and alike unnecessary destruction of this fine and appealing wild life species, and respectfully requesting that this bounty law be repealed.

Referred to a committee consisting of Nutting, Norris, Stephens.

Whereas, it has come to the knowledge of the Iowa Academy of Science that it is contemplated draining the artificial lake at the Amana Colonies, a stretch of water particularly important and inviting to all scientists and nature lovers, through the splendid lily growths that flourish there, unique because of their great rarity in the other sections of the United States,

Be It Resolved, that the chair appoint a committee of three to take this matter up with those interested in the drainage proposition, and, if possible, persuade the owner not to carry out his intention.

Referred to a committee with Professor Shimek as chairman.

Resolution by Mr. Hinman —

Whereas, the knowledge of sanitary water supply conditions in the state of Iowa, particularly in the smaller communities, is meager, due to the lack of any comprehensive survey of conditions throughout the state,

And Whereas, this information is of value to the State of Iowa, as a whole, in respect to the sanitation of the state, the development of adequate and proper water supplies, and the prevention of water-borne diseases,

Be It Resolved, by the Iowa Academy of Science that the Academy place itself on record as recognizing the urgent need of a general survey of water supply and sewage conditions throughout the state of Iowa, accompanied by thorough and complete laboratory and field inspection,

And Be It Further Resolved, that the President of the Academy be authorized to appoint one or more representatives of the Academy to meet with other representatives of official and scientific bodies, to formulate a plan for such a state-wide survey, such plan to be presented in the form of a bill before the coming legislature.

Referred to a committee consisting of Kay, Hinman and Norton.

REPORT OF THE COMMITTEE ON NECROLOGY

Your committee beg to report the death during the past year of Professor H. R. Werner of Iowa State College. A sketch of Professor Werner's life will be published in the Proceedings.

Signed L. H. Pammel
C. C. Nutting
Committee.

REPORT OF THE COMMITTEE ON CONSERVATION

We, the Committee on Conservation in the Iowa Academy of Science, beg leave to submit the following report:

I. We are in accord with the efforts of the State Conservation Board in the following policies:

1. We urge immediate action for the preservation of our streams and lakes because when once lost they can never be reclaimed as can our forests.
2. We endorse the policy of plant and game preserves along the rough lands of our streams and wish to encourage members of the Iowa Academy of Science to use these areas for scientific investigation.
3. We endorse the further purchase of lands for the use of State and County Parks.
4. We endorse the policy of setting aside the state parks for bird shelters and other purposes which call for undisturbed conditions.

II. We sanction and urge the open and closed season for hunting and fishing be revised and re-adjusted on a scientific basis to conform with the habits of the game animals concerned. We specifically call attention to the following:

1. Quail should be protected for another term of 5 years.
2. Hunting licenses should end on December 31 of each year.
3. The use of ferrets be prohibited, or each should bear a license the same as a hunter using them or a gun.
4. The prosecutor should receive half the fine after the cost is deducted for the prosecution of game violators.
5. In no case should muskrats be killed or molested by shooting, and the season for trapping them should be between November 1 and March 1 inclusive.
6. The open season for the fox squirrel should be from October 1 to November 15 inclusive. The limit should be five squirrels in one day.
7. No hunting license should be issued to individuals under eighteen years of age.
8. Trappers should be heavily licensed or each set trap bear a license tag.
9. The closed season for spring fishing should be so regulated that it covers the spawning season of our game fish.

III. 1. We believe the State Legislature should protect and preserve for scientific investigation, the areas in which our Indian mounds and their burial grounds are located. Laws should be framed penalizing their destruction and the removal of relics therefrom.

2. We sanction the purchase of such collections of Iowa Indian relics as have accurate data concerning their source.

IV. We are in accord with the plant disease survey as carried on by the United States Department of Agriculture, and believe it will lead to the control of the great losses to our principal crops.

All of which is respectfully submitted by

B. SHIMEK G. A. CHANEY
H. E. JAQUES W. H. DAVIS, *Chairman*
G. B. MACDONALD

REPORT OF THE MEMBERSHIP COMMITTEE

For Transfer from Associate to Fellow: F. M. Baldwin, J. Wilbur Dole, A. R. Fortsch, Samuel W. Geiser, D. J. Glomset, Albert Hartzell, Grover Hawk, G. W. Heitkamp, P. S. Helmick, V. A. Hoersch, J. L. Horsfall, Royal E. Jeffs, F. M. McGaw, H. L. Maxwell, D. E. Merrill, Geo. C. Morbeck, Beryl Taylor Mounts, E. Laurence Palmer, T. H. Quigley, O. B. Read, Marie Rees, Ivan L. Ressler, W. E. Rogers, Walter H. Schoewe, Althea R. Sherman, W. D. Shipton, John E. Smith, O. M. Weigle, C. W. Wester, J. F. Yothers.

For Election as Fellows: Bird T. Baldwin, E. W. Chittenden, Amy Daniels, Clifford H. Farr, reinstated; M. E. Graber, C. W. Hewlett, Charles Reuben Keyes, Bruce D. Reynolds, H. L. Rietz, Jos. J. Runner, L. P. Sherman, V. A. Suydam, Guy West Wilson, reinstated; W. H. Wilson.

For Election as Associates: A. R. Abel, Mildred Adams, Beulah E. Aiken, A. C. Bailey, Geo. Bennett, H. G. Campbell, M. Ellis, D. C. Ensign, T. Erickson, F. A. Fenton, Louise Fillman, A. Foster, Chas. Gleim, Mrs. C. Gleim, Dorothy Hanna, A. N. Harbert, F. S. Harper, V. Heaton, W. A. Hemmings, E. Hickman, R. H. Holbrook, J. W. Howell, J. Paul Jones, D. Kreth, C. E. Lane, D. F. Lawson, M. Lindemann, Clifford Lohman, J. T. Lonsdale, O. E. Lowman, E. C. McCracken, Mark McDonald, I. Maizlish, H. C. E. Meyer, Wier R. Mills, H. Nicholson, Mrs. L. Nims, Glenn Nixon, Lloyd North, A. Ollivier, F. Ollivier, R. L. Parker, T. L. Patterson, Leroy Patton, W. G. Prottsman, Paul Ralston, Victor H. Ries, Jas. B. Shumaker, Chas. E. Snipps, Chas. J. Spiker, L. I. Stecher, Margaret Stolt, Leon S. Ward, Carl Weeks, F. M. Weida, J. S. Whittaker, N. J. Williams, Irving Wolff.

LIST OF MEMBERS AND VISITORS IN ATTENDANCE

Mildred Adams, Iowa City; Miss Alison E. Aitchison, Cedar Falls; Dr. Henry Albert, Iowa City; F. F. Almy, Grinnell; A. K. Anderson, Cedar Falls; M. F. Arey, Cedar Falls; R. P. Baker, Iowa City; A. L. Bakke, Ames; Bird T. Baldwin, Iowa City; F. M. Baldwin, Ames; E. D. Ball, Ames; Louis Begeman, Cedar Falls; George Bennett, Iowa City; Jacob Berger, Marengo; E. M. Berry, Iowa City; P. A. Bond, Iowa City; Leo W. Briggs, Indianola; Leo Brown, Marengo; C. C. Bunch, Iowa City; E. J. Cable, Cedar Falls; Henrietta Calhoun, Iowa City; Charles Carter, Fairfield; Henry S. Conard, Grinnell; Ira S. Condit, Cedar Falls; R. I. Cratty, Ames; Charles Crofutt, Iowa City; W. H. Davis, Cedar Falls; Mary Doherty, Cedar Falls; H. R. Dill, Iowa City; Dwight C. Ensign, Iowa City; C. I. Erickson, Iowa City; T. H. Erickson, Mount Vernon; John Evanoff, Iowa City; A. E. T. Fant; Iowa City; Clifford Farr, Iowa City; Burton Faust, Brooklyn; Louise Fillman, Iowa City; F. A. Fenton, Ames; T. J. Fitzpatrick, Lincoln, Nebraska; Alice Foster, Cedar Falls; R. A. French, Des Moines; H. A. Geauque, Indianola; Waldo S. Glock, Iowa City; Bert C. Gose, Indianola; M. E. Graber, Sioux City; J. E. Guthrie, Ames; G. W. Heitkamp, Dubuque; Edgar R. Harlan, Des Moines; Floyd S. Harper, Iowa City; Grover C. Hawk, Iowa City; P. S. Helmick, Iowa City; Wm. A Hemmings, Mount Pleasant; W. S. Hendrixson, Grinnell; S. F. Hersey, Cedar Falls; C. W. Hewlett, Iowa City; J. J. Hinman, Jr., Iowa City; H. E. Jaques, Mount Pleasant; D. Warren Jewett, Des Moines; Rudolph Jordan, Iowa City; Harry M. Kelly, Mount Vernon; Charles R. Keyes, Mount Vernon; Charles N. Kinney, Des Moines; Nicholas Knight, Mount Vernon; Daniel Kreth, Wellman; C. E. Lane, Iowa City; James H. Lees, Des Moines; O. E. Lowman, Fayette; R. B. McClenon, Grinnell; E. C. McCracken, Ames; J. E. McCrory, Iowa City; J. V. McKelvey, Ames; R. Monroe McKenzie, Fairfield; Marie Miller; Elmer E. Moots, Mount Vernon; D. W. Morehouse, Des Moines; F. S. Mortimer, Iowa City;

Catharine Mullin, Iowa City; Helen Nicholson, Iowa City; M. A. Nordgaard, Grinnell; H. W. Norris, Grinnell; Lloyd North, Iowa City; W. H. Norton, Mount Vernon; C. C. Nutting, Iowa City; Arthur Oxley, Mount Pleasant; W. A. Owens, Mount Vernon; L. H. Pammel, Ames; Ralph L. Parker, Ames; Matilda Paul, Iowa City; J. N. Pearce, Iowa City; J. O. Perrine, Cedar Falls; P. V. Peterson, Cedar Falls; L. Charles Raiford, Iowa City; O. B. Read, Cedar Falls; J. F. Reilly, Iowa City; Ivan L. Ressler, Ames; Victor H. Ries, Cedar Falls; H. L. Reitz, Iowa City; E. W. Rockwood, Iowa City; B. C. Shearer, Fairfield; Leo. P. Sherman, Grinnell; B. Shimek, Iowa City; L. P. Sieg, Iowa City; Donald M. Smith, Ames; John E. Smith, Ames; Orrin H. Smith, Mount Vernon; Miss Clementina S. Spencer, Cedar Rapids; L. B. Spinney, Ames; M. A. Stainbrook, Brandon; F. C. Stanley, Oskaloosa; Lorle I. Stecher, Iowa City; T. C. Stephens, Sioux City; G. W. Stewart, Iowa City; Harold Stiles, Ames; Dayton Stoner, Iowa City; S. W. Stookey, Cedar Rapids; F. A. Stromsten, Iowa City; V. A. Suydam, Grinnell; Beryl Taylor, Iowa City; A. O. Thomas, Iowa City; John L. Tilton, Indianola; A. C. Trowbridge, Iowa City; Merriam H. Trytten, Decorah; Gertrude Van Wagenen, Iowa City; G. R. Wait, Iowa City; Otto Walter, Dubuque; E. E. Watson, Fairfield; H. J. Wehman, Iowa City; L. D. Weld, Cedar Rapids; H. F. Wickham, Iowa City; Ben H. Wilson, Mount Pleasant; Guy West Wilson, Fayette; Mabel C. Williams, Iowa City; Roger Wilson, Cedar Falls; R. B. Wylie, Iowa City; Albert Hartzell, Ames.

PRESENTATION OF THE CALVIN MEMORIAL PORTRAIT

To the Iowa Academy of Science

The Chairman of its Committee presents

THE CALVIN PORTRAIT

Unable to appear in person for the present program, I have been urged to present myself in some brief address. This I assure you is accomplished not without difficulty. In such attempt one misses so very much, if but in prospect, the happy concourse and sympathy of one's friends, the inspiration of fond, familiar scenes.

However, in the present instance, the task is lightened very much by virtue of the theme, and in the very purpose of our present simple, though unusual ceremony. Sad reminiscence, from fountains however full, may for this hour and presence be repressed, the significance of our whole proceeding so easily, so really a matter of felicitation.

As your committeeman, then, I beg to bring congratulations. This for several reasons. In the first place I venture to declare, as my settled judgment, that in the portrait before us, simply as a picture, we are indeed singularly fortunate. To be sure, in such a matter, each must form opinion for himself, but I expect for the days to come increasing compliment as the portrait becomes more and more familiar, not to members of the Academy only, but to observers generally.

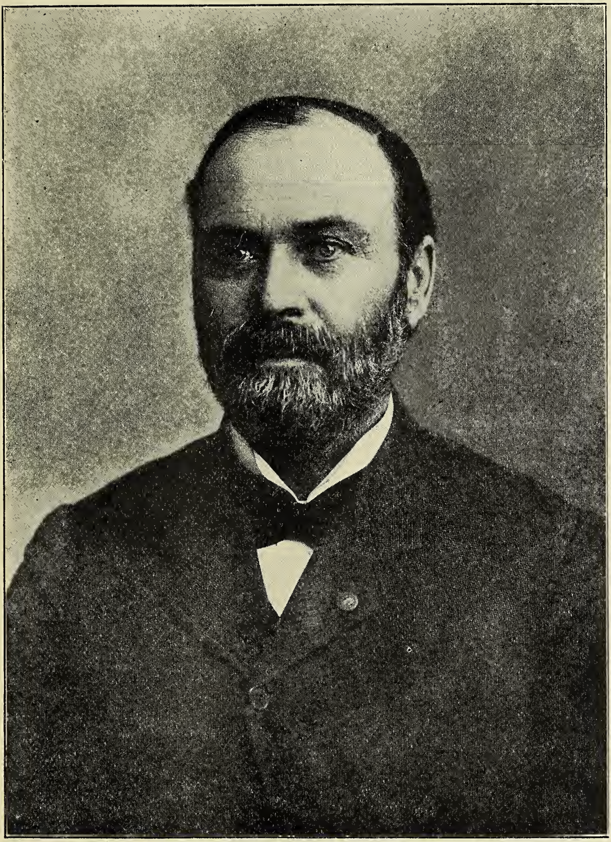
I think it will be conceded now that our distinguished artist has given his subject careful and conscientious study; he has brought to our service long and patient labor, and a skilful brush. There were serious difficulties. Not only had the artist not known the subject of his effort, he had never *even seen him!* When we think of this, and reflect that for very form and inspiration, he had in all his work, naught but a few very ordinary photo-prints, the result is indeed surprising; not in artistic excellency alone but in accuracy and impressiveness. Our artist should also share the congratulations of this day.

In the second place, we may now rejoice in the Academy's intent and action, manifest so long ago; in the effort of the members and fellows to bring the plans of the Academy to fitting consummation, as in the program of this hour; in this we have, I am sure, a sense of satisfaction to be renewed, we hope, again and again hereafter as the years go by.

It is fitting and beautiful for colleagues and fellow-laborers in any field to put in pleasing form some recognition of service rendered, some indication of esteem, some memorial by which the past may, for at least a little time, enrich and cheer the future. Especially is this the case where, as in pure research, service is so often without personal emolument, without thought of gain or even cost, brought forward as a pure gift to humanity, prompted by the simple love of truth, devotion to the beauty, and order, and high significance of the physical world. And if, as now, the unselfish labor has been conspicuous, the vision brilliant, the attainment great, the work accomplished memorable,— do we not honor ourselves in thus handing over to the State of Iowa, for the men and women of tomorrow, and yet tomorrow, memorial, such as this? Lo! here some concept of Iowa's most devoted lover; of the master-student of her prairies, her rivers, her forest, her flowers, her rocks, her soils, nor less her wonderful far-fetched history, locked indeed in the very form and structure of soil and stone, but revealed, set forth, not to this Academy alone, decade after decade, but to the young men and women of the commonwealth assembled in scores and hundreds as class succeeded class in the great University; and at last, to the scientific world, in volumes — today the grace and pride of the science of the State.

Here is no place for history or biographic details, did one dare indulge it; but may I so far abuse my privilege, and your patience as to tell how fifty years ago, and for many continuous years thereafter I saw a man go forth; in an open wagon, sometimes borrowed, more often hired, sometimes his own, traversing the road-less, bridge-less prairies of northern Iowa; enduring the heat of August suns, chilled by the damps of night, shelterless, tortured by mosquitoes, drenched by wild thunderstorms that made terrible the midnight hours; breakfasting at dawn and toiling until his camp-fire burned beneath the evening star. Fron Lansing to Clarinda, from Dubuque to Mason City, to Winterset, to Ottumwa; athwart the State, across the State, around the State he moved; climbing all rocky heights of nature's carving, pondering the talus of every open quarry, every wall of crumbling rock or sliding shale, wading the creek-beds and tracing the banks of larger streams, away from home for weeks together;—I knew such a man; in such fashion, and not otherwise, did he win the rich experience and world-wisdom presently brought in such overflowing measure to the service of the State of Iowa!

Not for what it has cost, but for what it means, we commit now to the keeping of the public, this simple memorial of our colleague. His



Yours very truly,
Samuel Calvin,

Born February 2, 1840; Died April 17, 1911.
Memorial will be found in Proceedings of the Iowa Academy of Science,
Volume XVIII, Page 11.

work is finished, but shall abide long as men live who love their heritage of time; may the work of our artist long endure!

In other worlds and centuries a people, reputed still the wisest, wittiest of earth, not only discovered that 'art is long' but likewise also seemed to know that only the skill of the artist does in some mysterious way avail to transmit the soul of things, the thing called inspiration to future days and centuries. So they took care of art. They saw to it that men in after times should see what form had Pericles and Plato. Blind Homer nor less Socrates found memorial in marble, if reports are true. Not all were equal to their greatest, but under their greatest every Greek could claim, did claim, and flush with pride that thrills even to this day.

Sometime, perhaps when the social life and institutions of this commonwealth of ours shall have become from river to river more homogeneous, shall crystallize as such things do, when the migration of people shall cease,— sometime this our people shall perhaps appreciate their own, sometime mayhap a 'temple of fame' shall rise. Shall it be some vast physical structure with marble columns shining, shall it be some noble masterpiece of letters, than brass or marble more enduring, lit by the light of intellect, by passing centuries unworn, undimmed? Whatever, whenever, or wherever the memorial rise, of this let us be sure,— upon it the name of our colleague shall appear, among the first have place, and all other commonwealths may rival us if they can!

Nay, my colleagues, there shall still remain, for all whose names in honor shine, memorial nobler, more enduring far. The State, the State itself a living thing, into its fibre have passed the lives of all who thus at the beginning toiled to make it great! The State, sane, noble, intelligent, immortal as we hope, shall inevitably bear in its every character the thought, the purpose high of these its founders, memorial long-lasting as the course of time.

THOMAS H. MACBRIDE.

ADDRESS OF DOCTOR PAMMEL ON BEHALF OF THE COMMITTEE

Mr. President:

Your committee begs leave to make the following report on the Calvin Portrait. At the quarter centennial meeting of the Iowa Academy of Science held in the art room of the Historical Building in Des Moines, April 26 and 27, 1912, a committee was appointed to arrange for a portrait of Doctor Calvin to be presented to the Academy and hung in the art room of the State Historical Department. This committee consisted of Dr. Thomas H. Macbride of the State University, Professor M. F. Arey of the State Teachers College, and Professor L. H. Pammel of Iowa State College. The following letter from the secretary of the Academy explains the scope of the committee.

> A motion was passed that a committee be appointed with power to act, to see that provision be made for the placing of a portrait of Samuel Calvin in the Historical Building. Doctor Macbride, Professor Arey and Doctor Pammel were appointed on this committee.

After a preliminary meeting of the committee it was left to Doctor Macbride to arrange for the painting of the portrait. Doctor Macbride arranged to have Professor Cumming paint the portrait under his direction, asking numerous old friends of Doctor Calvin to offer suggestions. The likeness is a splendid one and reflects credit on the artist and friends who so generously assisted in criticisms.

It fell to the lot of Professor Arey of the committee to arrange for contributions. These from members of the Academy amounted to $136.50. In addition there was paid from the treasury of the Academy the sum of $123.50. The remainder of the sum Professor Macbride received from other sources. The committee reported progress from year to year. On March 29, 1916, Professor Macbride wrote the following letter:

> Professor Cumming, the artist, tells me he has the portrait of Professor Calvin in such state of completion that he expects to be able to show it to the Academy at its next meeting in Des Moines.

The portrait, owing to unforseen conditions, was not presented. The committee reported progress and was continued. At the subsequent meetings in Ames in 1917 and Grinnell in 1918 the committee reported progress. At the 1919 meeting in Cedar Falls, Doctor Macbride for the Committee stated that the portrait was ready and to do honor to Doctor Calvin, it should be before the Academy an entire session. The task of presenting the portrait of Doctor Calvin to the Academy falls upon the Committee.

It is to be regretted that Doctor Macbride, the life-long friend of Doctor Calvin, cannot leave his family in California. The other members of the Committee feel that no one could more graciously have presented the portrait than the Nestor of this Academy. His fine spirit is with us. The Committee through its chairman has arranged the following program:

Addresses on behalf of the portrait committee — Professors Macbride, Pammel and Arey.

Address on behalf of the Academy moving the acceptance of the portrait. Professor Shimek.

Address on behalf of the Department of Geology. Professor Thomas.

Address on behalf of the Iowa Geological Survey. Professor Kay.

Remarks by the President of the Academy presenting the portrait to the State Historical Department. President Stephens.

Response by Mr. Edgar R. Harlan, Curator of the Historical Department.

It is fitting that this committee should express its appreciation of the labors of Doctor Calvin as a geologist to the State and Nation, an investigator of high order, a teacher of rare ability. a fine citizen and a soldier who helped the cause of freedom during the Civil War.

We honor him not merely as a scholar and teacher in a great university, but we honor him as a citizen of this great commonwealth and it is proper and fitting that Doctor Calvin's portrait should be a part of the State Historical Collection at Des Moines to be counted with the great men whose portraits adorn the walls of that gallery; to be counted among the men who have made Iowa great in science, religion and statecraft.

The Committee having discharged its duties presents this portrait to the Academy.

L. H. Pammel.

ADDRESS OF PROFESSOR AREY ON BEHALF OF THE COMMITTEE

Mr. President:

Since Professor Pammel has spoken so satisfactorily in behalf of the Committee I will confine myself to a brief characterization of Professor Calvin as a man. My acquaintance with him began about the time at which he became connected with the State University and fortunately for me I was quite intimately associated with him at times in field work in geology under circumstances that bring out the real nature of the man. I feel therefore that I can say in all sincerity that he was one of God's noblemen, great souled, high minded, a true friend and efficient in whatever line of work he chose to engage. An incident will illustrate at least two traits of his character. We were engaged in a survey of Winneshiek county which has more geology to the square foot than any other county in the state. It is equally superior in its botany. I knew that for a time he taught botany as well as geology at the University and was still interested in that subject. I was teaching botany as well as geology at the State Normal School at that time and naturally noted much in the vegetation about us that appealed strongly to me. One day as we were passing from one point of investigation to another some trees rare in Iowa attracted my attention and I spoke to him about them. The only notice he gave to the matter was a remark to the effect that we were now studying the geology of the county and we could not afford to divide our observation or thought with any other subject. The rebuke was given in such a kindly spirit that my feelings could not be said to have been hurt and I proceeded to profit at once by it. His habit evidently was to give himself wholly to the subject in hand, one reason why he succeeded so well in his work.

Among all the capable men who have given themselves in any degree to the pursuit of some phase of Iowa's geology, he stands preëminent so that when the subject is mentioned we naturally think of him. The richness of the Pleistocene in Iowa particularly interested him and his work is everywhere to be seen in the differentiation of its five ice sheets, yet his field notes on Taylor county which he had made preparatory to a report of that county, but which he did not live to complete, show that he had found a new problem that strongly appealed to him, namely the origin and nature of a certain superficial or near superficial phase of the Kansan, later to be known as the gumbotil of Kay. But I promised to be brief that others may have their opportunity to present their tribute of appreciation and respect.

M. F. Arey.

ADDRESS OF PROFESSOR SHIMEK ON BEHALF OF THE ACADEMY

Mr. President:

Rising to move the acceptance of the beautiful gift here presented, I do so with much hesitancy, for two reasons.

It was not until a little while ago that I learned just what was expected of me on this occasion, and there has been no time for even the orderly arrangement of the thoughts which should here find expression.

Then, too, I fear that the flood of memories which will come all unbidden will make it hard to do justice to the memory of the man whose kindly face looks out upon us from the canvas here presented.

I first learned to know Professor Calvin more than forty years ago, when as a Freshman I entered his department as the factotum whose duty it was to furnish field supplies for laboratory work, and during all the years that followed my respect and affection for him grew constantly. He was both teacher and friend, and it is difficult to decide in which capacity he gained the stronger hold on the affections of those who were brought in closer contact with him.

Neither time nor the occasion will warrant an extensive account of Professor Calvin's activities. As already noted in the deeply sympathetic letter of his long-time friend and colleague, Doctor Macbride, this is no time for biographical detail. We recall with pride his services as a citizen and soldier; his scientific achievements are a matter of record never to be forgotten; and the memory of his splendid character will remain longest with those who knew him best.

It is nearly fifty years ago that he came to the State University as Professor of Natural Science, and the record of his life is blended with the history of the development of the University and the State. Out of the chair of "Natural Science," or "settee" as he facetiously called it, have grown the strong departments of Geology, Botany and Zoology in the College of Liberal Arts, and that of Bacteriology in the College of Medicine. He was the organizer of the Iowa Geological Survey and for many years the State Geologist, and the record of his work in this connection is too well known to require repetition in this presence.

While we cannot now dwell upon the details of Professor Calvin's life, there are two qualities that stand out as particularly characteristic of him as a teacher, an investigator and a man, which seem to be especially worthy of note at this time. I refer to his extreme modesty and his sterling honesty. Would that it were possible to burn the memory and the appreciation of the value of these qualities into the minds and the consciousness especially of the younger generation of scientific workers! A man of strong convictions, yet he approached every problem modestly and with an open mind. There was none of that air of cock-suredness which is sometimes displayed by the narrow specialist, and which is sure to arouse mistrust. No doubt this modest attitude largely prepared the way for the soundness of his conclusions when finally reached.

His modesty was but a phase of that honesty which was his transcendent quality. He was not only honest in ordinary dealings, but he was honest with himself, and honest in his attitude towards the scientific problems which engrossed his attention. It is *this* phase of his character which I commend especially to those who are just entering upon a scientific career, for there is no other field in which open-minded honesty is more truly essential.

May this beautiful gift assist in perpetuating the memory of our beloved friend and colleague, and may the example of his noble life inspire us, and those who follow us, to an honest search for truth!

B. Shimek.

ADDRESS OF PROFESSOR THOMAS ON BEHALF OF THE DEPARTMENT OF GEOLOGY

Mr. President:

Speaking on behalf of the department founded by Professor Calvin and as one of his pupils during the maturer years of his life I may be pardoned for pointing out on this impressive occasion that the Geology Department of the University to-day has developed about the ideals of the noble man whose memory we are met to honor and whose portrait is before us. Indeed, his ideals have a profound influence like that of a guardian spirit over the department's activities. Even new instructors, who never knew Doctor Calvin, confess to a feeling of some benign power that seems to pervade the very atmosphere of Old Science Hall. Each member of the staff on occasion doubtless finds himself directed in his teaching methods and departmental policies by the wise standards set by our worthy predecessor. The years we are now passing through are the first stage, it seems to me, in the development of a wholesome tradition and it is such inspiring traditions as Calvin's ideals that go to make an institution great.

In the department of geology today the courses offered are largely those developed by Professor Calvin. "Principles of Geology," "General Geology," "Paleontology," "Geology of Iowa" are given in much the way he organized them. That these fundamental courses were broadly planned is evidenced by their flexibility, for today with registration in the department quadrupled since 1911 they to a large degree adequately meet the growing demands. Principles of Geology and General Geology are courses designed by Calvin for the general student who then as now wants the viewpoint of geology without becoming technically trained. More and more these courses are looked upon as cultural courses and as sources of inspiration; this is as Calvin would have them. Witness some of his favorite themes: The Great Life Story; The Glacial Story; The Face of Iowa; Geology and Revelation. The substance of these sermons and their spirit, in so far as we can transmit them, are being offered to ever increasing numbers of boys and girls of Iowa illustrated in great part by the very specimens he himself collected and depicted by illustrations and lantern slides which he made with his own hands. Calvin's collections from all parts of the state and country are the nuclei of present teaching and research materials. It is regrettable that his death cut short his mature plans of writing up and of describing many things he had to leave.

It is only after we are separated by many decades from the work of illustrious men that we begin fully to appreciate the greatness and enduring qualities of their work. Less than a brief decade lies between us and him who laid so well the foundations of geology in Iowa. More and more clearly, however, is there dawning upon us not only the extent to which we are indebted but also the extent to which students yet unborn will be indebted to Calvin's broad conceptions and scholarly interpretations of the geology of the state. The impetus which his rugged honesty, sincerity and high ideals have engendered will grow ever larger to the end that knowledge may abound and that the truth shall prevail.

A. O. THOMAS.

Owing to illness Professor Kay was unable to respond on behalf of the Geological Survey. Following the address of Professor Thomas President Stephens in a few words put the motion that the Academy accept the portrait. This was carried and the President then introduced Curator Harlan of the Historical Department, who accepted the portrait as follows:

ADDRESS OF CURATOR HARLAN ON BEHALF OF THE HISTORICAL DEPARTMENT IN ACCEPTING THE PORTRAIT

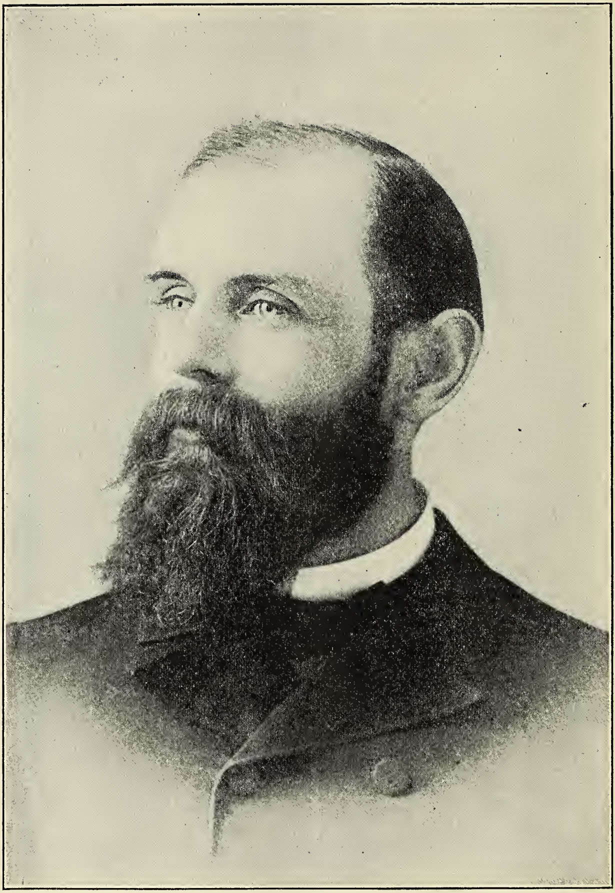
Mr. President:

A function of the Historical Department of Iowa is to have at hand the facts and the materials which testify of the merits of Iowa men and events. Merit so proved, which remains permanently apparent throughout all time, is the object of all true effort of the scholarly and the inspiration of all, unless the selfish, of every calling. The selection and preservation of the proofs of merit and of attainment being of the duty of the office I for the time occupy, it has been a constant, deep and firm satisfaction with which I have received the knowledge today and in other days of the great place arrived at by Samuel Calvin. The position led to by him, of the science, or branch of science, of which he was the chief Iowa ornament, as by your unanimous voice today I am advised, is a place respected through all the realm of scientific thought in America.

Not many types of evidence bear more sure and satisfactory testimony to the character of a man than the well done portrait. Carlyle has taught us best of that. And this canvas done honestly, considered now by you finally, presented formally to your State, shall carry with it to the place of its perpetual deposit, the stamp of your approval and thereby the indisputable claim of value as a work of history as it is a work of art.

It is therefore with appropriate satisfaction I am permitted by authority of law to do the small part toward honoring the memory of Samuel Calvin by accepting this delineation of his form approved by you, as I do here now accept.

EDGAR R. HARLAN.



R. Ellsworth Call

IN MEMORIAM

HERBERT R. WERNER

1888-1920

Herbert R. Werner, Assistant Professor of Zoology in Iowa State College, a member of this Academy, died of pneumonia following influenza, on February 14, 1920. To his associates he has left an example of perseverance, good fellowship and devotion to the highest ideals, and his untimely death at the age of thirty-two was a loss to the college and to the community of Ames.

Mr. Werner received his early education in the public schools of his native town, Orwigsburg, Pennsylvania. He attended Franklin and Marshall Academy and was graduated from Franklin and Marshall College, Lancaster, Pennsylvania, 1912, when he became an assistant in Biology. After receiving the degree of M. Ph. from his alma mater he accepted a fellowship at Princeton University where he received the M. A. degree, 1914. In the fall of the same year he came to Iowa State College as instructor in Zoology and later was appointed Assistant Professor. Professor Werner was interested in mammalian chromosomes and had carried on considerable research work in that subject which unfortunately was not completed at the time of his death.

Mr. Werner will be missed by his college associates but most of all by those who were privileged to be intimately acquainted with his daily work.

ALBERT HARTZELL.

R. ELLSWORTH CALL AND IOWA GEOLOGY

R. Ellsworth Call was one of the most versatile naturalists who ever came within the boundaries of our state. Although personally unknown to any of the present generation of Academy members he was in the first years of our society's existence one of its most active, earnest and productive workers. With his recent passing in Brooklyn, New York, where he resided for many years, the Academy lost one of its charter members and an early secretary. Call belonged to the old school of systematic naturalists, now fast approaching extinction. While he had wide knowledge of animals and plants he knew much about particular types and groups. A recognized authority on mollusks, he delved extensively into other branches of zoology, and he did considerable very creditable work in the field of geology. Withal he was an ideal teacher of the sciences and he was especially popular as a lecturer before the young people and mixed audiences.

Call's parents lived in Des Moines, and for a period of many years, even while his employment took him into distant states, he usually spent the summers with them. During this time his extensive collection of shells and his fine scientific library were housed in the Capital City. He was the author of many memoirs, mainly upon subjects of Conchology.

Richard Ellsworth Call was born on May 13, 1856, in Brooklyn, New York, where his early education was obtained in the public schools. From high school he went to Cazenovia Seminary, from which he was graduated in 1875. Then he attended Syracuse University, but did not remain to finish the prescribed course. While there he fell in at Ithaca with David Starr Jordan, John C. Branner, and other Cornell scientists of that day, who in after years were closely associated with his investigations. Leaving college he taught country school for several years, at the same time devoting his leisure hours to collecting and studying in natural history. In the meanwhile his parents moved to Des Moines. During the years 1890 and 1891 he attended Indiana State University, receiving the A. B. and A. M. degrees. In 1893 he finished the medical course at the Hospital College of Medicine of Louisville, Kentucky, graduating with the degree of M. D. Ohio University, at Athens, conferred upon him the honorary degree of Ph. D. in 1895. He died in New York City on March 14, 1917.

Call's principal vocation was teaching. He was connected with the schools all his life. Besides instructing in the sciences in the high schools of Stonington, Connecticut, Moline, Des Moines, Louisville, Brooklyn and New York City, he occupied for a time the Chair of Zoology in the Missouri State University. He served as curator of the Brooklyn Institute of Arts and Sciences; and for periods of three years each he performed the duties of superintendent of Schools of David City Nebraska, and of Lawrenceburg, Indiana. He was an able and entertaining lecturer, and his services in this field were much sought. His work as lecturer for the Board of Education of New York City was especially noteworthy and satisfactory.

Of his more productive work in pure science there was wide range. In geology his efforts were mainly of the reconnaissance type. Yet he published a number of geological memoirs of note. Joining the staff of the United States Geological Survey, which was then studying the old desiccated Lake Bonneville — the all but vanquished remnant of which is the Great Salt Lake of today, from the clays and sands of the old beaches of that vast ancient body of water he collected the molluscan shells, endeavoring to show by their depauperate character that they lived under the inhospitable environment of a glacial climate, to which Gilbert ascribed the origin of this great expanse of inland waters. Some of the forms unearthed proved to be new to science, and were so described.

After similar fashion he worked with the late W J McGee on the loess shells of central Iowa. Notwithstanding the fact that depauperate forms are found to be abundant at Des Moines, in other parts of the state they were not detected by subsequent investigators. Later, also, the loess itself was demonstrated to be not a deposit derived from the glaciers but an interglacial formation. However, together, McGee and

Call barely escaped making one of the great geological discoveries of the century — the establishment of the multiplicity of the Glacial Epoch. The Des Moines sections furnished all the evidence but they were not properly interpreted.

Call afterwards extensively studied the loess of the upper Mississippi Valley, and came to the conclusion that this remarkable loam formation was a great lake deposit, accumulated something after the manner of the beds of the alleged vast Tertiary lakes of the Great plains region. Here again his judgment was at fault, for all of the deposits of this description were finally proved to be mainly epirotic formations laid down by the winds. His close association with government folk in the far west evidently firmly implanted in his mind this early but erroneous notion. His views on this subject are elaborated in a series of articles which appear in the American Naturalist. These papers were long worthy of careful perusal if for no other reason than that they supplied the best summary of our scant knowledge on the loess up to the date of their publication.

During several summers Professor Call served as assistant geologist on the Arkansas Geological Survey under Dr. J. C. Branner. His main work was on the Crowley Ridge, a long narrow elevation of Tertiary formations rising out of the wide Mississippi flood plain in the eastern part of the state. The report was published as a special volume of the Survey series.

When resident of Iowa, Call became interested in the artesian waters and collected data from a number of deep drill wells put down in various parts of the state. His principal results appeared from time to time in the Bulletin of the Iowa Weather Service. Many brief papers and articles were published on geological subjects in the scientific journals.

Call published most extensively on the mollusks, fishes, and reptiles. A synopsis of the Unionidæ of the United States formed the initial number of a Bulletin series of the Des Moines Academy of Sciences and found wide circulation. The Unionidae of Arkansas formed a profusely illustrated memoir that was published by the St. Louis Academy of Science. His shorter papers on Conchology were many and varied. The "Anatomy of Campeloma" was a model of its kind, and was based entirely upon materials obtained around Des Moines.

One group of mollusks in which Call became very much interested was the little known family of the Strepomatidæ, turreted snails inhabiting southern rivers. The Coosa, Black Warrior, and Tombigbee rivers of Alabama in particular harbored these water snails. For a number of years he was accustomed to collect extensively in these streams and their numerous tributaries. Isaac Lea, Thomas Conrad, Thomas Say and Constantine Rafinesque described many species but these were never very well defined; and a large synonomy resulted. It was our Iowa naturalist's special mission to pass in review all the described forms, to collect abundantly from all the original localities, and to adjudicate the numerous varieties in accordance with modern canons of taxonomy. This he was able to do in most satisfactory fashion. Having accomplished this gigantic task he generously sent typical and authenticated sets of the shells to many of the principal museums of this country and Europe where conchology was stressed. Many private cabinets were also made beneficiaries of this work.

Investigations on the fishes were mainly systematic in character. Part of the time spent along these lines was in conjunction with Prof. Seth E. Meek. He made a very complete collection of the fish fauna of the Des Moines river basin, which for some reason was never quite finished or published in full. A preliminary account appeared in the Proceedings of our Academy. He worked for several years on the fishes of New York. How complete this work was at the time of his death was not known. Much was done towards working out a better taxonomy of North American fishes. In a similar way he was intensively taken up with improving the taxonomy of North American reptiles. The Fishes of the Ohio River was a magnificent volume and Call's most complete work on the group.

In the fields of botany important contributions were made to the knowledge of the hardwood forests of Arkansas, the ferns of the Ozarks, and the plants of Iowa.

When residing in Louisville, Call unearthed, among the historical documents of the Filson Club of that place, the unpublished notes of that eccentric French naturalist, Constantine Samuel Rafinesque, who for many years in the early part of the last century made America his home. In the "Life and Writings of Rafinesque" Call set aright most of the old naturalist's descriptions of invertebrates of the Mississippi Valley, which had long been the despair of systematists of later days. This sumptuous quarto volume was published by the Filson Club, and proved to be one of its most cherished publications. The monograph on the Mammoth Cave of Kentucky was a quarto tome, edition de luxe, sumptuously printed on deckle edge, antique wove, unsized paper and contained thirty plates. Its character was historic, scenic, biologic and bibliographic.

Call's was really a brilliant mind. Had he been set in a congenial environment and had he not been continually hampered by his teaching, which he was always forced to follow in order to gain a livelihood, he doubtless would have developed into one of the great naturalists of his country and perhaps of his day. His purse was always lean; and he could do little along purely scientific lines that he planned. Although genuinely generous many of his actions were often misinterpreted by those who did not know him very well. So preoccupied was his mind at times that he became very forgetful. Not infrequently he would borrow an armful of books from some friend and the very next day he could not for the life of him tell to whom they belonged. On this account some of these books doubtless never got back to the original owners. It was the same with specimens. Soon many persons began to judge him harshly. Really this was largely mistaken inference. On the other hand he was equally careless with his own property. Lending freely any of his books or specimens he promptly forgot by whom they were received; and it might be months before they turned up again.

These things changed greatly after his marriage, which took place rather late in life. His absentmindedness grew noticeably ameliorated. At the same time his powers of concentration of mind visibly deteriorated. His productive efforts became less spontaneous and more irregular. Within a lenstrum he ceased publishing altogether; and soon passed out of sight of his old scientific circle. From that day to the date of his demise, twenty-five years later, he remained completely inactive; and the newer generation of zoologists knew him not.

The experience of our own Academy furnishes a curious instance of his usual lack of mental equipoise. The minutes of the early meetings which were turned over to him as secretary on about the third or fourth session immediately vanished. He had laid them down somewhere while the members were chatting after adjournment. In his endeavor several years afterward to record the proceedings in a special blank book purchased for the purpose he lost two entire metings, forgot the titles of half of the papers read, and failed to enumerate most of the charter members and original promoters of the society. Several years later when the State of Iowa assumed the publication of the Academy's Proceedings Secretary Osborn did all he could to rectify these delinquencies by obtaining from each member abstracts of his papers and printing them *en masse*. In this way some members provided notes on no less than six to eight papers which they had actually presented and read but of which no record had been made in the minutes.

In the late eighties of the last century a number of Professor Call's friends in Des Moines, realizing fully both his brilliant attainments and his difficulty in getting a suitable living, put forth special effort to have him appointed to the headship of the science department of the Des Moines West High School, then a much sought post. In this they succeeded nicely; and he entered upon his duties with great zest and high hopes. But it was not long before there was an unfortunate flare-up between instructor and school committee in which the versatile and enthusiastic naturalist was soon worsted. The best and most entertaining lecturer the school had ever had, the most ardent scientist who had ever ventured to the city, and perhaps the best science teacher who ever darkened the doors of high school was summarily dismissed. But his students, with greatest enthusiasm and keen appreciation far beyond their years, had entered the fairy demesne of science. Some of these "delinquents" from that beginning followed the paths so auspiciously opened up and succesfully made science their life's occupation. Perhaps after all this intensive study of a circumscribed field was the best science training possible. *Quien sabe*?

Professor Call was my first acquaintance with a real live scientist of national reputation. It was very early in my career. As a youngster of thirteen years, in the first half of high school, I had already made modest beginning at collecting shells, insects, birds and minerals. My teacher was a John W. King, who was also principal. King was noticeably eccentric in his manners and methods, but he was an avowed follower of Herbert Spencer, and he was especially fond of trying out the Spencerian theories of education. So soon as he found out that any one of his pupils had become especially interested in any particular subject he at once set about to encourage him to greater and more systematic effort. Being a neighbor of Call's he made arrangement to take over one evening half a dozen of his kiddies, among them also Uly S. Grant, who has since become a distinguished authority on geology, and a leader in higher education, as dean of Northwestern University.

Upon our arrival at his home Call joyously gave up the entire evening to these youngsters, showing them his books and his cabinet of shells, all the while giving a fascinating running talk on the high points of interest. The youthful company had also thoughtfully come prepared; for they had their pockets full of specimens of which they wished to know the names. They had already learned the long Latin titles of some few forms but they wanted to enlarge their scientific vocabulary. Call willingly helped to do this.

Call was indeed a naturalist of the most versatile sort. This very fact prevented him from concentrating effort deeply upon any one thing or for any length of time. His exceptionally alert mind and normal great activity thus largely spent their force unavailingly. His efforts were bent along the line of the formal systematist rather than of the philosopher. With him product rather than process was the all-important desideratum. He was widely read; and of biological topics his knowledge almost bordered on the uncanny. There were few fields of science in which he could not discourse intelligently and at length in all their genetic, developmental and taxonomic aspects.

He was what is generally called a Bohemian, although always with serious ambitions. He was a brilliant talker whether in a small company or on the lecture platform, fully able at the moment to turn his vast knowledge to account. His conversation abounded in lively anecdote told with infinite zest; he was thoroughly genial and ready at good humored repartee; and he was never hampered by any excessive reverence for ancestral proprieties. Even an ordinary social gathering must have consisted of very ponderous interests if it could not be stirred into animation by a man with so much more quicksilver in his veins than falls to the lot of the average citizen.

Call was generous to a fault, helpful beyond measure, and thoroughly sympathetic. As a teacher he was seemingly without a peer. It is perhaps from this angle that the value of his great services should be judged rather than from that of cold, copious and creative productivity.

Charles Keyes.

THE ADDRESS OF THE PRESIDENT

THE TAXONOMIC UNIT

T. C. STEPHENS

The retiring president is expected to follow the custom of addressing the Academy upon some subject of general interest. Fortunately, custom does not require that such an address shall embody one's own research or investigation; but it may consist of a survey, or of reflections of a general nature.

It so happens that certain fields in which I have been somewhat interested have brought me to a study of the problem of the taxonomic unit in biology.

One difficulty which concerns many working biologists, and which seems to be becoming more and more acute, is the determination of the living forms upon which they work.

Insofar as zoological and botanical work is to have a permanent value in science it must at all times be open to verification; and it must at all times be possible to relate observations precisely to the natural forms upon which they were made. The necessity of stability in nomenclature is obvious to all.

Our studies in nature have proceeded so far, and differentiations are becoming so refined, that the problem of nomenclatural stability is becoming one of concern. In fact, there may be no such thing as stability; in which case the problem would be to build up a system that would cause the least amount of confusion in its operation.

The "species question" is not new to you; and to most of you who are concerned with the biological field, at least, the tendencies are familiar. I have been loath to present to you a discussion of the species question, partly because of its venerable theme, and partly because it has received the attention of some of the most illustrious biologists, both of the past and of the present. In fact, I think it was Darwin who exclaimed "How painfully true it is that no one has the right to examine the question of species who has not minutely described many." With this warning a wiser soul might hesitate to proceed further. And yet, the subject is one that cannot be evaded, and is one which cannot be solved for us by the science of any previous period.

In its philosophical aspects the species question is of interest; but from that point of view there is no pressing need of solution. As a scientific problem, however, it affects our daily work, and may become a barrier to progress.

Much has been said of the ideality versus the reality of the species concept. While the conception of a species may be purely a matter of the mind; and while there may still exist the debatable question as to whether the group or the individual is the real unit in nature; yet the fact remains that in practice we must have a unit.

When we endeavor to trace the historical development of any general idea in science it is customary to look as far back, at least, as Aristotle for a starting point. But in this case we do not find that Aristotle possessed any clear and defined notion of what we now call species. He recognized, and had names for, the different kinds of animals and plants, of course; but these differentiations were probably not based upon any generalized notions.

The first definition of species is usually attributed to John Ray, the Englishman, who lived in the seventeenth century. The dominant principle in Ray's conception was community of descent. As interpreted by Hertwig, Ray's definition of species was as follows: "For plants there is no other more certain characteristic for determining species than their origin from the seeds of specifically or individually like parents; that is to say, generalized for all organisms, to one and the same species belong individuals which spring from similar ancestors."

The next important contribution to the subject was made by Linnaeus, who said: "There are as many different species as there were different forms created in the beginning by the Infinite Being." ("Species tot sunt diversas formas ab initio creavit infinitum ens.") The problem in Linnaeus's time was to establish the reality of species and their immutability, rather than to examine critically the criteria by which they might be recognized.

Buffon's definition was: "A constant succession of individuals similar to and capable of reproducing each other." DeCandolle defined a species as "an assemblage of all those individuals which resemble each other more than they do others, and which are able to reproduce their like, in such a manner that they may be supposed by analogy to have descended from a single being or a single pair."

Johannes Muller and De Quatrefages followed in the same line of thought. The former referred to a species as "a living form represented by individual being, which reappears in the product of generation with certain invariable characters, and is constantly reproduced by the generative act of similar individuals." While De Quatrefages defined species as "an assemblage of individuals more or less resembling one another, which are descended or may be regarded as being descended, from a single pair by an uninterrupted succession of families." In these earlier years the conception of species was dominated by the principles of immutability and discontinuity.

More recently there has been a tendency to emphasize the value of physiological functions in the diagnosis of species and varieties. This seems to be an especially easy point of view for the student of bacteria and smaller fungi. The metabolic processes of the bacteria, for instance, seem to be more readily distinguished, if not more constant, than the structural peculiarities. And, of course, a very excellent case can be made out for the specificity of such physiological characters. It must be borne in mind, however, that back of every physiological process there must be a morphological organization which carries the same specific peculiarity. The same may be said of peculiar and characteristic secretions, such as gums, oils, alkaloids, etc.

During the early part of the preceding generation there was a trend away from the Linnaean conception of species. Thus, Huxley expressed his conception of species in this language: "When we call a group of animals, or of plants, a species, we may imply thereby, either that all these animals or plants have some common peculiarity of form or structure; or we may mean that they possess some common functional character."

Haeckel says that the word species "serves as the common designation of all individual animals or plants which are equal in all essential matters of form, and are only distinguished by quite subordinate characters."

In this latter group of definitions we will observe that the principle of structural similarity is dominant. Nothing can be more evident to the biologist, who is compelled to deal, even superficially, with the nomenclature of organisms, than that fundamental concepts and terms are in marked process of change. Half a century ago Professor Owen remarked: "I apprehend that few naturalists nowadays, in describing and proposing a name for what they call a 'new species,' use the term to signify what was meant by it twenty or thirty years ago." [1] It may be agreed that concepts must change with the development of knowledge, but it would seem that scientific terminology ought to remain as near constant as possible.

After this rather brief historical survey of the species concept it will be germane to inquire as to what concrete criteria have been, or can be applied. The analysis shows that there are three such criteria, viz., the genetic, the physiological, and the morphological.

The idea that hereditary descent is the essential test of specific rank seems to be the oldest and original point of view. As intimated, this was Ray's conception. This criterion is definite, but it fails in allowing for no expansion, no evolution. By virtue of continuity a species is always the *same* species. And this is manifestly in contradiction to the modern viewpoint. This criterion furnishes the basis for the modern principle of intergradation.

The criterion of relationship can have little value, because all forms and all groups, including subspecies, species, genera, etc., are related in this sense. So that relationship is a common property, and not a differential character. Furthermore, in nature it is usually impossible to know the parentage of forms.

The physiological test of species has had a long and honorable past. Many older writers were quite firmly convinced that true species could not interbreed. So that, interspecific sterility was accepted as a true test of a proper species. Time has shown, however, that it is not.

There are recorded cases of sterility in hybrids; there are recorded cases where sterility results from a cross in one direction, and fertility results from a cross in the other direction; there are recorded cases where fertility results from a cross in both directions; and there are, apparently, a few cases in which the hybrid shows a greater degree of fertility than in normal fertilization. Such facts indicate, no doubt, that all species do not possess the same degree of difference, physiologically, at least. But they also show that there is no constancy in the matter of sterility in hybrid offspring, and that such a criterion cannot be used in the test of species.

Aside from the matter of reproduction some functions have been regarded as having specific value; for example, in the pro-

1 "On the Osteology of the Chimpanzees and Orangs." Trans. Zool. Soc., 1858.

duction of certain secretions, such as gums, alkaloids, etc. Most especially, in the study of large groups of minute parasitic organisms, like the bacteria and other fungi, the effects of their metabolic activities upon living hosts or upon culture media not only are characteristic, but are quite easily discerned. The minute size of many of these organisms makes the application of the morphological test somewhat difficult. And while expediency may justify the use of physiological characters in such cases, this should not blind us in recognizing the inadequacy of this principle in general.

We may now consider the morphological criterion, viz., that similarity of structure brings individuals within the limits of the specific group, regardless of ancestry — known or unknown.

It goes without saying, almost, that we can have no other criterion for extinct species, whose only remains are structural. In the examination of structure we are able to measure and compare. All of the data are present. It remains but to fix the limits and bounds. Such a criterion of species harmonizes with the conception of a variable and mutable species.

But when the species varies or mutates beyond the confines of the defined species it becomes something else, under our eyes, just as we assume others have done in the prehistoric past. For, in the words of L. H. Bailey, "This notion that a species, to be a species, must have originated in nature's garden, and not in man's, has been left over to us from the last generation." [2]

The taxonomists of the present generation in science have not entirely graduated from the Linnaean conception of species, particularly as it includes the idea of fixity; although they are prone to look with disdain upon his meager binomial vocabulary. They mistake continuity for fixity and immutability. In their laudable efforts to harmonize classification with the probable phylogenetic history they forget that all groups above the individual are, in a measure, artificial and arbitrary, and of necessity must be, since we have no authentic record of their phylogenesis.

Our conclusion is, then, that the only true and scientific criterion of species is the one based upon morphology.

To what extent may the differentiations of living organisms be useful to science? What degree of difference should be recognized taxonomically? We may readily understand that where such living forms are under experimental observation for the purpose of determining genetic relationships, considerable care in cataloguing minute variations may be necessary; but where

2 Survival of the Unlike, page 110.

individuals are taken at random in nature, the same thing is not true.

It is interesting to learn that new forms in a single group (birds) are being recognized and named at the rate of about one thousand per decade in a single zoo-geographical region (Africa).[3] Many of these newly described forms are, doubtless, subspecies. The subspecies is a modern refinement of the older unit, the species, with the drawback that it is far more difficult to handle, requiring a considerable amount of material and a degree of skill possessed only by the specialist. The subspecies unit is being introduced not only in Africa, but also in America, and not only among birds, but in other groups of vertebrates and invertebrates, and in many of the groups of plants. The question as to the serviceability of this modern unit is, then, germane.

The subspecies lacks even the capacity for exact definement that is possessed by the Linnaean species. The only characteristic of subspecies is *intergradation*. The only avowed justification, on biological grounds, for recognizing and cataloguing subspecies is to provide for the possibility of detecting incipient species.[4] That it may be done on other grounds cannot be denied.

But, in order to provide for the very probable possibility of discovering incipient species some taxonomists, and others, seem to be willing to submerge the whole nomenclatural system into confusion and chaos. Perhaps it may be said, without injustice, that at the present time there are certain groups of both animals and plants whose taxonomy and nomenclature have reached such a state of confusion in about a direct proportion to the attention these groups have received from taxonomists — and this mostly a result of multiplication of subspecies.

When a group has been pretty thoroughly worked over for all the subspecies it will yield there will be nothing left for taxonomists to do but to make further revisions with the admission of hypersubspecies to be designated in tetranomials, and so on.[5]

3 *The Auk* (XXXVI, page 452) quotes *The Journal fur Ornithologie* (January, 1918) as authority for the statement that 979 new forms of birds have been named for Africa during the years 1905 to 1914.

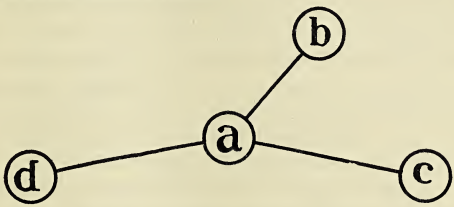
4 A clear-cut discussion of this question is to be found in certain papers in recent numbers of the *Journal of Mammalogy*. Dr. C. H. Merriam attacks the principle of intergradation and defends the morphological test. (Volume I, No. 1, pp. 6-9, 1919.) Mr. P. A. Tavener defends the principle of intergradation. (Volume I, No. 3, pp. 124-127, 1920.)

5 I am indebted to my colleague, Dr. A. W. Lindsey, for the following contemporaneous entomological example of taxonomic excess: F. E. Watson (*Journ. N. Y. Ent. Soc.*, XXVIII, page 232, 1920) described and named the following aberrant form of an Hesperiid, viz., *Poanes hobomok* form ♀ *pocahontas* ab. *friedlei*. *Pocahontas* is merely a melanic unisexual dimorphic form of *hobomok*, which varies considerably in the extent of its pale maculation. Friedlei is merely the darkest form of *pocahontas* yet recorded, and its christening seems to carry the matter to an unnecessary and objectionable degree. And, worst of all, the single type specimen

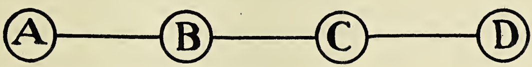
There is no logical reason for stopping short of this, and no law to prevent it. It would seem that the tendency here referred to is a result of a perverted specialization. One is led to wonder whether such a practice is designed to further the ends of science, or to furnish an occupation.

The whole problem of the determination of specific rank has been in the tentative stage from the beginning, and there is some reason to suspect that it will always be a matter surrounded with difficulty and variance of opinion. What is to be gained, therefore, in attempting to establish another hypothetical unit below the species?

There are two possible conceptions of specific variants. These variants may be regarded as due to fluctuating (continuous) variations, and their relationship should be represented by some sort of a radiate pattern, thus:



Or they may be due to orthogenetic variations, and should be represented in a linear system, thus:



In the latter case, no matter where we assign the ancestral type in the system, it need not have *direct* continuity with all of the other forms. So that, if A, B, C, and D are named forms of subspecific rank, and if A is regarded as the prototype, then B may be a subspecies, but not so with C and D. C might be called a hypersubspecies.

It might be supposed that D would differ from A to such an extent as to justify specific rank; but, according to a principle which has grown up in modern systematic zoology, so long as intergrading forms exist between A and D, the latter cannot be

of *friedlei* was reared artificially, and under such environmental conditions as produced also an unusually dark male; but the aberrantly dark male escaped a christening. To some this procedure will seem to be a prostitution of the purposes of taxonomy and nomenclature.

assigned to specific rank. Thus, no matter how unlike A and D may become, the presumption of common origin, as evidenced by intergrades, prevents their recognition as distinct species. This principle (of intergradation) is untenable from a general biological viewpoint because it is inconsistent with the doctrine of evolution. It is, in fact, a vestige of the discarded doctrine of immutability of species. How specific rank can be granted to *Lynx canadensis* and *Lynx ruffus,* for instance, and then denied to the extremes of variation in the Great Horned Owl, merely because of the existence of intergrades, is a puzzle which puts a strain on one's logical faculty.

On the other hand, if the study of any group of subspecies or varieties would permit their arrangement into a radial system, the explanation would be in harmony with well-understood biological principles, and with the facts of continuous variability. This system requires a prototype, hypothetical or known, upon which the name may be bestowed. The radial variates, continuous variations, are designated simply as varieties when it is necessary to distinguish them at all. Theoretically discontinuous variations produce species at once, and leave no intergrades.

I believe that ornithological taxonomists have found it usually impossible to determine prototypes among subspecies; and they have been satisfied merely to catalogue different forms which individual opinion may regard as having subspecific rank.[6]

What is to be gained, of value, by naming continuous variations, or any particular assemblage of continuous variations, such as a variety or geographic race? Will it not weaken an otherwise fairly satisfactory system of nomenclature? It is quite true that any one of them may represent an incipient species. And it is easily conceivable that any one may proceed in the development of still further unlikeness from the form with which it may be most closely related. The incipiency of this sort of thing seems to be too small a matter to be provided for in a nomenclatural system. As Loomis says, "In trying to manufacture a nomenclature for birds of remote ages, past and future, are we not putting an impediment in the way of the study of existing birds?"[7]

6 It is true that a committee of the American Ornithologists' Union has acted as a court which accepts or rejects proposals of new forms of North American birds; for some years the rulings of this committee were satisfactory and generally accepted. More recently the committee has not, apparently, been functioning. It is assumed that the flood of "revisions," with a perplexing array of newly proposed subspecies, has laid upon this committee an impossible task. It seems, at least, that such must be the inevitable outcome of the application of the principles of intergradation, subspecies, and trinomial nomenclature.

7 *The Auk,* XX, page 299, 1903.

Along with the subspecies unit comes trinomial nomenclature. The greatest objection to this lies, perhaps, in the difficulty involved, and the consequent restriction in use. It will not help to say that subspecies and trinomials are for the use only of taxonomic experts, and that others may be content with the species unit. There must be a common ground in order to promote coöperation and prevent misunderstanding and confusion. The taxonomist has no license for erecting a system which is unrelated to other biological fields. It must be emphasized that taxonomy and nomenclature are tools of the biologist, and not a branch of science *sui generis;* they serve no useful ends apart from their relation to other branches of biological knowledge. Thus the biologist has a right to discuss the manner in which taxonomy is helpful, or otherwise.

Other objections which have been offered to the subspecies unit and trinomial nomenclature may be summarized as follows:

(a) There is usually a variance in the judgment of the experts on the relative value of the minute characters upon which subspeciation is based.

(b) Subspecies and trinomials represent no stopping place, but lead directly to tetranomials and polynomials.

(c) Such ultra-refinement thwarts the purpose of any system by introducing uncertainty and lack of precision in the ends which taxonomy is designed to serve. For the sake of argument we might grant that the expert taxonomist might be able to work precisely even with subspecies, but we would immediately reply that that, in itself, would serve no useful end. When we split our subspecies one or more times we will be back to the good old pre-Linnaean days when, as pointed out by Loomis,[8] the Mockingbird was distinguished by the name of *Turdus minor cinero-albus non-maculatus.* Yet this is simplicity in comparison with the multiplicity of trinomially designated forms which only a half dozen persons in the world, perhaps, are qualified to determine.

(d) As urged by some of the British ornithologists when the trinomial system was proposed by the American school, perhaps the greatest objection is its liability to abuse. That such abuse has been practiced one example will suffice to show. In the recent pages of the leading American ornithological journal a new subspecies of teal duck was described, in which the differential character was the extension of a white crescentic patch from the

8 *The Auk,* XX, pp. 294-299, 1901.

front of the head around to the mid-occipital region, where the two white bands fused.[9] In the next issue of the same journal a writer reported that a duck of the same supposed subspecies, which had been kept in captivity in a public park, had molted a splendid example of the species.[10]

Finally, and in summary, the preceding remarks may be interpreted as a protest against the substitution of the subspecies for the species as a taxonomic unit. It seems unnecessary to offer evidence that there is a strong tendency in this direction.

Simple binomial nomenclature permits the designation of subspecific forms (i.e., varieties) where necessary in biological investigation, by the use of the term "variety" (usually abbreviated) followed by the varietal name. By this method no attempt is made to establish a new unit, and yet it provides a means of distinction where such is needed. By it incipient species may be recognized without jeopardizing the usefulness of the specific unit. In other words we would return to the *status quo* prior to the use of the trinomial system.

9 *The Auk*, XXXVI, pp. 455-460, 1919.
10 *The Auk*, XXXVII, pp. 126-127, 1920.

NOTES ON SOME PLANTS OF THE ARAPAHOE NATIONAL FOREST AND ROCKY MOUNTAIN NATIONAL PARK

L. H. PAMMEL AND R. I. CRATTY

One of us accepted an invitation to spend ten days in August, 1919, with the forestry students and Professor G. B. MacDonald, Professor G. C. Morbeck and Mr. D. C. Poshusta in the Arapahoe national forest. The camp was located at the junction of Spruce creek and the fork of St. Louis creek, near the ranger station, at an altitude of about 9,000 feet.

Mount Byers, one of the outstanding peaks of the region, was easily accessible. We are under obligations to the forestry department for the many kind courtesies shown us.

One of the most interesting botanical regions of northern Colorado is the Arapahoe district. The Arapahoe district in the present paper comprises the Arapahoe national forest and the Rocky Mountain national park. It is rich in scenic beauty, and of great interest to the scientist. The Rocky Mountain national park of 358 square miles, was established by taking an area from the Arapahoe national forest and the Colorado national forest. The Geologic Story of the Rocky Mountain National Park, a pamphlet of ninety pages by Dr. Willis T. Lee, published by the Government Printing Office in 1917, is very profusely illustrated with maps and views of the scenery and gives a most interesting description of the region, and is well worth a careful study by any one interested in this section of our country. The Colorado national forest contains the headwaters of such streams as the North Platte, Laramie, Cache La Poudre, Big Thompson and Boulder creeks. To the south are the Arapahoes,[1] a magnificent series of peaks.

The Arapahoe glacier is on the east slope of the Arapahoe peaks. The glacier is three-quarters of a mile long and of about

1 Dr. C. C. Parry, in one of his articles on The Far West in the *Chicago Evening Journal*, December 3, 1863, deplores the fact that the unmeaning term of Colorado (red) was applied to the then territory of Colorado. The name Arapahoe he thought might better have been used, or the worthier historical name of Jefferson or New Switzerland. It does seem to us as though this state with its magnificent streams and superb mountains should have commemorated the Indian.

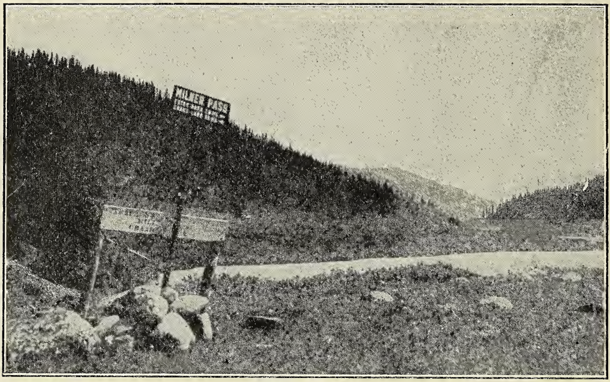


Fig. 1. Lodge Pole Pine and Lake, Milner Pass, Colorado. Specimen Mountain to the left not visible

the same width. The crevasses range in width from a few inches to several feet. Professor G. B. MacDonald, who visited the glacier in 1919, tells us that the crevasses are of unknown depth. It is said to move from fourteen to twenty-seven feet a year. The rate of movement of this glacier has been studied by Henderson,[2] who found in 1905 that the ice suddenly receded, but that in 1903 and 1904 it moved forward.

The Hallet glacier is a little farther north and has also diminished during the last nine years.

The Arapahoe national forest and the Rocky Mountain national park take in the continental divide, and are generally west of the Clear creek region and west of the Boulder canyon country. In this region are some magnificent peaks; the Arapahoe peak 13,506 feet, James peak 13,260 feet and to the southwest Parry peak 13,345 feet, Mount Eva 13,115 feet and Mount Flora 13,122 feet, Torrey peak 14,372 feet and Gray peak 14,384 feet. The magnificent botanical peaks, James, Parry, Torrey and Gray, are thus not widely separated. Dr. C. C. Parry[3] in 1861 applied the names; "Torrey and Gray to the twin peaks always visible from a conspicuous place and to the associate peak somewhat lower, Mount Engelmann. In these words I have endeavored to commemorate the joint scientific services of our triad of North

2 Journal of Geology, **13**:556; **13**:317.

3 Physiographical sketch of that portion of the Rocky Mountain range, at the headwaters of South Clear Creek and East of Middlepark, with an enumeration of the plants collected in this district, in the summer months of 1861: Am. Jour. Sci., 2 Ser. **33**:231, see p. 235.

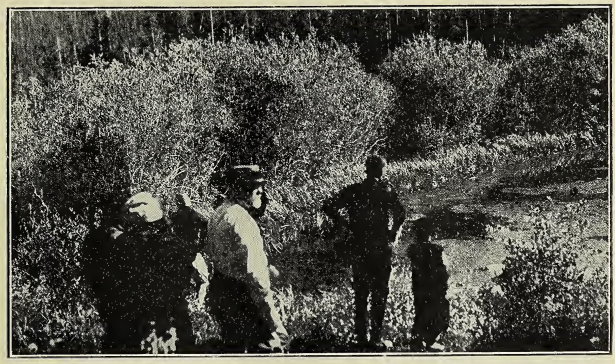


Photo. by MacDonald

Fig. 2. Beaver Bog, Spruce creek

American botanists, by giving their honored names to these snow capped peaks in the Rocky mountains."

Mount Byers, 12,778 feet, is to the west of James peak, whose drainage on one hand is into St. Louis creek or its tributaries to the north and into Williams creek to the south, all finally finding their way into Grand river. St. Louis creek empties its waters into the Fraser. The area of the Arapahoe forest in 1918 was given as 634,775 acres. A part of its area was taken out previously.

The region has been visited by many botanists. Dr. C. C. Parry made extensive collections in the region in 1861; much later, Dr. Asa Gray and Sir J. D. Hooker visited the Clear creek country. C. S. Crandall while connected with the Colorado Agricultural College did extensive collecting in the region. Dr. Parry explored Berthoud Pass, giving the altitude as 11,394 feet. He states in his physiographic sketches that near the headwaters of South Clear creek is a depression discovered by an engineer Berthoud who made a reconnoisance for the location of a direct road between Denver and Salt Lake. This road, the Union Pacific, however, later made its way over Sherman Hill in Wyoming. Doctor Parry also gave an account of Empire City in a series of letters[4] published in the Chicago Evening Journal and a subsequent article under the title "A Midsummer Week in Middle Park." In the latter article he describes Middle Park and the streams forming the headwaters of Grand river. He describes

4 Sept., 1864 (the exact date not at hand).

Photo. by MacDonald
Fig. 3. Fire Guard in Arapahoe National Forest; also several beaver bogs.

the location of Empire City, the mountains surrounding it, the deserted beaver dams and the view obtained of Bald mountain, Mount Flora and Parry's peak, of the Middle Park country, Grand River and its tributaries. He mentions "mazes of Beaver Dams" where you "flounder among the matted roots of willow thickets." Then he discusses the places then and now known as Sulphur Hot Springs and the main valley of Grand river, "which forces its way through transverse ridges." Another region visited by him in northern Colorado was Long's peak.

The exploring party of Hayden's Survey visited the region and made a study of it. Whether J. M. Coulter who was the botanist for some of Hayden's Surveys, visited the region, we do not know.[5] Marvine, who was the geologist of the Survey, gave a good description of Mount Byers and the drainage of Fraser river and its tributaries, as well as of Williams creek.

Mount Byers, where most of the collecting was done, is the northwest spur of the Berthoud pass. James peak and Mount Byers are culminating peaks of a part of the Forest river basin, Williams creek coming from the Clear creek loop. The west sides of the peaks are all easily approached, the east side has a precipitous approach. The region is covered with fine timber, and there have been fewer forest fires here than in any other

5 Hayden, Rep. U. S. Geological Survey of the territory embracing Colorado; explorations for the year 1873; 153.

region visited by us. There are fine stands of lodge pole pine and in the upper altitudes and narrow valleys are fine Engelmann spruce. There are two ways in which this region may be reached; one by rail, going over the Denver, Pacific and Northwestern, or Moffet road, along Boulder creek, passing Yankee Doodle lake on the eastern slope, over Rollins pass by way of Corona, down the west slope along one of the smaller tributaries of Fraser river. In going this way one passes in view of the magnificent Arapahoe peaks with the glacier, and James peak. The town of Fraser is in the broad plain of Fraser river. The foresters' camp was

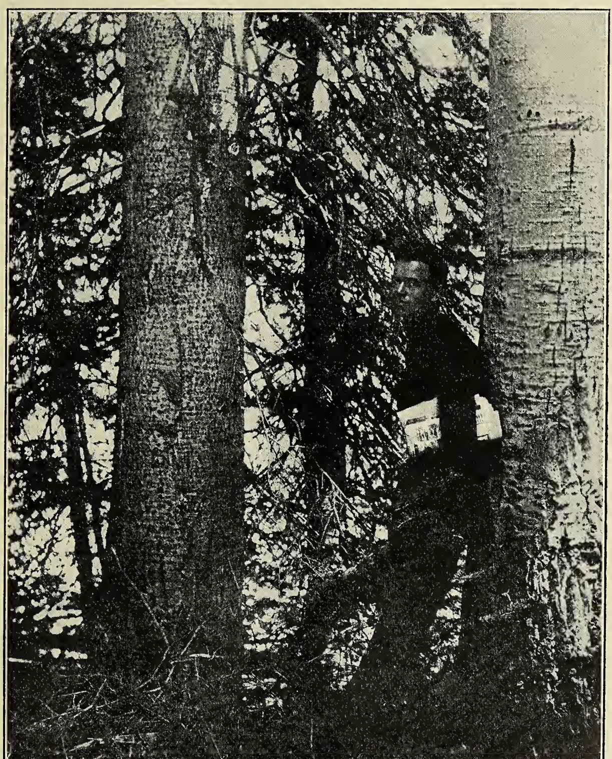


Photo. by MacDonald

Fig. 4. Trunk of Alpine Fir (*Abies lasiocarpa*) Mount Byers

located on one of the branches of St. Louis creek, at the junction with Spruce creek. The other route is by auto going along one of the branches of Fraser river, from the west and over Berthoud pass with a magnificent view of James peak and, to the southwest, Parry Mountain. Torrey and Gray peaks are further to the south. A fairly good road passes over the Berthoud pass, then through Empire, Idaho Springs, and the fine system of highways in the Denver mountain parks down to Golden, passing Lookout mountain where Bill Cody is buried.

In addition to the localities mentioned, a trip was made to Specimen Mountain in the Rocky Mountain national park, going by way of Fraser river, Camp Uray on Grand river and the Grand Lake country, spending a little time on Beaver creek and then over to Milner pass. A modern up-to-date highway is being constructed over the divide between the waters of the Pacific and the Atlantic so that this interesting region will be accessible to tourists. A small lake and some open park country occur just below the pass on the Atlantic slope. The Specimen Mountain country is interesting because of the mountain sheep, which at the time of our visit were grazing at timber line and above. It is also interesting because of volcanic rock, Specimen Mountain being an extinct crater.

There are comparatively few large parklike openings on the smaller tributaries. On the larger streams like Fraser river at Fraser the parks are larger and during the early summer are visited by an abundance of wild game. In these parks we observed an abundance of *Pedicularis groenlandica, Valeriana ceratophylla, Lappula floribunda, Swertia scopulina, Pseudocymopteris montana* and *Astragalus elegans.* In the swampy canyons and woods we observed the following plants: *Mertensia ciliata, Primula Parryi, Osmorrhiza obtusa, Angelica pinnata, Pyrola secunda, Lycopodium annotinum, Picea Engelmanni, Veratrum speciosum, Streptopus amplexifolius, Cypripedium acaule, Limnorchis viridiflora, Coeloglossum bracteatum, Lonicera involucrata* and *Senecio triangularis.*

The beaver bogs of the region are interesting. They are numerous at 9,000 to 9,500 feet altitude, not only on the smaller tributaries of St. Louis creek like Spruce creek, but on Grand river in the Specimen Mountain country and on the east slope. Doctor Parry in his paper, Physiographic Sketches, mentions how the currents of the mountain stream are interrupted by beaver dams and the subsequent growth of willow and alder bushes. On Spruce creek just above the camp three of these little ponds were observed. The dam consisted of small logs and vegetable matter overgrown with several species of willows. In these bogs we observed *Betula glandulosa, Salix irrorata, Rumex densiflorus, Trollius albiflorus, Parnassia fimbriata, Geum strictum, Pyrola secunda, P. chlorantha* and *Polemonium confertum.* In the burned over area the most conspicuous plants were *Phacelia sericea,*

Photo. by MacDonald

Fig. 5. Alpine Fir (*Abies lasiocarpa*) Mount Byers

Dracocephalum parviflorum, Sambucus microbotrys, Gayophytum ramosissimum, Chamaenerion augustifolium, Arnica cordifolia and *Cirsium foliosum.* Of the strictly Alpine plants at high altitude the following may be enumerated: *Cirsium eriocephalum, Trifolium dasyphyllum, T. nanum, Castilleja integra, C. pallida, Campanula rotundifolia, Tonestes pygmaeus, Erigeron elatior, E. glabellus, E. uniflorus, Rydbergia grandiflora, Actinella acaulis, Arnica fulgens, Hieracium albiflorum, Primula Parryi, Silene acaulis, Sedum integrifolium, S. Rhodanthum, S. stenopetalum, Heuchera parvifolia, Saxifraga austromontana, S. argentea, Dryas octopetala, Gentiana Romanzovii, G. Parryi, Ribes Coloradense* and *Swertia scopulina* and numerous willows. The timber line conifers in the region are *Pinus Murrayana, Picea Engelmanni* and *Abies lasiocarpa.*

It is of interest to note that some of the common European plants are naturalized at high altitude. Just below Berthoud pass, timothy (*Phleum pratense*) was common. The common lamb's quarter (*Chenopodium album*) was found along the highway at an altitude of 10,000 feet near Berthoud and Milner pass. Potatoes were growing at the ranger station, 9,000 feet, apparently not killed by the night freezing in early August. Peas in a garden at the ranger station produced a good crop. In early August for several nights white hoar frost covered the vegetation of the region, but it did not prevent the native plants in the region from blooming abundantly.

CATALOGUE OF PLANTS

In the following list the grasses were determined by Doctor A. S. Hitchcock, and the willows by Doctor C. R. Ball. The plants were collected by L. H. Pammel, D. C. Poshusta, Professor G. B. MacDonald and Professor G. C. Morbeck.

PTERIDOPHYTES

Polypodiaceae

Woodsia oregana D. C. Eaton. Milner Pass, 11,700 feet; rocks; not common.

Equisetaceae

Equisetum arvense L. West fork of St. Louis creek; Mount Byers; Grand river, 10,000 feet; common in moist places.

Lycopodiaceae

Lycopodium annotinum L. Beaver bog on west fork of St. Louis creek; not common.

GYMNOSPERMS

Pinaceae

Pinus flexilis James. Below Berthoud Pass, 9,000 feet; east slope of the Rockies near Empire.

P. murrayana Balf. Timber line below 11,000 feet; Spruce creek; Mount Byers; Specimen Mountain.

P. scopulorum Sarg. Golden, 8,500 feet; Empire.

Picea Engelmanni (Parry) Engelm. West fork of St. Louis creek; Mount Byers, 10,000 feet; Grand river, 10,000 feet; Empire; Spruce creek, leaves three centimeters long. In swamps, canyons and slopes of mountains below timber line.

P. pungens Engelm. Clear creek canyon.

Abies lasiocarpa (Hook.) Nutt. Spruce creek; Mount Byers, 10,500 feet; Specimen Mountain, 10,000 feet; Milner pass, 11,500 feet; Berthoud Pass, 8,500 feet. Slopes of mountains below timber line.

Pseudotsuga taxifolia (Poir) Britton. Lookout Mountain, 8,500 feet; Empire; slopes of mountains.

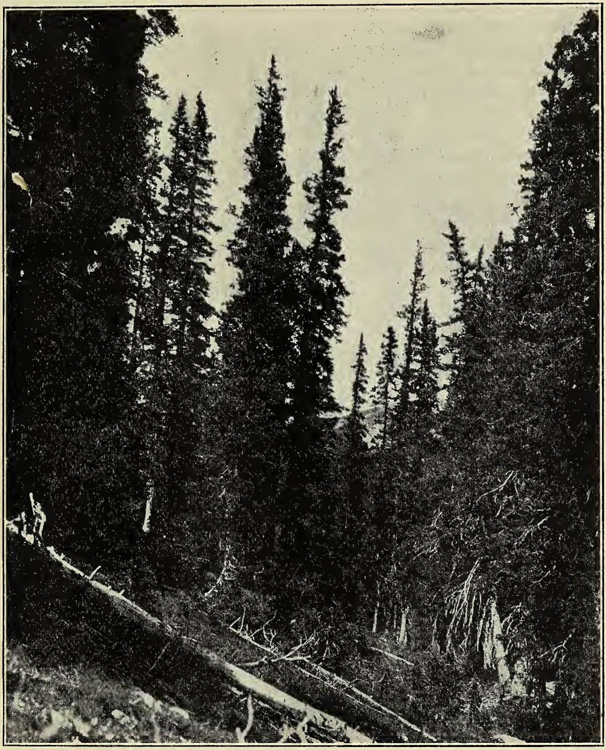


Photo. by MacDonald

Fig. 6. Engelmann Spruce, Mount Byers

Juniperus scopulorum Sarg. Lookout Mountain, on dry slopes, 8,500 feet; Berthoud Pass, east slopes of Rockies, 8,500 feet.

J. communis sibirica (Burgd.) Ryd. Mount Byers; Camp Uray. Common on slopes of mountains in woods of lodge-pole pine.

ANGIOSPERMS

Gramineae

Phalaris arundinacea L. Berthoud Pass, 10,000 feet; common.

Muhlenbergia racemosa (Michx.) B. S. P. Denver; common near irrigation ditches.

M. montana (Nutt.) Hitch. Lookout Mountain.

Aristida longiseta Steud. Lookout Mountain.

Stipa Nelsoni Scribn. Specimen Mountain, 12,500 feet; west fork of St. Louis creek; open places.

S. viridula Trin. Manitou; west fork of St. Louis creek; Lookout Mountain; common on mountain slopes.

S. Vaseyi Scribn. Lookout Mountain.

Phleum alpinum L. Mount Byers, 10,500 feet; Specimen Mountain, 12,900 feet; common in parks and meadows.

Alopecurus aristulatus Michx. West fork of St. Louis creek.

Sporobolus cryptandrus (Torr.) Gray. Lookout Mountain; Denver streets and vacant lots.

S. asperifolia Nees. & Meyer. Lookout mountain.

Cinna latifolia (Trev.) Griseb. Spruce creek, Arapahoe national forest; moist places in spruce woods.

Agrostis hiemalis (Walt.) B. S. P. Specimen Mountain, 9,500 feet; Mount Byers, 10,000 feet; west fork of St. Louis creek; Lookout Mountain; Fraser, in burnt-over areas.

A. humilis L. Mount Byers. 12,000 feet; Milner Pass, 10,700 feet. Moist places near snow banks.

Calamagrostis canadensis (L) Beauv. Beaver bog, west fork of St. Louis creek; Specimen Mountain, 12,000 feet; Mount Byers, 9,000 feet; Berthoud Pass. In moist places near springs and creeks.

C. purpurascens R. Br. Mount Byers.

Deschampsia caespitosa (L) Beauv. Mount Byers, 10,500 feet; Milner Pass, 11,700 feet; Berthoud Pass; Specimen Mountain, 12,500 feet; west fork of St. Louis creek; Fraser. Common in parks and open places.

Trisetum spicatum (L) Richt. Mount Byers, 12,000 feet; Specimen Mountain, 12,900 feet; Camp Uray on Grand river, 10,000 feet; Fraser; west fork of St. Louis creek.

T. montanum Vasey. Berthoud Pass, 11,000 feet, on Pacific slope.

Avena fatua L. Lookout Mountain.

Danthonia intermedia Vasey. West fork of St. Louis creek; Mount Byers.

D. californica Bolander. Lookout Mountain.

Bouteloua olygostachya (Nutt.) Torr. Common near Denver and Manitou.

B. gracilis (H. B. K.) Lag. Lookout Mountain.

Koeleria cristata Pers. Lookout Mountain; Berthoud Pass.

Bromus Richardsonii Link. Specimen Mountain, 10,000 to 12,000 feet; Camp Uray, Grand river; Mount Byers; Fraser. In parks and pine woods.

B. Porteri (Coult.) Nash. Mount Byers, 10,500 feet; Lookout Mountain.

Poa pratensis L. Camp Uray, Grand River; west fork of St. Louis creek; Lookout Mountain; common in pine woods.

P. alpina L. Mount Byers; Milner Pass, 10,700 feet; Specimen Mountain, 10,000 feet; west fork of St. Louis creek. Abundant above timber line.

P. leptocoma Trin. Specimen Mountain, 12,000 feet; Mount Byers, 12,000 feet. In moist places, edge of snowbanks.

P. crocata Michx. Mount Byers, 10,500 feet, moist places.

P. reflexa Vassey & Scribn. Milner Pass, 10,700 feet. In moist spruce woods.

P. exilis Scribn. Mount Byers.

P. nemoralis L. West fork of St. Louis creek.

P. Wheeleri Vasey. Milner Pass, 10,700 feet. Moist woods.

P. artica. R. Br. Mount Byers, Arapahoe national forest.

P. lucida Vasey. Mount Byers, several collections.

Festuca idahoensis Elmer. Camp Uray on Grand river.

F. Thurberi Vasey. West fork of St. Louis creek; Mount Byers; Fraser.

F. rubra L. Camp Uray; common.

F. saximontana Ryd. Camp Uray on Grand river.

F. brachyphylla Schultes. Mount Byers, Arapahoe national forest. Open places; several collections.

Photo. by MacDonald

Fig. 7. Fireweed (*Chamaenerion angustifolium*) Spruce creek, Arapahoe National Forest

Panicularia nervata (Willd.) Kuntze. Spruce creek; Mount Byers, 9,500 feet. In springy places.

Agropyron pseudo-repens Scribn. & Smith. Specimen Mountain, 9,000 to 12,000 feet. This was identified as *A. tenerum.* It is not the same as the Iowa plant.

A. tenerum Vasey. Mount Byers, 9,000 feet; Camp Uray, Grand river; west fork of St. Louis creek; Lookout Mountain; Fraser.

A. Pringeli (S. & S.) Hitch. Mount Byers.

A. caninum (L) Beauv. Lookout Mountain.

A. Smithii Ryd. Lookout Mountain.

A. Richardsonii Schrad. Denver.

A. violaceum (Hornem.) Vasey. Milner Pass, 12,000 feet.

Hordeum jubatum L. Mount Byers; Fraser.

H. caespitosum Scribn. St. Louis creek. Identified as *H. jubatum.*

Elymus canadensis (L) Beauv. Denver; Manitou; Lookout Mountain. Dry mountain slopes.

E. robustus Scrib & Smith. On the plains near Denver.

E. glaucus Buckley. Spruce creek near Fraser, 9,500 feet. Mountain slopes.

E. triticoides Buckley. Lookout Mountain.

Sitanion elymoides Raf. Mount Byers, 9,000 feet; Specimen Mountain, 12,900 feet.

Cyperaceae

Carex utriculata Boott. Mount Byers, timber line and alpine meadows.

C. atrata L. Specimen Mountain, 12,000 feet, timber line and alpine grassy places.

C. bella Bailey. Specimen Mountain, 11,500 feet. Open grassy places.

C. nova Bailey. Milner Pass, 10,700 feet. Moist meadows.

Juncaceae

Juncus Drummondii E. Meyer. Specimen Mountain, 11,500 feet. Moist places.

J. mertensianus Bong. Spruce creek; Camp Uray, Grand river. In dry soil.

Luzula parviflora Ehrh. Milner Pass, 11,700 feet; Specimen Mountain, 11,500 feet; Mount Byers, 12,000 feet; beaver bog on west fork of St. Louis creek.

L. spicata (L) DC. Mount Byers, 12,000 feet. Dry open places near timber line.

Liliaceae

Calochortus Gunnisoni S. Wats. Specimen Mountain. Near timber line in open meadows.

Melanthaceae

Zygadenus elegans Pursh. West fork of St. Louis creek. Common in meadows and parks.

Veratrum speciosum Ryd. Beaver bog, west fork of St. Louis creek, 9,500 to 10,500 feet. Moist, springy places in Engelmann spruce woods.

Convallariaceae

Streptopus amplexifolius (L) DC. Beaver bog, west fork of St. Louis creek. Common in springy places in spruce woods.

Iridaceae

Sisyrinchium occidentale Bicknell. In dry, open parks, 9,500 feet, west fork of St. Louis creek.

Orchidaceae

Cypripedium acaule L. Spruce creek. Rare in spruce woods.

Limnorchis viridiflora (Cham.) Ryd. Mount Byers, 10,000 feet. Below timber line.

Coeloglossum bracteatum (Willd.) Parlatore. Mount Byers, 12,000 feet; Golden.

Corallorrhiza Vreelandii Ryd. Spruce woods along Spruce creek.

C. multiflora Nutt. Mount Byers, 10,000 feet. Spruce woods and springy places.

Salicaceae

Populus tremuloides Michx. Rocky Mountain national park, 9,000 feet; Spruce creek, 9,400 feet; Camp Uray, Grand River; Berthoud Pass below timber line.

P. angustifolius James. Berthoud Pass; Empire; Golden. Common.

P. deltoides Michx. Golden; Manitou. Common.

Salix fragilis L. Cultivated at Golden.

S. amygdaloides Anders. Golden.

S. pseudomyrsinites Anders. Beaver bog, 9,000 feet; Camp Uray, Grand river, 9,000 feet; Spruce creek, 9,500 feet.

S. monticola Bebb. Grand river, Rocky Mountain national park, 9,500 feet; Specimen Mountain, 10,000 feet.

S. saximontana Ryd. Specimen Mountain, 11,500 feet; Mount Byers, 9,500 feet.

S. brachycarpa Nutt. Specimen Mountain; beaver bog, west fork of St. Louis creek, 9,000 feet.

Photo. by MacDonald

Fig. 8. Alpine Thistle (*Cirsium eriocephalum*) and other alpine plants

S. Wolfii Bebb. Beaver bog, west fork of St. Louis creek, 9,000 feet; Spruce creek.

S. glaucops Anders. Spruce creek, 9,500 feet, two sheets; Specimen Mountain, 10,000 feet, two sheets, and one sheet from 11,500 feet; Mount Byers, 10,500 feet, three sheets.

S. chlorophylla Anders. Rocky Mountain national park, 9,500 feet; Mount Byers, 11,000 feet.

S. subcoerulea Piper. West fork of St. Louis creek, 9,000 feet; Spruce creek; beaver bog on west fork of St. Louis creek, 9,000 feet.

S. geyeriana Anders. West fork of St. Louis creek.

S. scouleriana Barr. Lookout Mountain, 8,500 and 11,500 feet; Spruce creek.

S. exigua Nutt. Golden, along streams.

S. irrorata Anders. Specimen Mountain; Camp Uray; Fraser; common in bogs.

S. Fendleriana Anders. Camp Uray; Fraser.

Betulaceae

Betula glandulosa Michx. West fork of St. Louis creek; Rocky Mountain national park; Grand river; Beaver creek; Fraser.

B. fontinalis Nutt. Berthoud Pass, 9,000 feet, in beaver bog; Grand river; Beaver creek.

Alnus tenuifolia Nutt. Spruce creek; Rocky Mountain national park, 9,000 feet; in bogs and springy places.

Fagaceae

Quercus Gambellii Nutt. Denver and Manitou. Common on mountain slopes.

Polygonaceae

Eriogonum alatum Torr. Lookout Mountain.

E. umbellatum Torr. Lookout Mountain; Golden; common in spruce woods.

E. effusum Nutt. Golden.

E. rosensis Nels & Kennedy. Specimen Mountain, 12,000 feet, apparently this species.

Oxyria digyna (L) Campdera. Specimen Mountain, 12,900 feet; Mount Byers, 12,500 feet; common at and below timber line.

Rumex mexicanus Meisn. Specimen Mountain, 11,500 feet; Milner Pass; dry, open, burnt-over areas.

R. densiflorus Osterh. Beaver bog on west fork of St. Louis creek, not common.

Polygonum viviparum L. Milner Pass; frequent in bogs.

P. douglasii Greene. West fork of St. Louis creek; common in burnt-over areas.

P. bistortoides Pursh. Mount Byers, 11,500 feet; common in moist places near timber line.

Chenopodiaceae

Chenopodium album L. Specimen Mountain, introduced along trails.

C. botrys L. Golden; frequent in waste places.

Blitum capitatum L. Specimen Mountain, 9,500 feet; burnt-over areas.

Monolepis Nuttalliana (R. & S.) Engelm. Specimen Mountain, 11,000 feet.

Nyctaginaceae

Allionia linearis Pursh. (*Oxybaphus angustifolius* Sweet) Golden; in open places.

Caryophyllaceae

Silene Menziesii Hook. Specimen Mountain, 11,000 feet; in woods.

S. acaulis L. Specimen Mountain, 12,000 feet; Mount Byers, 12,000 feet; common above timber line.

Lychnis Drummondii Hook. Mount Byers; common near timber line.

Stellaria longipes Goldie. Mount Byers, near timber line.

Cerastium arvense L. Mount Byers, 9,500 feet; west fork of St. Louis creek.

Arenaria Fendleri Gray. Specimen Mountain, 11,500 feet; Mount Byers, 12,000 feet.

Ranunculaceae

Caltha rotundifolia (Huth.) Greene. Mount Byers; springy places near timber line.

Trollius albiflorus (Gray) Ryd. Specimen Mountain, 12,000 feet; Mount Byers, 11,000 feet; Milner Pass, 11,700 feet; common in moist springy places.

Aquilegia coerulea James. Milner Pass, 11,700 feet; Specimen Mountain, 12,900 feet; common at and below timber line.

Delphinium reticulatum A. Nels. Mount Byers, 10,500 feet; Specimen Mountain, 12,000 feet; Milner Pass, 11,700 feet.

D. subalpinum (Gray) A. Nels. Beaver bog on the west fork of St. Louis creek.

D. glaucescens Ryd. Mount Byers.

Anconitum columbianum Nutt. Spruce creek; in moist, springy places.

Anemone globosa Nutt. West fork of St. Louis creek, 9,000 feet; Milner Pass, 10,700 feet; gravelly places.

A. cylindrica Gray. Lookout Mountain; Golden; in dry places.

Clematis ligusticifolia Nutt. Golden and Manitou; common along streams.

Ranunculus Drummondii Greene. Specimen Mountain, above timber line.

Thalictrum Fendleri Engelm. Spruce creek, in meadows.

T. sparsiflorum Turcz. Beaver bog on west fork of St. Louis creek, 9,500 feet; Spruce creek, 9,500 feet.

Berberidaceae

Berberis repens Lindl. (*B. aquifolium* Pursh; *Mahonia repens* Don.) Mount Byers, 10,500 feet; common in pine woods and burnt-over places.

Papaveraceae

Corydalis montana Engelm. Spruce creek, in burnt-over woods.

Cruciferae

Thalspi alpestre L. Milner Pass, 10,500 feet.

Cardamine cordifolia Gray. Camp Uray, Grand river, 10,000 feet;

Mount Byers, 12,000 feet; west fork of St. Louis creek; in springy places.

Arabis Drummondii Gray. Specimen Mountain, 11,000 feet.

Smelowskia americana Ryd. Mount Byers, 12,500 feet.

Draba streptocarpa Gray. Specimen Mountain, 11,500 feet.

Sisymbrium pinnatum (Walt.) Britton. (*S. canescens* Nutt.) Mount Byers; in burnt-over pine woods.

S. sophia L. Golden; a common weed in dry places.

Crassulaceae

Sedum integrifolium (Raf.) Nels. Specimen Mountain, 11,500 feet; west fork of St. Louis creek; moist places.

S. rhodanthum Gray. Specimen Mountain, 12,900 feet; Mount Byers, 11,000 feet; moist places near melting snow.

S. stenopetalum Pursh. Specimen Mountain, 11,500 feet; Mount Byers, 11,000 feet.

Saxifragaceae

Parnassia fimbriata Banks. Spruce creek, 9,500 feet; in moist meadows.

Heuchera parvifolia Nutt. Mount Byers, 12,000 to 12,500 feet; moist places in spruce woods.

Mitella pentandra Hook. Spruce creek; moist woods.

Saxifraga austromontana Wiegand. (*S. cognata* and *S. glacialis*), Mount Byers, 12,000 feet; west fork of St. Louis creek.

S. arguta Don. (*S. punctata*). Specimen Mountain, 12,500 feet; above timber line.

Ribes parvulum (Gray) Ryd. Camp Uray on Grand River; Mount Byers, 10,500 feet.

R. coloradense Coville. Specimen Mountain, 12,000 feet.

R. cereum Lindl. Berthoud Pass; Empire.

R. aureum Pursh. Golden.

Hydrangeaceae

Jamesia americana T. & G. Empire.

Rosaceae

Cercocarpus parvifolius Nutt. Manitou; Berthoud Pass, 8,500 feet; Golden; on dry mountain slopes.

Purshia tridentata DC. Camp Uray on Grand river; common.

Physocarpus tridentata (Ryd.) Nels. (*P. opulifolius* in part.) Lookout Mountain and Golden; common in ravines.

Dryas octopetala L. Specimen Mountain, 11,500 feet; Mount Byers, 12,000 feet; mountain meadows above timber line.

Dasiphora fruticosa (L) Ryd. (*Potentilla fruticosa* L.) Specimen Mountain, 11,000 feet; Berthoud Pass; common along streams and in parks.

Rubus melanolasius Focke. (*R. strigosus* in part.) Camp Uray on Grand river; common at timber line.

Sibbaldia procumbens L. Milner Pass, 11,700 feet; Mount Byers, 12,000 feet; common in mountain meadows.

Fragaria americana (Porter) Britton. Common in pine woods, parks and meadows.

Potentilla effusa Dougl. Mount Byers; Specimen Mountain, 11,000 feet.

P. millegrana Engelm. (*P. leucocarpa* Ryd.) Mount Byers.

P. wyomingensis A. Nels. Mount Byers, 11,000 feet.

Geum strictum Trin. Spruce creek.

Sieversia ciliata B. Don. (*Geum triflorum*) Spruce creek; Mount Byers.

S. turbinata (Ryd.) Greene (*S. Rossii*) Specimen Mountain, 11,900 feet.

Rosa Woodsii Crepin. Mount Byers; Spruce creek; Golden. Ravines and along streams — not in a condition to be clearly identified.

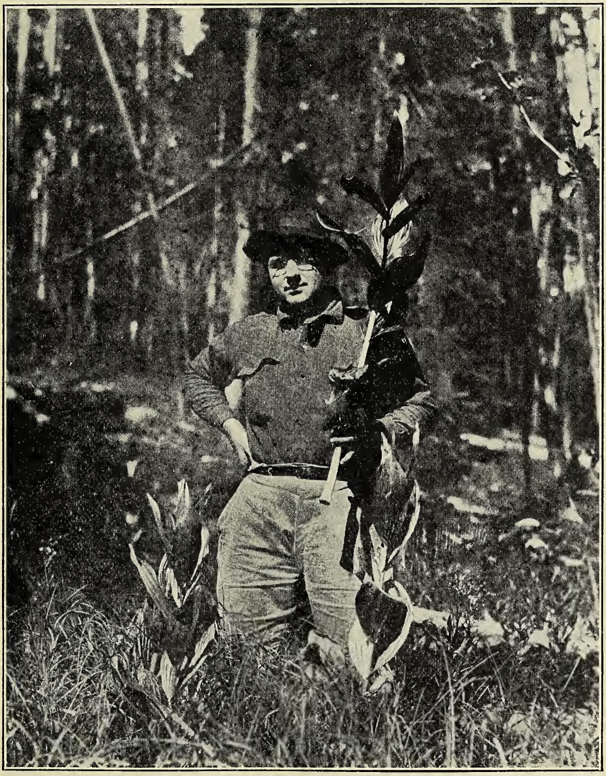


Photo. by MacDonald

Fig. 9. *Veratrum speciosum*

Amelanchier alnifolia. Spruce creek; along streams and in ravines.

Prunus americana Marsh. Manitou; thickets on mountain sides.

P. pennsylvanica L. Golden; along streams.

P. demissa (Nutt.) Walp. Golden; in thickets and ravines, on mountain sides.

Leguminosae

Thermopsis montana Nutt. West fork of St. Louis creek; mountain sides.

Lupinus argenteus Pursh. Golden; common on mountain slopes and in dry places.

L. parviflorus Nutt. Common at Camp Uray on Grand river.

Medicago sativa L. Golden; naturalized on mountain sides.

Trifolium dasyphyllum T. & G. Specimen Mountain, 12,900 feet; Mount Byers, 10,000 to 12,900 feet; near timber line.

T. nana Torr. Specimen Mountain, 12,900 feet; Mount Byers, 12,000 feet.

Astragalus alpinus L. Specimen Mountain, 11,500 feet; west fork of St. Louis creek, 9,000 feet; tall forms in mountain meadows.

A. elegans Hook. (*A. oroboides* var *americana* Gray) Mountain meadows at the base of Mount Byers.

Glycyrrhiza lepidota Pursh. Golden; along irrigation ditches.

Psoralea tenuifolia Pursh. Mountain slopes near Golden.

Vicia americana Muhl. West fork of St. Louis creek, 9,000 feet; Mountain parks.

Robinia neo-mexicana Gray. Manitou; introduced and naturalized.

Geraniaceae

Geranium Richardsonii Fisch. & Traut. Manitou; lower part of Mount Byers; common in parks.

G. Fremonti Torr. Spruce creek; Golden; Berthoud Pass.

Anacardiaceae

Rhus trilobata Nutt. Manitou; common on dry mountain slopes.

Celastraceae

Pachystima myrsinites Raf. Spruce creek; west fork of St. Louis creek.

Aceraceae

Acer glabrum Torr. Golden; mountain ravines and along streams.

Rhamnaceae

Ceanothus Fendleri Gray. Mountain slopes near Golden.

C. velutinus Dougl. Spruce creek; in burnt-over pine woods.

Malvaceae

Sidalcea candida Gray. Foot of Mount Byers, 9,000 feet; in mountain meadows and parks.

Loasaceae

Mentzelia albicaulis Dougl. Dry mountain slopes near Golden.

Elaeagnaceae

Shepherdia canadensis (L) Nutt. Mount Byers; in pine and spruce woods.

Onagraceae

Gayophytum ramosissimum T. & G. West fork of St. Louis creek; common in burnt-over areas.

Chamaenerion angustifolium (L) Scop. (*Epilobium spicatum* Pursh) Camp Uray on Grand river; Specimen Mountain, 12,900 feet; Mount Byers, 9000 feet; common in burnt-over areas.

Epilobium adenocaulon Hausk. Spruce creek; Mount Byers; in bogs and springy places.

Gaura coccinea Pursh. Manitou; common on dry mountain slopes.

Umbelliferae

Osmorrhiza obtusa (C. & R.) Fernald. In spruce woods along the west fork of St. Louis creek.

Daucus carota L. Golden; naturalized along irrigation ditches.

Conium maculatum L. Golden; naturalized and abundant; said to have been introduced about 1907.

Angelica pinnata Wats. Beaver bog on the west fork of St. Louis creek.

A. Lyallii Wats. Specimen Mountain, 11,500 feet.

Ligusticum Porteri C. & R. Camp Uray on Grand river, 11,000 feet; Lookout Mountain, Arapahoe national forest; east fork of St. Louis creek.

Pseudocypmopteris montana Hook. West fork of St. Louis creek, 9,000 feet.

Heracleum lanatum L. Beaver bog on the west fork of St. Louis creek, and in springy places.

Pyrolaceae

Pyrola secunda L. Springy places in spruce woods along the west fork of St. Louis creek.

P. chlorantha Sw. Beaver bog on west fork of St. Louis creek; Mount Byers, 10,500 feet.

Pterospera andromeda Nutt. Mount Byers; common on slopes in pine and spruce woods.

Ericaceae

Arctostaphylos uva-ursi L. Spruce creek; Lookout Mountain; common in pine woods.

Vaccinium oreophyllum Ryd. Milner Pass, 10,700 feet.

V. caespitosum Michx. West fork of St. Louis creek; common on slopes and in pine woods.

Primulaceae

Primula Parryi Gray. Milner Pass, 10,700 feet; moist, springy places and on edge of snow banks.

Androsace septentrionalis L. Camp Uray on Grand River; Milner Pass, 11,700 feet; Mount Byers; common in burnt-over woods.

Gentianaceae

Gentiana plebeja Cham. Specimen Mountain, 11,000 feet.

G. plebeja Holmii Wetts. Milner Pass, 11,700 feet.

G. elegans A. Nels. Specimen Mountain, 11,000 feet.

G. Andrewsii Griseb. Lower slope of Mount Byers; apparently this species.

G. Parryi Engelm. Near timber line, Specimen Mountain, 12,900 feet.

G. Romanzovii Ledeb. (*G. frigida*) Specimen Mountain, 12,500 feet; Mount Byers.

Swertia scopulina Greene. Milner Pass, 10,700 feet; Specimen Mountain; 12,800 feet; in moist meadows.

Frasera speciosa Griseb. Lookout Mountain; Golden; common in dry pine woods.

Polemoniaceae

Gilia gracilis Hook. West fork of St. Louis creek.

G. aggregata (Pers.) Spreng. Common near Camp Uray on Grand river.

Polemonium pulchellum Bunge. Specimen Mountain; Mount Byers.

P. occidentale Greene. West fork of St. Louis creek; Mount Byers.

P. confertum Gray. Mount Byers, 12,000 feet.

P. millitum (Gray) Nels. Mount Byers.

Hydrophyllaceae

Phacelia glandulosa Nutt. Manitou.

P. sericia (Graham) Gray. Mount Byers, 12,000 feet; east fork of St. Louis creek, 11,500 feet.

Boraginaceae

Lappula floribunda (Lehm.) Greene. Spruce creek; common in woods and parks.

Eritrichium argenteum Wight. Mount Byers, 12,500 feet.

Mertensia ciliata (Torr.) Don. (*M. sibirica* Don.) Specimen Mountain, 9,500 to 12,000 feet; west fork of St. Louis creek; Mount Byers, 9,000 feet; common in springy places.

M. alpina Don. Mount Byers, 11,000 feet; mountain meadows below timber line.

Verbenaceae

Verbena bracteosa Michx. Golden; a common weed in dry places.

Labiataceae

Mentha spicata L. Golden; introduced along irrigation ditches.

Dracocephalum parviflorum Nutt. Grand river, 9,500 feet; dry places.

Marrubium vulgare L. Golden. Introduced on dry mountain slopes.

Stachys scopulorum Greene. Golden; near irrigation ditches.

Monarda fistulosa L. Golden; common in ravines.

Scrophulariaceae

Pentstemon glaber Pursh. Milner Pass; moist places in mountain parks.

P. procerus Dougl. West fork of St. Louis creek; Mount Byers; Specimen Mountain; east fork of St. Louis creek.

Veronica alpina L. Milner Pass, 10,700 feet.

V. americana Schwein. West fork of St. Louis creek; Mount Byers, 9,500 feet.

Mimulus Hallii Greene. Milner Pass, 11,700 feet; moist mountain parks.

Rhinanthus crista-galli L. Milner Pass, 11,700 feet; Specimen Mountain, 11,500 feet; Mount Byers, 9,500 feet.

Pedicularis groenlandica Retz. Milner Pass, 11,700 feet; mountain meadows.

P. Parryi Gray. Mount Byers; east fork of St. Louis creek; Camp Uray on Grand river, 10,000 feet; pine woods and meadows.

P. bracteosa Benth. Milner Pass, 10,700 feet; Arapahoe national forest.

Castilleia integra Gray. Mount Byers; Specimen Mountain, 11,500 feet; common at timber line.

C. pallida septentrionalis Gray. Arapahoe national forest; Milner Pass, 10,700 feet; moist places.

C. confusa Greene. Lookout Mountain; Camp Uray on Grand river; dry pine woods.

Orthocarpus luteus Nutt. Lookout Mountain.

Rubiaceae

Galium boreale L. Grand river, 10,000 feet; west fork of St. Louis creek; in pine woods.

G. triflorum Michx. Spruce creek; moist meadows.

G. trifidum L. Foot of Mount Byers.

Caprifoliaceae

Sambucus microbotrys Ryd. In pine and spruce woods.

Linnaea borealis L. Beaver bog on west fork of St. Louis creek.

Lonicera involucrata Banks. Grand river, 10,000 feet; Mount Byers; moist places in spruce woods.

Campanulaceae

Campanula rotundifolia L. Lookout Mountain; Spruce creek; Grand river, 9,000 feet; west fork of St. Louis creek, 9,000 feet; Mount Byers, 12,000 feet; Specimen Mountain, 11,500 feet.

C. Parryi Gray (*C. planifolia*). Mountain meadows.

Valerianaceae

Valeriana ceratophylla (Hook.) Piper. Mount Byers; west fork of St. Louis creek, 9,000 feet; common in meadows and parks.

Compositae

Thelesperma gracile (Torr.) Gray. Golden.

Liatris punctata Hook. Lookout Mountain; common in dry places.

Gutierrezia sarothrae (Pursh) B. & R. Common on dry mountain slopes.

Grindelia subalpina Greene. Lookout Mountain.

Chrysopsis villosa Nutt. Lookout Mountain; Golden; Fraser; common on dry mountain slopes.

C. hispida (Hook) DC. Berthoud Pass; Camp Uray.

Chrysothamnus lanceolatus Nutt. (*Bigelovia Douglasii* var. Gray.) Grand river.

C. graveolens (Nutt.) Greene. Camp Uray on Grand river.

Oreochrysum Parryi (Gray) Greene. (*Aplopappus Parryi* Gray) Specimen Mountain, 11,500 feet; west fork of St. Louis creek; Spruce creek; Grand river.

Solidago scopulorum (Gray) Nels. (*S. corymbosa* Nutt.; *S. multiradiata scopulorum* Gray) Milner Pass, 11,700 feet; Mount Byers; Lookout Mountain.

S. nana Nutt. Mount Byers, 10,500 feet; Lookout Mountain.

S. serotina Ait. (*S. pitcheri*) Camp Uray on Grand river.

Tonestes pygmaea (T. & G.) Nels. (*Aplopappus pygmaeus* Gray) Mount Byers, 12,000 feet.

Aster glaucus T. & G. Specimen Mountain, 11,500 feet.

A. Porteri Gray. Lookout Mountain.

A. Geyeri (Gray) Howell. Denver.

Machaeranthera canescens (Pursh) Gray. (*Aster canescens* Pursh.) Specimen Mountain; west fork of St. Louis creek, 9,500 feet.

M. viscosa (Nutt.) Greene. (*Aster canescens* var. Gray) Golden.

Erigeron macranthus Nutt. Specimen Mountain; west fork of St. Louis creek.

E. elatior (Gray) Greene. (*E. grandiflora elatior*) Specimen Mountain, 12,000 feet; Milner Pass, 10,700 feet.

E. salsuginosus (Rich.) Gray. Specimen Mountain, 11,500 feet.

E. concinnus T. & G. Lookout Mountain.

E. Coulteri Porter. Mount Byers, 10,500 feet.

E. pinnatasectus (Gray) Nels. (*E. compositus* var. Gray) Specimen Mountain, 12,900 feet.

E. glabellus Nutt. Specimen Mountain, 12,000 feet.

E. speciosus DC. Spruce creek, 9,100 feet.

E. uniflorus Gray. Mount Byers, 12,000 feet.

Antennaria dioica Gaertn. Spruce creek; west fork of St. Louis creek, 9,000 feet; Milner Pass; dry, open parks and woods.

A. arida Nels. Golden.

Anaphalis subalpina (Gray) Ryd. (*A. margaritacea* as to Colorado range) Mount Byers, 12,500 feet; Berthoud Pass.

Ambrosia artemisiaefolia L. Golden.

Wyethia arizonica Gray. West fork of St. Louis creek, 9,000 feet; meadows.

Madia glomerata Hook. Common near Fraser.

Actinella acaulis (Pursh) Nutt. Specimen Mountain, 11,500 feet.

Rydbergia grandiflora (Pursh) Greene. Specimen Mountain, 11,500 feet; Mount Byers, 12,000 feet; above timber line.

Achillea lanulosa Nutt. West fork of St. Louis creek; Mount Byers, 12,000 feet.

Artemisia frigida Willd. Manitou.

A. tridentata Nutt. Camp Uray on Grand river; common.

A. cana Pursh. Grand river.

A. pedatifida Nutt. Lookout Mountain.

A. fulgens Pursh. (*A. alpina*) Specimen Mountain, 12,000 feet.

Arnica cordifolia Hook. Specimen Mountain; common in woods and burnt-over areas.

A. subplumosa Greene (*A. rivularis* Greene) Mount Byers.

A. celsa Nels. West fork of St. Louis creek.

Senecio balsamitae Muhl. Specimen Mountain, 10,000 feet; Mount Byers, 9,000 feet.

S. Bigelovii Hallii Gray. Camp Uray on Grand river.

S. eremophilus Rich. Camp Uray on Grand river; Spruce creek; Specimen Mountain, 11,500 feet.

S. blitoides Greene. Berthoud Pass, 10,500 feet; common near highway.

S. triangularis Hook. Specimen Mountain, 11,500 feet; beaver bog on west fork of St. Louis creek, 9,000 feet; Mount Byers.

S. amplectens Gray. West fork of St. Louis creek.

S. perplexus Nels. (S. lugens in part) West fork of St. Louis creek.

Hieracium albiflorum Hook. Specimen Mountain, 11,500 feet.

Lactuca virosa L. (*L. scariola integrata*) Manitou; a common introduced, noxious weed.

Troximon purpureum (Gray) Nels. Camp Uray on Grand river; Spruce creek.

T. arizonicum Greene. Milner Pass, 10,700 feet; Mount Byers, 10,500 feet; Specimen Mountain, 12,000 feet.

Cirsium megacephalum (Gray) Cockerell. Golden; in woods.

C. eriocephalum Gray. Specimen Mountain, 12,000 feet; Berthoud Pass.

C. Drummondii T. & G. Grand river.

C. foliosum (Hook) DC. Specimen Mountain, 9,000 to 10,000 feet; mountain parks.

THE GERMINATION OF SOME TREES AND SHRUBS AND THEIR JUVENILE FORMS*

L. H. PAMMEL AND C. M. KING

In our studies of seedlings during the year 1918-1919 there have been included representatives of the following families: Salicaceæ, Urticaceæ, Berberidaceæ, Leguminosæ, Rutaceæ, Vitaceæ, Cornaceæ, Sapotaceæ and Oleaceæ.

Salicales

Salicaceae

Populus deltoides Marsh. Cottonwood. See figure 10, A.

Seeds of the cottonwood were flying May 27, 1919. On August 15, 1918, on the borders of the lake upon the Iowa State College campus seedlings were abundantly growing, with five to ten leaves.

Cotyledons still remaining on the seedling, one centimeter in length, one-half centimeter in width; petiolate, smooth; in shape ovate, with cordate base. Rootlets fibrous, abundant. Stem smooth, reddish. First leaves smooth, ovate, lanceolate, nearly entire, petiole short. Succeeding leaves increasing in length and width; fourth and fifth leaves ovate, at base obtuse angled, apex acute angled, pinnately veined, crenate margin; petiole of fourth and fifth leaves longer than first to third. Later leaves approaching deltoid in shape.

Urticales

Urticaceae

Ulmus racemosa Thomas. Cork elm. See figure 10, B.

Seeds of this elm were freely falling May 30, 1919, at the Ledges, Boone county. Collections that were made and planted at this time in the greenhouse germinated June 15, 1919.

Germination epigaeous, the seed coat often being brought to the surface as the seedling grows. Cotyledons two, broadly oval, slightly pubescent above; hypocotyl pubescent. Stem above the cotyledons pubescent. First pair of leaves strongly pinnate veined, doubly serrate. Lower surface of leaf pubescent, especially on the veins; stem densely glandular pubescent.

* Contribution No. 3 on the Germination of Woody Plants.

Fig. 10a. *Populus deltoides* Marsh. Cottonwood seedling, showing cotyledons and four subsequent pairs of leaves. *Drawn by C. M. King*

Fig. 10b. *Ulmus racemosa* Thomas. Cork elm. Seedling showing cotyledons and first pair of leaves. *Drawn by C. M. King*

Fig. 10c. *Berberis macracantha* ("No. 7" from Sargent, Arnold Arboretum) Barberry. Seedling showing cotyledons and first pair of leaves. *Drawn by C. M. King*

Fig. 10d. *Berberis laxiflora oblanceolata* ("No. 22," from Sargent). Seedlings, showing cotyledons and first and second pair of leaves. *Drawn by C. M. King*

Fig. 10e. *Citrus Decumana* L. Grape fruit. Seedling showing the two large cotyledons and two subsequent pairs of leaves. *Drawn by C. M. King*

Fig. 10f. *Ampelopsis heterophylla.* Blume. Woodbine. Seedling showing cotyledons *Drawn by C. M. King*

Ranunculales

Berberidaceae

Berberis macrocantha ("No. 7" from Sargent, Arnold Arboretum). See figure 10, C.

Seeds collected, 1918; planted in earth on bench in greenhouse Nov. 20, 1918; germinated April, 1919.

Hypocotyl three-fourths inch above the ground. Cotyledons oblong, fleshy with very short stalk, paler underneath, slightly tinged with purple, a few hairs. First leaf reniform or cordate, spinose-dentate; upper surface conspicuously three-veined, with reticulations, smooth, lower surface pale. Stem smooth, stipules small. Second leaf smooth; petiole one-fourth to five-sixteenths inch in length. Root with yellowish tinge.

Berberis laxiflora oblanceolata ("No. 22," from Sargent). See figure 10, D.

Seeds received fall of 1918; planted in greenhouse Nov. 20, 1918; first seedling appeared April 1, 1919, the second on April 28.

Epigaeous. Hypocotyl erect, terete, one-half to three-fourths inch in length, slightly tinged with purplish green. Cotyledons oblong, obtuse, fleshy, with very short stalk. A few hairs on the cotyledon. First leaves simple, alternate, petioled, stipulate; glabrous, reticulately-veined, spiny, serrate, reniform or cordate, green above, glaucescent underneath. Some spines of the margin directed upwardly. Stem suffused with red. Petioles filiform. Stipules minute, adnate to the petiole. Root and lower part of the stem yellowish.

Citrus Decumana L. Grape fruit. See figure 10, E.

Fresh seed planted January, 1919; germinated March, 1919.

Germinated hypogaeous; cotyledons remaining in the seed; greenish white in color, oblong, obtuse, fleshy. First pair of leaves roundish to ovate, one and one-half inches long, bright green, nearly opposite, fleshy. Stem mottled; a few hairs present. Petiole short, not articulated to the stem, slightly pubescent. Second pair of leaves ovate, bright green, with slight pubescence. Third pair of leaves like the preceding; not articulated. Root long, straight, whitish.

Rhamnales

Vitaceae

Ampelopsis heterophylla Blume. Woodbine. See figure 10, F.

Seeds collected fall of 1918; planted in greenhouse bedding soil, March 8; germinated April 20, 1919.

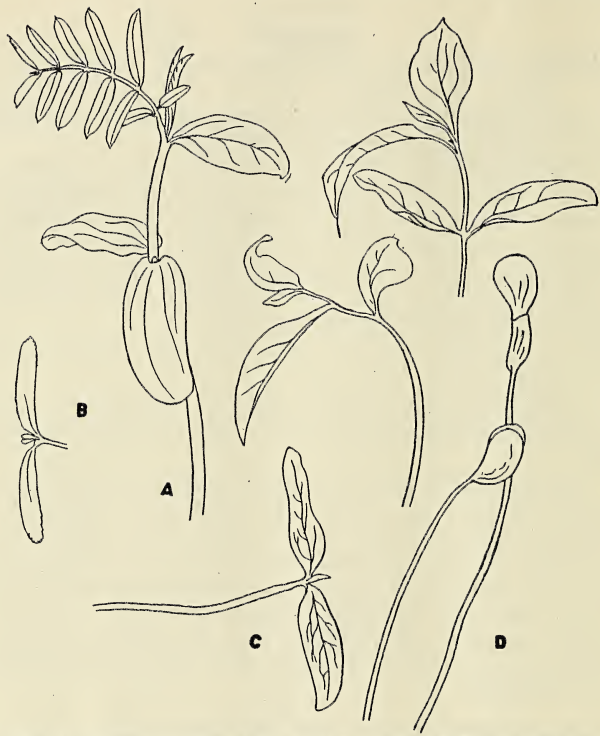


Fig. 11a. *Sesbania macrocarpa* Muhl. Pea tree. Seedling showing the large cotyledons and first and second subsequent leaves. *Drawn by C. M. King*
Fig. 11b. *Ptelea trifoliata* L. Hop tree. Seedling showing cotyledons. *Drawn by C. M. King*
Fig. 11c. *Nyssa sylvatica* Marsh. Black gum. Seedling showing the large cotyledons. *Drawn by C. M. King*
Fig. 11d. *Diospyros virginiana* L. Persimmon. Seedlings, showing the unfolding cotyledons and several subsequent leaves. *Drawn by C. M. King*

Germination epigaeous. Hypocotyl pale. Cotyledons long-stalked, cordate in general outline. Petiole erect, but leaf blades of cotyledons at right angles, prominently veined, smooth. First leaf cordate, coarsely dentate, slightly pubescent below, and on the margin. Root long, slender, whitish; lateral roots long.

Rosales

Leguminosae

Sesbania macrocarpa Muhl. Pea-tree. See figure 11, A.

Seeds from South Carolina, collected fall of 1918; planted in greenhouse Nov. 12, 1918; germinated April 1, 1919; second seedling appeared April 20.

Hypocotyl three to six inches in length. Cotyledons thick, fleshy, elliptical. Stem glaucous, smooth. First leaf simple, pinnately veined, smooth, spotted, paler underneath; stipules small, slender, obtuse-pointed; petiole short. Second leaf pinnately compound, odd pinnate, with mucro in place of leaf; petiole short; stipule small, pointed; leaflets entire, elliptical, mucronate. Third leaf abruptly pinnate; leaflets smooth, a few scattered hairs on veins and margins of the leaflets. Rachis channeled, with mucro. Young leaves slightly sensitive.

Geraniales

Rutaceae

Ptelea trifoliate L. Hoptree. See figure 11, B.

Seeds collected fall, 1918; stratified out of doors; planted in greenhouse, March 8, 1919; germinated May 2, 1919.

Hypocotyl finely pubescent. Cotyledons oblong, obtuse, shortly petiolate, at ends minutely crenulate; deep green; glabrous.

Umbelales

Cornaceae

Nyssa sylvatica Marsh. Black gum. See figure 11, C.

From Camp Gordon, Georgia. Seeds collected fall of 1918; stratified out of doors; planted in greenhouse, March 8, 1919. germinated May 1, 1919.

Germination epigaeous. Hypocotyl slender, reddish green. Cotyledons fleshy, oblong-ovate, short petioled, green above, paler beneath, smooth, margin entire. Size of cotyledon, one inch in length, one-third inch in width. Stem above cotyledon slightly hairy. First leaf hairy above, smooth below, hairy on margin.

In general aspect resembling dogwood.

Ebenales

Sapotaceae

Diospyros virginiana L. Persimmon. See figure 11, D.

Seeds collected near Kansas City, fall of 1918; planted Nov. 12, 1918, in greenhouse; germinated March 25, 1919, 95 per cent.

Seeds collected near Clemson, South Carolina, fall of 1918; stratified out of doors; planted in greenhouse, March 8, 1919. Germinated March 28, 1919, 95 per cent.

Hypocotyl when first appearing, arched, bringing the seed up with it, as it straightens. The cotyledons gradually emerge as the seed coat is thrown off. Growth of seedling rapid, hypocotyl elongating to six inches or more; in color reddish to purplish green. Cotyledons elliptical, shining, smooth above and below, short petioled, margins incurved. First leaves lanceolate, smooth above, and below, green, nearly opposite. Root long, straight, with a number of lateral roots. Roots all dark-colored.

GENTIANALES

Oleaceae

Fraxinus americana L. White ash.

Seeds collected on campus, Iowa State College, 1918; stratified out of doors; planted in greenhouse, March 8, 1919. Germination percentage low.

Germination epigaeous. Hypocotyl smooth, purplish. Cotyledons linear-lanceolate, elongated, lower surface slightly hairy. Epicotyl smooth, purplish, green. First pair of leaves simple, ovate-lanceolate, pale green, somewhat glaucous below, pubescent on midrib, darker green above, margins with hairs, dentate; slightly petioled, buds in axils of each leaf. Stalk between first and second pair of leaves yellowish, resinous. Second pair of leaves petioled, pubescent on margin when they unfold. Third leaves just as they push out, yellowish, granular.

DEPARTMENT OF BOTANY
IOWA STATE COLLEGE

THE TEACHING OF PLANT PATHOLOGY

W. H. DAVIS

It is not the intention of the writer to give an exhaustive treatise on the teaching of Plant Pathology but to stimulate thought for better methods of teaching, for broader presentation of the subject and for more practical courses.

Plant pathology is a comparatively new science, having its origin about 1855 when de Bary published his classic "Die Brand Pilze." Many sciences have been developed for generations thereby affording a greater lapse of time for the thorough organization of the subject matter. A great part of this material has been passed on to the layman by word of mouth. War, manufacture, commercialism and other agencies have added their bit to the usefulness of the older sciences. Great impetus has been given to the development of plant pathology during the war by the propaganda for the eradication of the barberry and by the Plant Disease Survey of the U. S. Government. As one worker has expressed it, "Plant Pathology is coming into its own."

The methods of placing the practical facts of plant pathology before people who can use them most effectively, should be improved. At present, this is being done by literature, courses in agricultural colleges and extension work. It is estimated that only five per cent of the people can intelligently read and apply the subject matter of bulletins, that the courses offered in agricultural colleges are generally too highly specialized for practical purposes and that the extension work in this line is negligible and often unsatisfactory. Be that as it may, better means for informing the people should be employed. It is interesting to note that the losses on thirteen crops for the year 1918 were reported by the U. S. Government on August 1, 1919, as about one and one-third billion dollars. Such a vast leak in our "Ship of State" should be a strong argument for the better dissemination of control methods to save our most important crops.

A member on an Iowa draft board said that he was surprised to know that a great portion of those who registered there for service had no more than a fifth grade education. It is a fact that more than three-fourths of our agricultural population leave school before reaching the eighth grade and that less than ten per cent ever matriculate in a college or university where instruction in plant pathology is offered. The grades do not present any of the simplest facts of plant diseases, there are no elementary books on the subject and the teachers have never received instruction in it. High school botany is nearly a thing of the past in Iowa, hence the few facts on disease organisms that were formerly presented in that subject are now in a dormant stage. The people who can make the best use of this knowledge do not have the facts of plant pathology presented to them so freely as those of the other sciences.

Agricultural colleges seem to be the Mecca for the dissemination of the subject. The methods of dissemination which they employ seem to fall into four classes which might be designated as pedagogic, practical, mediocre and bewildering.

Pedagogic.— This course connects the laboratory work with the text book. It teaches types of comparison, linking this work to the previous subjects of botany, chemistry, zoology, and other allied sciences. The instructor does not take it for granted that every one is to become a specialist but that everyone there desires to learn the identification of many disease forms, and also the symptomology and controls. The subject matter of this course is adapted to the kind of work for which students are fitting themselves and to the general mentality. Scientific minutiæ like the sexuality of the basidiomycetes do not concern this instructor and are no part of the course.

Practical.— In this course, the needs of the students are considered first of all and methods may be laid aside. Laboratory work may or may not be connected with the text lesson. As one professor told the instructor, "Any way to get it across."

Mediocre.— Part of the subject matter is practical, some methods worth while are employed, a few specimens are shown in class. More time is spent on the names of the genera, species, cytological structures of host and parasite, together with experiences of agriculturists.

Bewildering.— Here the instructor presents such a conglomeration of scientific classification; of Latin names of families, genera and species; fruiting forms and structures; together with scientific data, histories and names of investigators, that only a mature individual with excellent preparation and superhuman ambition for studying can fathom "What it is all about." It is a kind of

German school method whereby enough literature on one parasite is cited to keep a student reading all day. The student whose reading discretion is not developed at this stage is bewildered by the multitude of apparently impractical and meaningless terms.

It behooves every teacher of plant pathology to place the interesting and vital facts of the subject matter before the students and farmers in the most attractive and practical way possible. Those now teaching it will some day be considered as pioneers and a great deal depends upon them whether or not this economic science succeeds.

No extensive treatise of laboratory work can be given here but there ought to be some improvement in the method used. In the first place, the object of the task or experiment is not definitely and concisely stated. For example, "To study mold" is not sufficient as an object, because the student can take his text and study mold. This is not an experiment.

There should be a definite distinction between a laboratory period, a study period, a recitation period and a lecture period. Each is a separate kind of clear cut work and ought not to be confused with the others. If the instructor were teaching the different kinds of molds he might have as an object "How may I tell some different kinds of molds?", "How do their spores vary in size, shape, color and formation?", together with other definite questions which cannot be answered by yes or no. Of course, drawings and descriptions should be asked for. The object may be summed up in a conclusion. The instructions for laboratory outlines in plant pathology are generally good. This seems to be the best developed portion of the subject. Probably a little time should be given at the first of the term to teaching methods in scientific drawing and lettering, together with the care and use of the microscope. The questions arise: how many drawings should be copied from reprints and texts? How much of the laboratory should be given to reading text materials? This is for the instructor to decide. The poorer his collection of diseased types, the poorer his equipment and the poorer the instructor, the more time is spent in reading and copying during the laboratory period. Of course, the poorer will be his class, for the power of interpretation and analysis of symptomology will be lost. This will weaken the student's ability of classification which is so necessary before he may know the necessary control for the parasites.

SUMMARY

1. Plant pathology is a comparatively new subject and the subject matter and teaching methods are not so well organized as in the older sciences.
2. The layman knows less about the subject matter than about other sciences which are easily transmitted by word of mouth.
3. Some elementary facts of plant pathology should be taught in our public schools because the greater part of our agricultural population receive education there.
4. Our public schools are doing practically nothing towards preventing an annual loss of one and one-third billions dollars to thirteen of our most important crops.
5. Better pedagogy should be applied to the teaching of plant pathology.
   a. Let the course be concerned with little about many parasites rather than much about few.
   b. Let the course be adapted to the class of students.
   c. Definite questions or objects should be given the students whereby the laboratory periods may be devoted to observation and investigation. This will stimulate research work.
   d. Definite summaries or conclusions should be given to all work. There should be answers to the objects or questions.

Iowa State Teachers College

THE VEGETATION OF CAPE BLANCO

MORTON E. PECK

To most of us the name of Cape Blanco has a familiar sound, bringing back as it does recollections of the geography lessons of our early school days, when we learned that it was the most westerly point of the United States south of Alaska. We may possibly have learned also that it is one of the most dangerous points for vessels on our western coast. Beyond these two brief facts the knowledge of very few of us extends.

On June 26 and 27, 1919, the writer visited this most interesting locality and made a brief survey of the flora. The results of his observations are recorded in the present paper. The area, limited as it is, merits a much more detailed study than it has received, but the facts here set down may have a certain interest for those who have little personal acquaintance with the plant life of the Pacific coast.

Cape Blanco is on the coast of Curry county, Oregon, about ten miles south of the Coos-Curry county line, and nearly sixty miles north of the Oregon-California line. It is twenty miles further west than the point where the latter touches the coast, and to the north of the cape the shore line falls away to the eastward about as many miles in an equal distance. It thus forms a prominent geographical feature on the western coast,— the most conspicuous, in fact, between Puget Sound and San Francisco Bay.

Topographically it is peculiar, consisting, except at the extreme point, of an almost dead level promontory barely a mile in length and less than half that distance in width at its eastern end or base. Its seaward extremity curves sharply to the northward, has a more irregular surface, and ends in precipitous cliffs. In line with the extreme point are two or three high rocky islets of the same character as the shore cliffs and cut from them by wave erosion. The descent to the sea is nearly everywhere more or less precipitous, and the distance is somewhat less than two hundred feet.

Cape Blanco is certainly the windiest point in Oregon. It is fully exposed to the violent storms of winter, which are of very frequent occurrence, and during summer strong gales are blowing from the northwest almost continually. High winds, rendered much more effective by the level character of the surface, have, more than any other one factor, given the vegetation its peculiar aspect.

As we approach the cape from the eastward, a little over a mile from its outermost extremity we find the forest beginning to leave off rather gradually. For some distance there is a scattered growth of Spruce (*Picea sitchensis*) and Pine (*Pinus contorta*) which are more and more dwarfed as we advance, and finally disappear altogether.

Near where the forest ends there is a large swamp tract covered with a remarkably dense growth of a strongly marked variety of *Juncus effusus* (var. *exigus* Fern. & Wieg.?) with very slender, drooping, wiry stems. Bordering the *Juncus* area is a large field of Lupines (*Lupinus columbianus*) making a brilliant display of intensely blue color.

On leaving the forest we come out into a section more fully exposed to the force of the wind, and the effect of this exposure is very striking. Tall vegetation of every kind wholly disappears. The all-dominating species is the Coast or Shot Huckleberry (*Vaccinium ovatum*). The rounded clumps, very uniform in size and shape, sloping gently to the northward, more abruptly to the south, remind us strongly, as we look across the wide, level stretches, of low, even swells on a large body of water. Every bush is a densely matted mound of vegetation, the rigid, interlacing twigs scarcely covered by the small leaves. Not a twig stands out beyond the general surface; all are as closely cropped by the wind as the most carefully trimmed hedge. Here and there in a slight depression there is a dwarfed growth of sphagnum moss, and accompanying it are several sphagnum bog plants, the most noticeable being a handsome Lily (*Lilium kelleyanum*). Elsewhere a slender and stately species, here it is not permitted to grow an inch taller than the mounded Huckleberry bushes that shelter it.

As we advance the dwarfed bushes are yet more dwarfed, dwindling down until they are only a few inches in height, and finally thinning out and disappearing altogether. The area now before us looks at a distance like a close-cropped pasture, save that in a pasture there are usually some plants that grazing animals find unfit for food and permit to grow more or less undisturbed. Here all are treated alike by the wind. Everything hugs the earth with a desperate tenacity. A fine large Iris (*Iris douglasiana*) has stems but four or five inches long growing in horizontally radiating tufts. *Hordeum nodosum* assumes the same form. *Achillea millefolium,* or one of its numerous forms, though erect, attains a height of but a few inches. Here and there may be seen a stout Thistle, of a species not determined, sprawling flat along the ground. A remarkable Helenium (*Helenium bolanderi*) has its stem shortened to one-fourth the normal length. The Lupine previously mentioned, *Lupinus columbianus,* usually three or four feet tall, has prostrate stems only a foot or so in length. *Castilleia miniata, Coneoselinum gemelini, Sanicula arctopoides* and many others assume no less remarkable forms.

The extreme dwarfing of vegetative structures does not extend in the slightest degree to the inflorescence, so that in many cases the flowers and flower clusters appear disproportionately large. This is especially true of *Iris douglasiana, Castilleia miniata, Helenium bolanderi,* and *Lupinus columbianus.* The last named species has its whole aspect so altered that the observer in the field could recognize its identity only by taking note of the series of intergrades that occur between this and the usual form as he passes into the more and more exposed areas.

This level, wind-swept section presents a brilliant floral display. In addition to the species above mentioned, most of which occur in profusion, there is an abundance of *Lupinus littoralis,* a large-flowered form of *Cerastium arvense, Bellis perennis, Erigeron glaucus, Baeria macrantha,* and many others, each contributing to the varied color effect.

As previously stated, the extreme point of the cape curves sharply to the northward. The Cape Blanco lighthouse is located a little way back from the western edge of the promontory just where the bend is made. The contour of the land is such that about the lighthouse and for some distance to the north of it, in fact, nearly to the extreme point, there is partial protection from the wind, permitting a grove of low Spruce trees to maintain a footing. In this small sheltered area the vegetation is strikingly different from that in the section just described. Many of the same species occur, but growing to normal size. In addition there is an abundance of *Calamagrostis aleutica, Coelopleurum lucidum, Heracleum lanatum, Lathyrus sulphureus, Vicia gigantea, Medicago indica, Eriophyllum staechadifolium* (?), and others. In places there are dense thickets, made up mostly of *Rubus spectabilis, Gaultheria shallon, Vaccinium ovatum,* and *Myrica californica.* All this is very similar to the usual coast vegetation of Oregon.

Coming to the extreme point, which runs out into a very narrow ridge, with precipitous sides, we find ourselves again in a situation fully exposed to the winds, and also to clouds of fine spray driven up from the waves breaking on the rocks below, and again everything is excessively dwarfed. *Achillea millefolium* is a hand-breadth in height, while the dense growth of *Festuca rubra* is scarcely taller. *Castilleia miniata, Statice armeria, Epilobium franciscanum, Erigeron glaucus, Senecio bolanderi,* and many others partake of the same character.

The faces of the isolated crags, too steep, hard and exposed for the accumulation of sufficient soil to support ordinary vegetation, bear patches here and there of *Sedum spathulifolium,* and elsewhere are thickly starred with another and very remarkable Stonecrop, *Dudleya farinosa.* Many of the plants, especially those growing under the hardest conditions, appear quite destitute of the dense glaucus bloom to which the species owes its specific name.

Along the south side of the promontory the conditions are somewhat less severe. On the extreme margin, almost overhanging the precipitous descent to the sea, is a fine flourishing colony of *Mesembryanthemum acquilaterale,* a strange plant, with fleshy leaves that are triangular in cross section, and handsome rose-colored flowers. Here too is an abundance of Crowberry (*Empetrum nigrum*) with long, prostrate, heath-like branches creeping over and almost smothering the low huckleberry bushes. Alpine Timothy (*Phleum alpinum*) and a small Mariposa Lily, *Calochortus maweanus* are not uncommon.

Following the coast line a little farther to the east and south, we find the land sloping down a little, giving sufficient protection from the north wind to permit small Spruce and Pine trees to maintain themselves. As we recede from the coast line they grow taller and pass into the ordinary coast forest. The vegetation accompanying them also assumes the usual character.

While ecologically there is no more interesting place on the Oregon coast than Cape Blanco, it is scarcely less interesting from the standpoint of plant distribution. Thus *Baeria macrantha,* here found in remarkable abundance, is not known to occur elsewhere in the state. *Lilium kelleyanum* is extremely rare. *Sanicula arctopoides* is known from but one or two other Oregon localities. *Mesembryanthemum aequilaterale* is a waif from the southward, not hitherto known from far north of San Francisco Bay. A *Cirsium* and an *Agoseris,* not yet determined specifically, are likely to prove new to the state. Further search probably would reveal other rarities, but this list is sufficiently remarkable for so restricted an area. To the field botanist the southern Oregon coast as a whole offers unusual attractions, and in this respect no point surpasses Cape Blanco.

Willamette University
Salem, Oregon

THE MAJOR VEGETATION OF LAKE OKOBOJI

ROBERT B. WYLIE

The major vegetation of Lake Okoboji consists chiefly of submersed seed plants. The algae are always in evidence and play an important part in the life of the lake since they are used as food by many lower animals, but with the exception of *Chara* they are seldom conspicuous and never large.

The aquatic seed plants present a wide range in size, structure, and flowering habits, but with the exception of the duckweeds, (which are only visitors on the main lake), they are good sized plants, and some of them are very large. The botanist sees in these submersed Angiosperms a group of plants of special interest since they present a double set of adaptations. Each must in the past have gained high achievement as a land plant, and they subsequently taking to the water, there has been superimposed another set of habits and structures especially related to the present environment.

Most people realize in a general way at least that there must be some such relation between the animal and plant life of the lake as there is between these groups on land. The lake animals are dependent directly, or indirectly, upon the associated plants for food, excepting of course such food materials as are washed into or fall upon its waters. The water plant is eaten directly by some of the fish, but usually it is transmitted to some of the higher lake animals through a series of lower organisms who derive their food from the plants. So intimate is this relationship that the success or failure of one form influences in corresponding proportion the welfare of other organisms which seem remote and independent.

The major vegetation also provides shelter, attachment, and breeding places, as well as food for the animals. All of which suggests that the life of a permanent fresh water lake, like Okoboji, presents a complex series of inter-relationships between the various forms that dwell in its waters. With this in view various studies carried out at the Iowa Lakeside Laboratory have been directed towards determining the number and kinds of organisms in Lake Okoboji, and the establishment of values for the many partners in the life-program of its waters. There must be a knowledge of the animals and plants present, with information as to their numbers, seasonal changes, and distribution. Gradually as these facts are assembled certain relationships may be made out. Obviously the question of main interest and importance is the bearing of all this upon the fish. It is hoped that the Laboratory, preferably in coöperation with state and national agencies, may contribute something toward this problem.

As a part of the program there was carried out in the summer of 1919 a general survey of the larger plants of Lake Okoboji. The beginning of the work was delayed until the vegetation had reached full development for that year. During August a group of three workers from the Laboratory surveyed the shore zone of this lake, recording the kinds, relative abundance, and distribution of the submersed seed plants. No account was taken of the vegetation of cut off ponds or bordering swamps, as the study was limited to the plants of the lake proper.

Nearly two hundred stations were established on the borders of Lake Okoboji and cross sections were surveyed out at right angles to the margin until the water became too deep for larger plants. Dredgings along these lines were made with a many pronged hook, and depth measurements were taken with a weighted line. This survey was made possible largely through the courtesy of Mr. W. E. Albert, State Fish and Game Warden, who kindly loaned the Laboratory a small motor-boat for the work.

The location of the boat was determined in part by estimating distances and also by sighting across headlands, etc., to known points on other parts of the shore and subsequently by use of map to plot in the points of observation. Owing to periods of windy weather it was not possible to study all parts with equal care. While the exact location could not always be known, especially on rough water, the results are sufficiently accurate to outline the submersed vegetation, the extent of the beds, and certain relations to depth, bottom, and shore configurations. A chart showing the results of this general survey has been prepared; it may be useful as a guide in the more intensive study of the various parts and also of the lake as a whole. The map accompanying this article, prepared from these data, is much simplified as it shows only the total areas occupied by the larger plants. It is very difficult to indicate on a small map the distribution of all the species. The portions filled in with small circles show the distribution of *Cerataphyllum demersum*. The dotted areas represent portions of the lake bottom having large plants, other than *Ceratophyllum,* and including *Chara* beds (Fig. 12).

Since Okoboji is much the deepest of this group of lakes and has large areas of considerable depth one is surprised to learn the extent of the weed-beds in its waters. According to this survey about eleven hundred acres of lake bottom are occupied by larger plants. The total area of the lake is approximately 3700 acres which means that nearly thirty per cent of its area was underlaid with plants in 1919. This does not mean of course that they showed at the surface over that proportion of the lake; in most places they were entirely out of surface view.

In discussing these findings it should be borne in mind that the extent and character of these weed-beds vary somewhat from year to year. Modifications of the season, particularly the spring and early summer, would likely alter the relative proportion of the various species. Obviously changes in the lake level, from year to year, would markedly influence their lateral distribution. With lower water level the deeper species could grow out farther into the lake. Since these forms are very sensitive to depth a depression of a foot or two in lake-level would permit a marked encroachment under the open waters of bays where the substratum is suitable for these species. All attempts to artificially modify the level of the water should take into account the certain influence such changes would have upon the vegetation of the lakes. Lower water would mean not only considerable extensions of weed-beds, but would bring to the surface areas of weeds not suspected at higher levels.

The following list includes the species that are most commonly found in Lake Okoboji:

Bidens Beckii Torr.
Ceratophyllum demersum L.
Elodea ioensis Wylie.
Heteranthera dubia (Jacq.) MacM.
Myriophyllum spicatum L.
Naias flexilis (Willd.) R. & S.
Potamogeton amplifolius Tuck.
Potamogeton natans L.
Potamogeton prectinatus L.
Potamogeton praelongus Wulf.
Potamogeton pusillus L.
Potamogeton Richardsonii (Benn.) Ryd.
Potamogeton zosterifolius Schum.
Ranunculus circinatus. Sibth.
Scirpus validus Vahl.
Vallisneria spiralis L.
Zannichellia palustris L.

Other species of aquatic plants are occasionally encountered but the above named forms constitute the chief formations of the lake. Forms like the duckweeds are frequent migrants from ponds having outlet into the lake but do not thrive in the open water except in the most sheltered places. All free floating plants in the open lake are soon beached, where they die.

Most of the plants are fairly constant in their expression in the open lake, having definite relations to depth, substratum, and exposure to wave action. But some of the above list are typically pond plants which in the lake proper do not find favorable habitat. *Heteranthera* and *Elodea* might be cited as examples and these are sometimes encountered in the most unexpected places. The former has not been noted flowering at the surface of the water in Lake Okoboji though it sets seeds regularly through a cleistogamous pollination. The species of *Elodea* could not be determined in many cases as it flowers sparingly in the open lake while blossoming profusely in the ponds and shallower lakes of the region. All plants noted in bloom were *E. ioensis.*

Favorable habitats have well marked formations consisting usually of a number of associated species having similar requirements. The shallower portion of Millers Bay, partly cut off from the larger body of water by a submerged bar, contains an assemblage that has remained remarkably constant through the ten years it has been under observation. Within a couple of hundred yards of the grounds of the Lakeside Laboratory are found all the plants noted in the above list for the lake. Each of the other major bays would give a similar list, but the less desirable habitats would give fewer species.

The character of the bottom is of great importance in determining the make up of the formations in any given area. In most places rocky shores are associated with greater exposure to wave action, so it is difficult to weigh, from observation, the relative merits of these two factors. Such places have usually more abrupt slopes so do not offer anchorage for a zone of plants wide enough for much mutual protection. The headlands on the west side and much of the eastern side of the lake exhibit these conditions and are the barer borders. In these regions *Chara* is a prominent and often the dominant plant. The region between Elm Crest and Gull Point with similar stretches on other shores present vast *Chara* beds with relatively few Angiosperms with them. *Potamogeton natans* is very commonly admixed and in many cases this is true of *Potamogeton Richardsonii.* Certain of the smaller and well rooted forms are abundant in the shallow margins — here are frequently found such as *Heteranthera dubia, Naias flexilis,* and occasionally *Zannichellia.*

Sandy beaches on concave shores offer a very different set of conditions. There is usually a relatively barren zone of shifting sandy bottom into which creep a number of seed plants, *Potamogeton Richardsonii, P. pectinatus, Naias, Elodea, Vallisneria,* etc. Such shores soon deepen off into the bay-formations containing *Potamogeton amplifolius, P. praelongus, P. natans, P. zosterifolius, Ceratophyllum, Myriophyllum, Ranunculus,* etc.

Depth plays a most important part,— light probably being the determining factor. About fifty per cent of the light falling on open water is reflected, and the remainder diminishes rapidly through absorption with increasing depth. Most of the species of seed plants are eliminated at a depth of twelve feet, and plants that flower at the surface may be prevented from setting seed at lesser depth than that just given. In Lake Okoboji *Ceratophyllum demersum*, discussed briefly below, is the conspicuous plant at depths greater than seven or eight feet. It forms extensive beds, where the bottom is favorable, at depths ranging from six to nearly twenty feet, ending rather abruptly at about the latter depth. It is limited to areas with soft bottoms, and in such situations is a most efficient and successful plant. According to this preliminary survey *Ceratophyllum* occupied about 700 acres of the bottom of Lake Okoboji in 1919. The accompanying map has the Ceratophyllum beds marked by small circles.

Ceratophyllum demersum forms great masses of vegetation in Millers Bay, Emerson Bay, and at the north end of the lake. Lesser beds occur in Smiths Bay, and Haywards Bay. A glance at the map shows that it forms a narrow zone most of the way along the west side of the lake except on convex shores and the barren stretch from Elm Crest to Gull Point. The east side of the lake below Haywards Bay shows relatively little *Ceratophyllum,* due to the abrupt slope and stony bottoms.

It will be noted that *Ceratophyllum* thrives only on shelving shores and in bays; in such places sufficient mud may accumulate to insure a soft bottom. *Ceratophyllum* has no roots but modified branches are buried in the soft substratum, and afford feeble anchorage. The plants have a specific gravity only slightly less than water even when fully active in midsummer. The stems sink in water but the buoyancy of the leaves keep the plants upright. Detached plants, however, will not float on the water. Recalling their ability to grow at considerable depths it will be seen that they are relatively unharmed by wave action. Following heavy storms it is the rooted plants rather than the rootless *Ceratophyllum* that are thrown up on the beach.

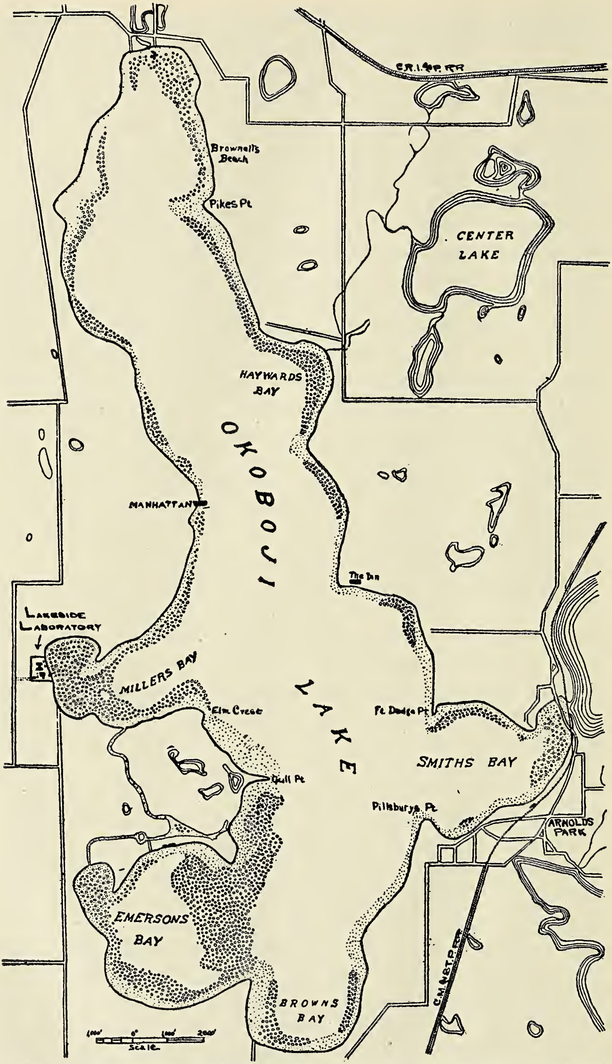


Fig. 12. Map showing distribution of larger plants in Lake Okoboji. Dotted areas indicate mixed larger plants, including Chara. Regions marked by small circles have *Ceratophyllum demersum.*

Ceratophyllum seems also to enjoy relative immunity to annoying algæ. The gelatinous species of *Rivularia* do not adhere to it in great numbers as compared with *Myriophyllum* and others that are fairly swamped by these epiphytes. Similarly, since *Ceratophyllum* typically remains submerged it does not offer anchorage to the free floating filamentous forms which make so much trouble for plants that bring their flower stalks to the surface.

Algæ regularly enter all these assemblages of seed plants and play an important part, usually to the detriment of the larger plants. Cyanophyceæ, especially *Rivularia,* attach to all their submersed parts, except that *Ceratophyllum* has partial immunity. These epiphytes must seriously interfere with their functions as frequently a large part of the leaves and stems is gummed over by them. As noted above the filamentous algæ form extensive masses over shallow waters where the flower stalks and other parts of submersed plants project above the surface. In quiet water *Rhizoclonium* forms heavy "blankets" that bring disaster to all entangled forms.

The Chara beds are very extensive, covering hundreds of acres of the bottom of Lake Okoboji. Their biological significance is rather obscure. Animals seem not to eat them freely and these formations constitute what might be called the desert areas of the lake. Studies of the Chara beds are being taken up to determine their extent, the component species, depth relations, etc., and to outline their relations to other plants and to animals. They constitute one of the unknown factors in the life of Lake Okoboji.

These "water weeds" sustain a very close relation to the whole question of fish in these lakes. The results of this survey are merely preliminary to the more intensive and detailed study of the various parts of Lake Okoboji and the other lakes of the group. It is of some significance at least that during the entire month given to this survey, and during which time hundreds of people were observed fishing in various parts of Lake Okoboji, no fish were being caught except in or along the edge of these masses of major vegetation.

Department of Botany
State University of Iowa.

SOME ALASKA FUNGI

J. P. ANDERSON

This list is based entirely on collections and observations by the writer. Only parasitic fungi and those appearing shortly after the death of the host plant are included, as these are the only ones to which sufficient attention has been paid. Quite a number of rusts (Uredinales) have been collected but are not included as it is the intention to list them in a separate paper. With few exceptions the fungi in this list are based on material collected at Sitka during the years 1914 to 1916 inclusive. The determinations were largely made by the U. S. Department of Agriculture at Washington. The Misses Vera K. Charles and A. E. Jenkins determined most of the species.[1]

So far as is known to the writer the only papers dealing with the fungi of Alaska, outside of some previous notes by himself,[2] are the report of the Harriman Alaska Expedition[3] and the references therein given by Dr. Trelease to previous mention of fungi from Alaska.

PLASMODIOPHORALES

Plasmodiophora brassicae Wor. Club-Root. On roots of *Brassica oleracea* and vars., *Brassica campestris, Raphanus sativus.* This disease is quite common and sometimes destructive on the different members of the cabbage group. It is less common on turnips, rutabagas, and radishes.

Bacteriaceae

Bacillus phytophthorus Appel. Black Leg. On *Solanum tuberosum.* Introduced with seed potatoes.

Pseudomonas campestris (Pam.) E. F. Smith. Black Rot. On *Brassica oleracea* and vars. Black rot sometimes damages cabbage and brussels sprouts.

Pseudomonas radicicola (Bey.) Moore. Tubercules have been noted on the roots of various legumes, including *Trifolium, Medicago, Cytisus.*

Pseudomonas tumefaciens (S. & T.) Stev. Crown Gall. In 1917 a few plants of Marguerite or Paris Daisy (*Chrysanthemum frutescens*) were received at Juneau from Seattle, Wash. Some crown gall was noted on

[1] Specimens have been deposited in my own herbarium at Iowa State College, and in the United States Department of Agriculture. J. P. A.

[2] Anderson, J. P., Fungus diseases: Rept. Alaska Agri. Expt. Stations, 1914 and 1915. Notes on the Flora of Sitka: Iowa Acad. Sci., XXIII, 1916.

[3] Saccardo, J. P., Peck, C. H., and Trelease, W., Fungi of Alaska: Harriman Alaska Series of the Smithsonian Institution, Vol. 5, 1910. Cryptogamic Botany.

these. The writer propagated from them and although the cuttings were far removed from the galls the characteristic enlargements appear occasionally on plants of the species even after several asexual generations. Not observed on other hosts when grown in Alaska.

Peronosporaceae

Peronospora obovata Bon. On *Spergula arvensis.* A common parasite.

Peronospora parasitica (Pers.) DeBy. On *Arabis hirsuta.* Collected in the basin back of Juneau. Does not appear to be common or widely distributed.

Plasmopara epilobii (Raf.) Schroet. On *Chamaenerion latifolium.* Common.

Erysiphaceae

Erysiphe cichoracearum DC. On *Artemisia elatior, Solidago* sp., *Chrysanthemum hortorum.* Quite common at Skagway on *Artemisia* and at Haines on *Solidago.*

Erysiphe graminis DC. ? On *Agrostis exarata.* Common in the conidial stage but perithecia not observed.

Erysiphe polygoni DC. On *Aquilegia formosa, Geum macrophyllum, Lathyrus maritima.* Common at Haines and Skagway.

Microsphaera alni (Wallr.) Wint. Collected at Sitka and Skagway on *Alnus sitchensis.*

Sphaerotheca humuli (DC.) Burr. On *Epilobium alandulosum, Fragaria* hybrids, *Ribes bracteosum, Rubus spectabilis.* A very common species especially on the first and fourth hosts.

Sphaerotheca humuli fuliginea (Schlecht.) Salmon. On *Arnica latifolia.* Collected at Skagway.

Sphaerotheca mors-uvae (Schw.) B. & C. On *Ribes lacustre, Ribes grossularia, Ribes vulgare.* Common and generally destructive on the first two hosts. *Ribes vulgare* is generally quite immune but some varieties are affected to a limited extent.

Sphaerotheca pannosa (Wallr.) Lev. On *Rosa* spp. Varieties of cultivated roses belonging to several types are susceptible, especially in the greenhouse.

Sphaerotheca sp. On *Chamomilla sauveolens* at Skagway.

Uncinula salicis (DC.) Wint. On *Populus trichocarpa, Salix sitchensis, Salix* sp. (native).

Sphaeriaceae

Ceriospora ribis P. Henn. & Plo. On stems of *Ribes bracteosum.*

Cucurbitaria conglobata (Fr.) Ces. On dead stems of *Alnus sitchensis.*

Diaporthe calosphaeroides E. & E. On stems of *Sambucus pubens.*

Diaporthe concrescens (Schw.) Cke. On stems of *Ribes* sp. (gooseberry).

Diaporthe marginalis Pk. On stems of *Alnus sitchensis.*

Diaporthe salicella Fr. On stems of *Salix* sp. (cult.).

Didymella eupyrea (Sacc.) Michel. On old overwintered stems of *Urtica lyallii.*

Didymosphaeria sp. On leaves and stems of *Elaeagnus angustifolia.*

Leptosphaeria coniothyrium (Fckl.) Sacc. On dead stems of *Ribes nigrum.*

Leptosphaeria culmifraga (Fr.) Ces. & DeNot. On leaves and sheaths of *Calamagrostis aleutica.*

Leptosphaeria sp. (*folliculata* E. E.?) On leaves of *Carex sitchensis.*

Leptosphaeria sp. On old stems of *Vicia faba.*

Melogramma sp. On stems of *Menziesia ferruginea.*

Mycosphaerella fragariae (Tul.) Lindau. On leaves of *Fragaria* sp. (cultivated hybrids). Quite common but only occasionally destructive.

Mycosphaerella pinoides Berk. & Blox. On leaves, stems and pods of *Pisum sativum.* In its conidial form (*Ascochyta pisi*) this fungus is very common and destructive; especially late in the season when it may ruin what is left of the crop. The perithecia appear in late September and October.

Mycosphaerella populi Schr. On leaves of *Populus balsamifera.* Collected in the conidial stage known as *Septoria populi.*

Phomatospora sp. On the bark of old stems of *Chamaenerion spicatum.*

Sphaerella adusta Niessl. On the old stems of *Chamaenerion spicatum.*

Sphaerella caryophylli Pass. On leaves of *Dianthus caryophyllus.*

Sphaerella adusta Niessl. On old stems of *Chamaenerion spicatum.*

Sphaerella gaultheris C. & E. On leaves of *Gaultheria shallon.*

Sphaerella rumicis (Desm.) Cke. On leaves of *Rumex occidentalis.*

Venturia clintoni Pk. On leaves of *Cornus canadensis.*

Venturia kalmiae Pk. ? On leaves of *Kalmia microphylla.*

Venturia kunzei Sacc. On leaves of *Rubus pedatus.*

Venturia pomi (Fr.) Wint. (*V. inaequalis* (Cke.) Alderh.) On leaves and fruit of *Pyrus malus.*

Hypocreaceae

Claviceps microcephala (Wallr.) Tul. In the inflorescence of *Calamagrostis aleutica, C. langsdorfii, Dactylis glomerata, Phleum pratense.*

Claviceps purpurea (Fr.) Tul. In the inflorescence of *Elymus mollis, Hordeum boreale.*

Nectria cinnabarina (Tode) Fr. On dead stems of *Alnus sitchensis, Amelanchier* sp., *Chamaenerion spicatum, Prunus cerasus, P. domestica, P. padus, Pyrus baccata, P. diversifolia, P. malus, Rosa nutkana, R. rugosa, Ribes bracteosum, R. nigrum, R. sanguineum, R. vulgare, R.* sp. (gooseberry), *Rubus parviflorum, R. spectabile, R. strigosus, Salix viminalis, Salix purpurea, Sorbus sitchensis, Sambucus pubens, Viburnum* sp. This species makes its appearance from December to April, the conidial stage (*Tubercularia vulgaris*) appearing first, but quickly followed by the perithecia. It seems to attack nearly all kinds of recently killed wood including prunings from woody plants. On *Chamaenerion spicatum* which has an herbaceous stem the perithecia did not develop, but on all the more woody plants perithecia develop in abundance. It has not been observed as really parasitic on any species, but wood that has been in a dying condition in the fall has been observed as affected in the early spring following.

Dothidiaceae

Phyllachora graminis (Pers.) Fckl. On leaves of *Calamagrostis langsdorfii.*

Phyllachora heraclei (Fr.) Fckl. On leaves of *Heracleum lanatum.*

Phyllachora pteridis (Reb.) Fckl. Common on fronds of *Pteridium aquilinum pubescens.*

Phyllachora wittrockii (Eriks.) Sacc. On the tips of the stems of *Linnaea longiflora.*

Plowrightia ribesia (Pers.) Fr. On stems of *Ribes hudsonianum, R. vulgare.*

Microthyriaceae

Asterina cupressina Cke. On *Chamaecyparis nootkatensis.*

Coryneliaceae

Tripospora elegans Cda. On stems of *Sambucus pubens.*

Hysteriaceae

Lophodermium arundinaceum (Schr.) Chev. On old leaves of *Elymus mollis.*

Lophodermium pinastri (Schrad.) Chev. On needles of *Picea sitchensis.*

Phacidiaceae

Rhytisma andromedae (Pers.) Fr. On leaves of *Andromeda polifolia.*

Rhytisma salicinum (Pers.) Fr. On leaves of *Salix* spp. (native).

Rhytisma vaccinii Schr. On leaves of *Vaccinium parvifolium.*

Rhytisma sp. On leaves of *Menziesia ferruginea.*

Dermatiaceae

Cenangium cerasi Fr. On stems of *Prunus cerasus.*

Dermatea cerasi (Pers.) Fr. On stems of *Prunus cerasus.*

Tympanis sp. On stems of *Ribes bracteosum.* This is a highly destructive parasite and causes more damage to the host than any other disease or all other diseases to which it is subject.

Mollisiaceae

Fabraea ranunculi (Fr.) Karst. On leaves of *Ranunculus occidentale.*

Pseudopeziza ribis Kleb. On leaves of *Ribes bracteosum, R. nigrum.*

Pseudopeziza trifolii (Bernh.) Fckl. On leaves of *Trifolium pratense.*

Exoascaceae

Exoascus cerasi Fckl. Causing witches brooms on *Prunus avium.* Not observed on *P. cerasus.*

Exoascus deformans (Berk.) Fckl. On leaves and stems of *Amygdalus persica.*

Ustilaginaceae

Ustilago avenae (Pers.) Jens. In spikelets of *Avena sativa.*

Thelephoraceae

Exobasidium vaccinii (Fckl.) Wor. Causing distortions on *Cassiope mertensiana, Menziesia ferruginea, Vaccinium vitis-idaea.*

Phomataceae

Ascochyta colorata Peck. On leaves of *Fragaria* sp.

Ascochyta pisi Lib. See *Mycosphaerella pinoides.*

Ascochyta sambuci Sacc. On leaves of *Sambucus nigra aurea.*

Ascochyta sp. On leaves of *Ammodenia peploides major.*

Coniothyrium olivaceum Bon. On stems of *Rubus strigosus, Sambucus pubens.*

Coniothyrium sp. On leaves of *Prunus* hybrids. Seemingly quite destructive.

Cytospora leucostoma (Pers.) Sacc. On stems of *Prunus padus.*

Cytospora sp. On stems of *Alnus sitchensis.*

Cytospora sp. On stems of *Prunus domestica.*

Cytosporina ludibunda Sacc. On stems of *Prunus cerasus.*

Diplodia deflectens Karst. On stems of *Lonicera tatarica.*

Dothiorella latitans (Fr.) Sacc. On leaves of *Vaccinium vitis-idaea.*

Phoma actua (Fuck.) Mich. On old stems of *Urtica lyallii.*

Phoma majanthemum Pk. On leaves and petioles of *Unifolium eschscholtzianum.*

Phoma sp. On stems of *Salix* sp.

Phomposis sp. (*padina* (Sacc.))? On stems of *Prunus cerasus.*

Phomopsis sp. On stems of *Pyrus baccata.*

Phyllosticta digitalis Bell. On leaves of *Digitalis purpurea.*

Phyllosticta gallorum Thum. On leaves of *Caragana arborescens.*

Phyllosticta plantaginis Sacc. On leaves of *Plantago macrocarpa.*

Phyllosticta sp. On leaves of *Solanum tuberosum.*

Rhabdospora inaequalis Sacc. On stems of *Sorbus sitchensis.*

Rhabdospora interrupta (B. & C.) Sacc. On stems of *Viburnum opulus.*

Rhabdospora rubi Ell. On stems of *Rubus strigosus.*

Septoria alnifolia E. & E. On leaves of *Alnus sitchensis.*

Septoria canadensis Pk. On leaves of *Cornus canadensis.*

Septoria coptidis B. & C. On leaves of *Coptis asplenifolia.*

Septoria drummondii E. & E. On leaves of *Phlox drummondii.*

Septoria gramineum Desm. On leaves of *Agrostis exarata, Calamagrostis.*

Septoria hyalina E. & E. On leaves of *Viola palustris.*

Septoria ribis Desm. On leaves of *Ribes grossularia.*

Septoria rubi West. On leaves of *Rubus spectabilis.*

Leptostromataceae

Entomosporium maculatum Lev. On leaves of *Pyrus diversifolia, Sorbus sitchensis.* The perfect form of this parasite is *Fabraea maculata* (Lev.) Atk.

Leptothyrium alneum (Lev.) Sacc. On leaves of *Alnus sitchensis.*

Melanconiaceae

Colletotrichum lindemuthianum (Sacc. & Magn.) Briosi & Cavara. On pods of *Phaseolus vulgaris.*

Coryneum foliicolum Fckl. On leaves of *Pyrus malus.*

Coryneum longistipatum Berl. On stems of *Amelanchier* sp., *Pyrus malus.*

Coryneum sp. On leaves of *Ribes alpinum, R. triste.*

Coryneum sp. On stems of *Viburnum* sp. ? There is some doubt about the identity of this host. It may be a form of *Acer tatarica.*

Gloeosporium ribis (Lib.) Mont. & Desm. See *Pseudopeziza ribis.*

Melanconium spic-carpon Lk. On stems of *Alnus sitchensis.*

Pestalozzia lignicola Cke. On stems of *Salix purpurea.*

Pestalozzia truncata Lev. On stems of *Salix purpurea.*

Pestalozzia truncata rubi Karst. On stems of *Rubus strigosus.*

Moniliaceae

Aspergillus sp. On leaves and stems of *Rubus strigosus.*

Botrytis cinerea Pers. (*B. vulgaris* Fr.) On *Apium graveolens, A. petroselinum, Brassica oleracea* and vars., *Calendula officinalis, Callistephus hortensis, Cheiranthus cheiri, Coleopleurum gmelini, Coreopsis* sp., *Dianthus caryophyllus, D. hedwigi, Dimorphotheca aurantiaca, Eschscholtzia californica, Euphorbia pulcherrima, Fragaria* spp., *Heliotropium peruvianum, Iberis umbellata, Lactuca sativa, Lathyrus odoratus, Linaria cymballaria, Lobelia erinus, Lycopersicum cerasiforme, L. esculentum, Mathiola incana annua, Mimulus lutens, Myrsiphyllum asparegoides, Nicotiana tabacum, Papaver* spp., *Prunus* spp., *Ribes aureum, R. nigrum, R. triste, R. vulgare, Rosa* spp., *Rubus idaeus, R. parviflorum, R. strigosus, Solanum tuberosum, Tagetes erecta, Thymus officinalis, Tropaeolum majus, Vicia fabia, Viola tricolor, Zinnia elegans.*

The above list, though a long one is by no means complete. The writer at first started to preserve specimens of all species affected but soon dispaired as there seemed to be no species of flowering plant immune. Though a weak parasite it is easily the most destructive fungus of southeastern Alaska. The conidia do not seem able to directly infect vigorous and healthy parts of plants but will readily infect weakened or dying parts and where these come in contact with healthy tissues the mycelium rapidly spreads. One of the commonest initial infections is in the fading petals of the flowers. Where these fall on the leaves the leaves soon become infected and the fungus often reaches the stem through the petiole, resulting in the girdling of the stem and the death of the parts above. Old leaves that have lost their vigor are also direttly infected. The fungus is easily transferred from one species to another when the infected portions of one species come in contact with tissues of the other. The fungus seems to spread more rapidly in the tissues of some hosts than in others. Weather conditions are a potent factor in the spread of the parasite as it is much more destructive during prolonged cloudy and rainy weather than during bright clear weather. During prolonged spells of wet weather some kinds of plants will be almost ruined. Several bright days in succession very noticeably check the ravages of the fungus. The crop of garden currants was very much reduced one season by its ravages owing to unfavorable weather at blooming time. As a rule it is worse in the greenhouse than outside. During prolonged cloudy weather it is sometimes necessary to fire up in order to reduce the humidity of the air in the greenhouse even during the summer. This is also our chief damping off fungus.

Oospora scabies Thaxter. Potato Scab. On tubers of *Solanum tuberosum.* Quite common in some soils.

Ramularia heraclei (Oud.) Sacc. On leaves of *Heracleum lanatum.*

Ramularia tulasnei Sacc. See *Mycosphaerella fragariae.*

Ramularia sp. On leaves of *Plantago major.*

Dematiaceae

Cercospora sp. On leaves of *Castilleja pallida.*

Cladosporium carpophilum Thum. On leaves of *Prunus padus.*

Cladosporium heliotropii Erikss. On leaves of *Heliotropium peruvianum.*

Cladosporium paeoniae Pass. On leaves of *Paeonia* sp.

Cladosporium sp. Undetermined species of *Cladosporium* occur on *Gaillardia* sp., *Prunus mahaleb, Ribes hudsonianum, Viburnum pauciflorum.*

Hadrotrichum linearis Pk. On leaves of *Calamagrostis langsdorfii.*

Haplobasidium pavoninum V. Höhn. On leaves of *Aquilegia* spp.

Helminthosporium avenae-sativae (B. C.) Lindau. On leaves of *Avena sativa.*

Macrosporium brassicae Berk. On leaves of *Brassica oleracea.*

Stilbaceae

Sporocybe sp. On fruits of *Ledum groenlandicum.*

Tuberculariaceae

Fusarium oxysporium Schl. On tubers of *Solanum tuberosum* causing rot.

UNCLASSIFIED

Sclerotium sp. In fruits of *Rosa rugosa.*

Sclerotium sp. On stems of *Sambucus pubens.*

HOST INDEX

Agrostis exarata Trin. Erysiphe graminis, Septoria graminum.

Alnus sitchensis (Regel.) Sarg. Cucurbitaria conglobata, Cytospora sp., Diaporthe marginalis, Leptothyrium alneum, Melanconium spic-carpon, Microsphaera alni, Nectria cinnabarina, Septoria alnifolia.

*Amelanchier sp. Coryneum longistipatum, Nectria cinnabarina.

Ammodenia peploides major (Hook.) Wight. Ascochyta sp.

*Amygdalus persica L. Exoascus deformans.

Andromeda polifolia L. Rhytisma andromedae.

*Apium spp. Botrytis cinerea.

Aquilegia formosa Fisch. Erysiphe polygoni.

*Aquilegia spp. Haplobasidium pavoninum.

Arnica latifolia Bong. Sphaerotheca humuli fuliginea.

Artemisia elatior (T. & G.) Ryd. Erysiphe cichoracearum.

*Avena sativa L. Ustilago avenae, Helminthosporium avenae-sativae.

*Brassica campestris L. Plasmodiophora brassicae.

*Brassica oleracea L. and vars. Botrytis cinerea, Macrosporium brassicae, Plasmodiophora brassicae, Pseudomonas campestris.

Calamagrostis aleutica Bong. Claviceps microcephala, Leptosphaeria culmifraga.

Calamagrostis langsdorfii Trin. Claviceps microcephala, Hadrotrichum linearis, Phyllachora graminis, Septoria graminum.

*Calendula officinalis L. Botrytis cinerea.

*Caragana arborescens Lam. Phyllosticta gallorum.

Carex sitchensis Prescott. Leptosphaeria sp.

* Indicates cultivated plant.

Cassiope mertensiana (Bong.) G. Don. Exobasidium vaccinii.
Castilleja pallida Kunth. Cercospora sp.
Chamecyparis nootkatensis (Lamb.) Spach. Asterina cupressina.
Chamaenerion latifolium (L.) Sweet. Plasmopara epilobii.
Chamaenerion spicatum (Lam.) S. F. Gray. Phomatospora sp. Sphaerella adusta, Sphaerella caulicola, Sphaerella sp.
Chamomilla sauveolens (Pursh) Rydb. Sphaerotheca.
*Chieranthus cheiri L. Botrytis cinerea.
Chrysocoptis asplenifolia (Salisb.) Nutt. See Coptis asplenifolia.
*Chrysanthemum frutescens L. Pseudomonas tumefaciens.
*Chrysanthemum hortorum. Erysiphe cichoracearum.
Coelopleurum gmelini (DC.) Ledeb. Botrytis cinerea.
Coptis asplenifolia Salisb. Septoria coptidis.
*Coreopsis sp. Botrytis cinerea.
Cornus canadensis L. Septoria canadensis, Venturia clintoni.
Dactylis glomerata L. Claviceps microcephala.
*Dianthus caryophyllus L. Sphaerella caryophylli.
*Dianthus spp. Botrytis cinerea.
*Digitalis purpurea L. Phyllosticta digitalis.
*Dimorphotheca aurantiaca DC. Botrytis cinerea.
Elaeagnus angustifolia L. Didymosphaeria sp.
Elymus mollis Trin. Claviceps purpurea, Lophodermium arundinacearum.
Epilobium glandulosum Lehm. Sphaerotheca humuli.
Epilobium see also Chamaenerion.
*Eschscholtzia californica Cham. Botrytis cinerea.
*Euphorbia pulcherrima. Botrytis cinerea.
*Fragaria spp. Ascochyta colorata., Botrytis cinerea, Mycosphaerella fragariae, Sphaerotheca humuli.
*Gaillardia aristata Pursh. Cladosporium sp.
Gaultheria shallon Pursh. Sphaerella gaultheris.
Geum macrophyllum Willd. Erysiphe polygoni.
*Heliotropium peruvianum L. Botrytis cinerea, Cladosporium heliotropii.
Heracleum lanatum Michx. Phyllachora heraclei, Ramularia heraclei.
Hordeum boreale S. & S. Claviceps purpurea.
*Iberis umbellata L. Botrytis cinerea.
Kalmia microphylla (Hook.) Heller. Venturia kalmiae.
*Lactuca sativa L. Botrytis cinerea.
Lathyrus maritima Bigel. Erysiphe polygoni.
*Lathyrus odoratus L. Botrytis cinerea.
Ledum groenlandicum Oeder. Sporocybe sp.
*Linaria cymbalaria Mill. Botrytis cinerea.
Linnaea longiflora (Torr.) Howell. Phyllachora wittrockii.
*Lobelia erinus L. Botrytis cinerea.
*Lonicera tatarica L. Diplodia deflectans.
*Lycopersicum spp. Botrytis cinerea.
Malus, see Pyrus.
*Mathiola incana annua Voss. Botrytis cinerea.

Menziesia ferruginea Smith. Exobasidium vaccinii, Melogramma sp., Rhytisma sp.

*Mimulus luteus L. Botrytis cinerea.

*Myrsiphyllum asparagoides. Botrytis cinerea.

*Nicotiana tabacum L. Botrytis cinerea.

*Paeonia sp. Cladosporium paeoniae.

*Papaver spp. Botrytis cinerea.

*Phaseolus vulgaris L. Colletotrichum lindemuthianum.

Phleum pratense L. Claviceps microcephala.

*Phlox drummondii Hook. Septoria drummondii.

Picea sitchensis (Bong.) T. & M. Acolium sp., Lophodermium pinastri.

*Pisum sativum I. Mycosphaerella pinodes.

Plantago macrocarpa C. & S. Phyllosticta plantaginis.

Plantago major L. Ramularia sp.

*Populus balsamifera L. Mycosphaerella populi.

Populus trichocarpa T. & G. Uncinula salicis.

*Prunus avium L. Exoascus cerasi.

*Prunus cerasus L. Cenangium cerasi, Cytospora ludibunda, Dermatea cerasi, Nectria cinnabarina, Phomopsis sp.

*Prunus domestica L. Cytospora sp., Nectria cinnabarina.

*Prunus mahaleb L. Cladosporium sp.

*Prunus padus L. Cladosporium carpophilum, Cytospora leucostoma, Nectria cinnabarina.

*Prunus hybrids. Coniothyrium sp.

*Prunus spp. Botrytis cinerea.

Pteridium aquilinum pubescens Underw. Phyllachora pteridis.

*Pyrus baccata L. Nectria cinnabarina, Phomopsis sp.

Pyrus diversifolia Bong. Entomosporium maculatum, Nectria cinnabarina.

*Pyrus malus L. Coryneum foliicolum, Coryneum longistipatum, Nectria cinnabarina, Venturia pomi.

*Raphanus sativus L. Plasmodiophora brassicae.

Ranunculus occidentalis Nutt. Fabraea ranunculi.

*Ribes alpinum L. Coryneum sp.

Ribes bracteosum Dougl. Ceriospora ribis, Pseudopeziza ribis, Sphaerotheca humuli, Tympanis sp.

Ribes hudsonianum Richards. Cladosporium sp. Nectria cinnabarina, Plowrightia ribesia.

Ribes lacustre (Pers.) Poir. Sphaerotheca mors-uvae.

*Ribes nigrum L. Leptosphaeria coniothyrium, Nectria cinnabarina, Pseudopeziza ribis.

*Ribes sanguineum Pursh. Nectria cinnabarina.

*Ribes grossularia. Septoria ribis, Sphaerotheca mors-uvae.

Ribes triste Pall. Coryneum sp.

*Ribes vulgare Lam. Nectria cinnabarina, Plowrightia ribesia, Sphaerotheca mors-uvae.

*Ribes sp. (Gooseberry). Diaporthe concrescens, Nectria cinnabarina.

*Ribes spp. Botrytis cinerea.

Rosa nutkana Presl. Nectria cinnabarina.

*Rosa rugosa Thunb. Nectria cinnabarina, Sclerotium sp.

*Rosa sp. Sphaerotheca pannosa.

*Rosa spp. Botrytis cinerea.

Rubus pedatus Smith. Venturia kunzei.

Rubus spectabilis Pursh. Septoria rubi, Sphaerotheca humuli.

*Rubus strigosus Michx. Aspergillus sp., Coniothyrium olivaceum, Nectria cinnabarina, Pestalozzia truncata rubi, Rhabdospora rubi.

Rubus spp. Botrytis cinerea.

Rumex occidentalis S. Wats. Sphaerella rumicis.

*Salix purpurea L. Nectria cinnabarina, Pestalozzia lignicola, Pestalozzia truncata.

Salix sitchensis Sanson. Uncinula salicis.

*Salix viminalis var. Nectria cinnabarina.

Salix sp. Uncinula salicis.

*Salix sp. Diaporthe salicella, Phoma sp.

Sambucus pubens Michx. Coniothyrium olivaceum, Diaporthe calosphaerioides, Nectria cinnabarina, Sclerotium sp., Tripospora elegans.

*Sambucus nigra aurea Sweet. Ascochyta sambuci.

*Solanum tuberosum L. Bacillus phytophthorus, Botrytis cinerea, Fusariun oxysporium, Oospora scabies, Phyllosticta sp.

Solidago sp. Erysiphe cichoracearum.

Sorbus sitchensis Roem. Entomosporium maculatum, Nectria cinnabarina, Rhabdospora inaequalis.

*Tagetes erecta L. Botrytis cinerea.

*Thymus vulgaris L. Botrytis cinerea.

Trifolium pratense L. Pseudopeziza trifolii.

*Tropaeolum majus L. Botrytis cinerea.

Unifolium eschscholtzianum (Anders. & Bess.) Wight. Phoma majanthemum.

Urtica lyallii Wats. Didymella eupyrena, Phoma acuta.

Vaccinium parvifolium Smith. Rhytisma vaccinii.

Vaccinium vitis-idea L. Exobasidium vaccinii, Dothiorella latitans.

*Viburnum opulus L. Rhabdospora interrupta.

Viburnum pauciflorum Paylaie. Cladosporium sp.

*Viburnum sp.?? Coryneum sp., Nectria cinnabarina.

*Vicia faba L. Botrytis cinerea, Leptosphaeria sp.

Viola palustris L. Septoria hyalina.

*Viola tricolor L. Botrytis cinerea.

*Zinnia elegans Jacq. Botrytis cinerea.

Juneau Florists,
Juneau, Alaska.

NOTES ON THE DISTRIBUTION OF MIDSUMMER BEE PLANTS IN THE MISSISSIPPI ZONE OF CLAYTON COUNTY

ADA HAYDEN

With intent to determine (1) what plants were available to bees in late summer, (2) how these plants were located with reference to water reservoirs and (3) which of these plants were most valuable to the bee, some observations were made in Clayton county, Iowa, August 20 to September 9, 1919. The vicinity of McGregor, Beulah, Garnavillo, Guttenberg, Clayton, Prairie-du-Chien, and some of the adjacent islands of the Mississippi about McGregor were visited. Since the water supply is related to the topography and the distribution of plants is relative to both these factors, the geology and topography should be kept in mind.

Topography.— This county has a variant topography and includes many geologic formations. The highest elevation is 1,185 feet on the divide between Turkey and Yellow rivers, tributaries of the Mississippi, which bounds this county on the east. According to Norton, in the southeast section of the county lies an area of Iowan drift where old valleys have been filled and the surface has assumed an aspect of gradual sags and swells. The older drift is said to contribute little to topographic influence. The topography of the county outside of the Iowan drift plain is that of the driftless area. It has been subject to long continued and deep erosion. The northern tier of townships and a belt about eight miles wide along Mississippi river lie within this driftless area. The ancient base plain of erosion to which this area has been reduced has been elevated to about 1000 feet above sea level. Subsequent erosion by numerous streams and their tributaries has deeply carved this region, forming a network of narrow valleys.

Geology.— The Pleistocene deposits include the loess, the Iowan drift, the Kansan drift and the Nebraskan drift. Along the high precipitous escarpments of the Mississippi where the older rock strata are exposed may be seen the St. Croix sandstone, one of the oldest rocks of Paleozoic times, (Figs. 13 and 14) and next to it the Prairie-du-Chien limestone followed by the St. Peter sandstone and the Galena-Platteville limestone and dolomite. In these rocks the numerous springs of Clayton county have their

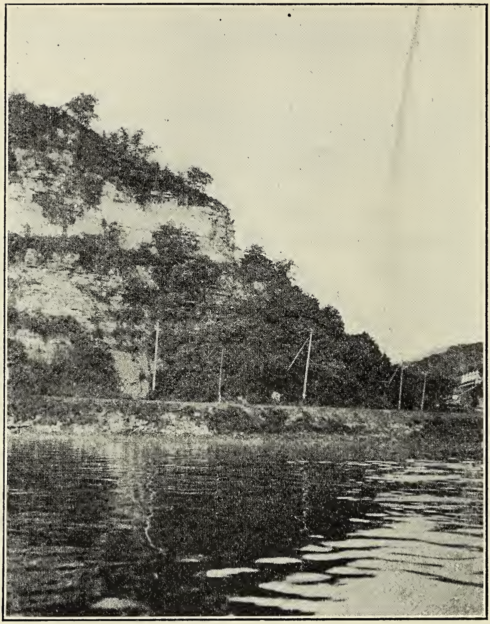


Fig. 13. Point Ann. West shore of Mississippi River near McGregor.

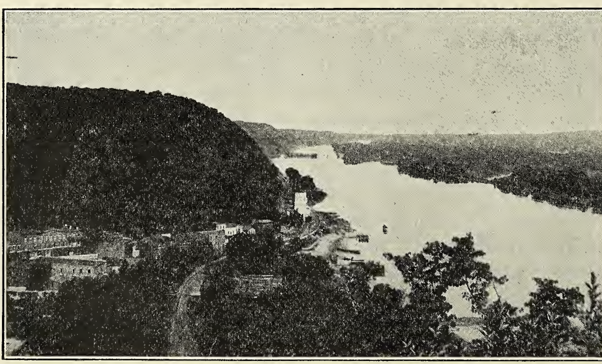


Fig. 14. The Heights. McGregor. Islands to the right.

source. The St. Peter sandstone gives rise to small springs while the larger ones have their source in the Prairie-du-Chien and the Galena-Platteville limestones (Fig. 15).

Edaphic and Floral Features.— Where these alternatingly pervious strata of limestone and sandstone and less pervious strata

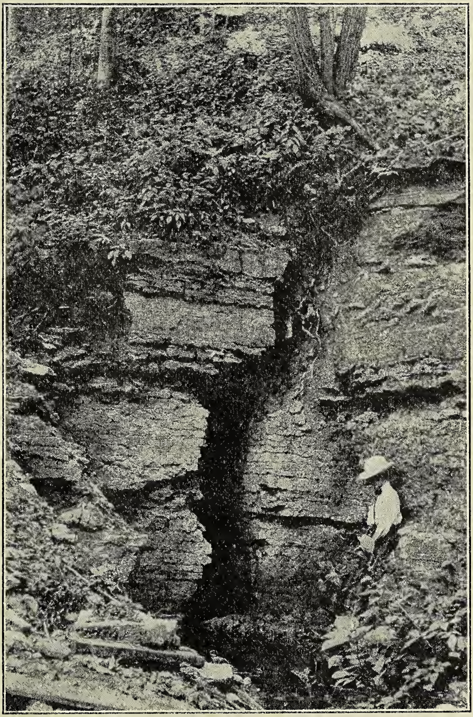


Fig. 15. One of a group of seven springs. Bluffs near Clayton, Iowa.

of shale lie parallel are ideal conditions for the formation of springs, which are numerous on every hand, some being the sources of vigorous little streams. The soil includes both pulverized limestone and sandstone in quantities and is abundantly supplied with moisture. Sandstone derivatives include small quantities of compounds of silicon, aluminum, iron, magnesium, calcium, sodium and potassium while limestones include principally com-

Fig. 16. Bluffs along west shore of Mississippi river. Abounds in asters and goldenrods. West slope.

pounds of calcium and magnesium. All of these elements are essential for plant foods. It is generally recognized that the flora of limestone and sandstone regions differ, but this region in which both limestone and sandstone occur abundantly, shows a richer flora with reference to number of species of plants than is generally seen in a region in which either sandstone or limestone is the dominant constituent.

While the west side of the river bears a luxuriant mesophytic forest, (Fig. 16) with only an occasional dry ridge or exposed peak bearing the prairie verdure, the weathered and exposed Wisconsin shore of the river in this vicinity bears a sparse and

Fig. 17. Weathered aspect of Wisconsin shore near Prairie du Chien. East slope. Silky aster, Fragrant Goldenrod and Blazing Star.

Fig. 18. Prairie verdure of Wisconsin shore near Prairie du Chien. Blazing stars, Large flowered goldenrods and Pasque flower.

more xerophytic forest with a broad expanse of treeless prairie. (Figs. 17, 18, 19.)

TYPICAL FLORA OF THE WEST SHORE OF MISSISSIPPI RIVER

Acer nigrum, A. saccharum, A. saccharinum, Fraxinus alba, F. viridis, F. nigra, F. americana, Ulmus americana, U. fulva, Celtis occidentalis, Carya alba, Quercus alba, Q. acuminata, Q. rubra, Q. macrocarpa, Juglans cinerea, J. nigra, Tilia americana, Mitella diphylla, Asperella hystrix, Lobelia siphilitica, Campanula americana, Osmorrhiza brevistylis, Podo-

Fig. 19. *Quercus velntina, Betula papyrifera, Rhus glabra,* Xerophytic aspect of Wisconsin shore near Prairie du Chien.

STATISTICS RELATING TO VISITATION

Date	Hour	Locality	Name of Plant	Wind	Light
8/26/19	11-11:30 a.m.	McGregor, Ia., West side Mississippi River	Polymnia canadensis (Leaf cup)	S. E.	Clear
8/28/19	1:00 p.m.	McGregor, Ia., West side Mississippi River	Polymnia canadensis (Leaf cup)	S. E.	Clear
8/28/19	3:00 p.m.	McGregor, Ia., West side Mississippi River foot of dry cliff	Sicyos angulatus (Wild cucumber)	S. E.	Clear
9/1/19	3:30-4 p.m.	Prairie du Chien, Wis., East side of Mississippi River	Sicyos angulatus (Wild cucumber)	S. E.	Clear
8/28/19	4-4:30 p.m.	McGregor, Ia., West side Mississippi River base of rocky cliff	Cirsium lanceolatus (Bull thistle)	S. E.	Clear
8/28/19	4-4:30 p.m.	McGregor, Ia., West side Mississippi River	Clematis paniculata (white clematis)	S. E.	Clear
8/28/19	4:00 p.m.	McGregor, Ia., West side Mississippi River foot of cliff	Nepeta cataria (catnip)	S. E.	Clear
8/28/19	11:00 a.m.	Beulah, near Bloody run	Linaria vulgaris (toadflax)	S. E.	Cloudy showers
9/1/19	1:25 p.m.	Prairie du Chien, Wis., East side of Missisippi Riv., flood plain	Physostegia lanceolata (False turtle's head)	S. E.	Clear
9/1/19	1:25 p.m.	Prairie du Chien, Wis., East side of Missisippi Riv., flood plain	Physostegia lanceolata (False turtle's head)	S. E.	Clear
9/1/19	2:30 p.m.	Prairie du Chien, Wis., East side of Missisippi Riv., flood plain	Helenium autumnale (Sneeze weed)	S. E.	Clear
9/3/19	2:00 p.m.	Island in Mississippi River near McGregor	Helenium autumnale (Sneeze weed)	N. W.	Clear
9/2/19	4:00 p.m.	Prairie du Chien, Wis., flood plain	Grindelia gum weed, tarweed	S. E.	Cloudy
9/2/19	3:00 p.m.	Prairie du Chien, Wis.,	Aster salicifolius (Swamp aster)	S. E.	Cloudy
9/3/19	2:36 p.m.	Near Prairie du Chien, Wis., Bergman's Island in Miss. River	Mentha canadensis	S. E.	Cloudy showers
9/4/19	12:30 p.m.	Bergman's Island, E. of McGregor in Mississippi River	Polygonum pennsylvanicum (Knot weed)	S.	Clear
9/5/19	3:00 p.m.	Mouth of Yellow Riv.	Solidago Missouriensis	N. W.	Clear
9/9/19	1:00 p.m.	Oneida, Sand	Solidago Missouriensis	S. E.	Clear

OF MIDSUMMER PLANTS BY BEES

Habitat		Insect	Ave. No. Visits Per 20 Min.	Range in 20 Min.	No. Insects Per Min. in 2 Square Meters
Soil	Exposure				
Rocky gravelly soil	Shady slope	Small bumble bee	17	14-21	6-5-7
Gravelly soil	Foot of dry rocky cliff, East Exp.	Small bumble bee	18	15-22	16-18 small bumble bees
Gravelly soil	Foot of dry cliff, dense vegetation, shady East slope	Honey bee	15	15-18	1 wasp, 10 insects, yellow jacket, honey bee
Rich loam alluvial	Flood plain, moist open all sides	Small bumble bee	14	11-17	6-8, wasp, yellow jacket, honey bee
Gravelly loam	Foot of dry rocky cliff, East Exp.	Honey bee	21	15-25	5-7 small bumble bees
Gravelly loam	Foot of dry rocky cliff, dense vegetation, East Exp.	Honey bee	15	15-18	Honey bee, yellow jacket
Gravelly loam	Foot of dry rocky cliff, East Exp.	Large bumble bee	36	30-32	10 honey bees
Loam alluvial	Flood plain, rocky limestone	Small bumble bee	Bees hung up under flower during shower		
Loam alluvial	Flood plain exposed all sides	Honey bee	36	31-47	Wasps, small bumble bee, honey bee
Loam alluvial	Flood plain exposed all sides	Honey bee	20	14-26	Wasps, small bumble bee, honey bee
Loam alluvial	Flood plain exposed all sides	Honey bee	24	20-33	Large bumble bees, small bumble bees, 10-15
Loam alluvial	Flood plain exposed all sides	Honey bee	35	35-46	Honey bees 1, 10-50 honey bees, 10-30 bumble bees
Loam	Dry bank near river	Small bumble bee	57	50-64	
Alluvial	Swamp flood plain	Honey bee	41	39-50	Small bumble bee, yellow jacket, honey bee
Alluvial	Swamp, edge of lakes on island	Honey bee	38	25-50	
Alluvial	Edge of lakes on island	Honey bee	39	35-40	
Alluvial	North bank of river	Honey bee	45	37-50	
Sandy loam	Railroad track	Honey bee	51	50-55	Wasp, fly, beetle

phyllum peltatum, Hepatica acutiloba, Cystopteris fragilis, C. bulbifera. Camptosorus rhizophyllus, Asplenium Filix-femina, Pellea atropurpurea, Botrychium virginianum, Adiantum pedatum, Struthiopteris Germanica, Hydrastis canadensis, Actaea rubra, Panax quinquefolium, Arabis racemosa, Cypripedium pubescens, Caulophyllum thalictroides, Rhus typhina, Clematis virginiana, Hamamelis virginiana, Physocarpus opulifolius, Sicyos angulatus, Polymnia canadensis, Impatiens pallida, Impatiens biflora.

FLORA OF THE BLUFFS ON THE EAST SHORE OF MISSISSIPPI RIVER NEAR PRAIRIE du CHIEN

Quercus velutina, Populus tremuloides, Betula papyrifera, Carya alba, Ulmus fulva, Rhus glabra, Rhus toxicodendron, Corylus americana, Vitis vulpina, Andropogon furcatus, A. scoparius, Sorghastrum nutans, Sporobolus longifolius, Bouteloua curtipendula, B. hirsuta, Panicum scribnerianum, Elymus robustus, Muhlenbergia mexicana.

PLANTS FREQUENTED BY HONEY BEES

(Figures 20, 21, 22)

Compositæ
- Aster salicifolius
- Grindelia squarrosa
- Helenium autumnale
- Polymnia canadensis
- Solidago canadensis
- Solidago missouriensis
- Solidago rigida

Cucurbitaceae
- Sicyos angulata

Labiatae
- Lycopus americana
- Mentha canadensis
- Nepeta cataria

Leguminosae
- Apios tuberosa

Polygonaceae
- Polygonum muhlenbergii
- Polygonum pennsylvanicum

Ranunculaceae
- Clematis virginiana

Scrophulariaceae
- Scrophularia marilandica

No accurate data were taken on the distribution of flowers per unit area. Plants with loose paniculate inflorescence such as *Clematis* and *Sicyos* or racemes such as those of *Polygonum* or the looser clusters of *Apios* involved much more of the time as well as the energy of the bee in covering space and making visits. The Compositæ such as Golden Rod or Helenium produce obviously manyfold more flowers per unit area than the plants of the former groups. All of the plants listed have the colonial habit with the exception of the rare *Apios* or *Scrophularia.* The Compositæ along the streams or the shaded west river banks were much more sparsely distributed than on the islands (Fig. 23) or on the flood plains (Fig. 24) where acres of white *Aster, Cardinal, Lobelia* or *Golden Helenium* emblazoned the earth. The *Asters* and *Heleniums* of the flood plain and islands were giants compared with the dwarfs of the meadow country inland.

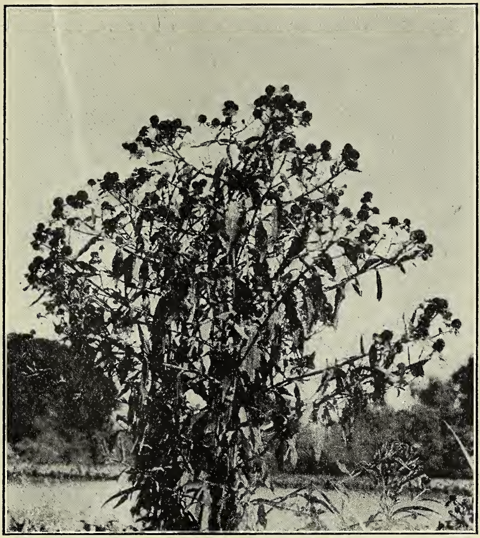


Fig. 20. *Helenium autumnale*

Fig. 21. *Polygonum pennsylvanicum*

Fig. 22. *Grindelia squarrosa*

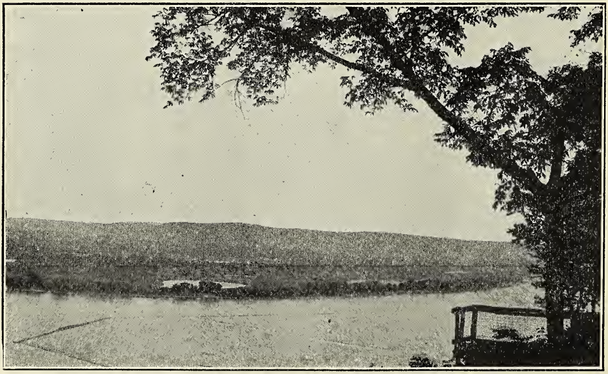


Fig. 23. Lakes in islands of the Mississippi

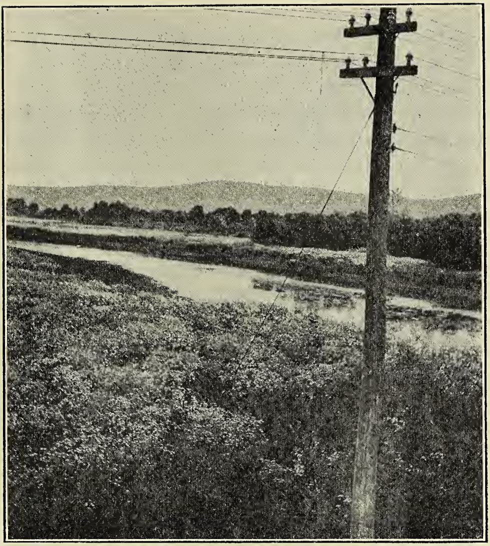


Fig. 24. *Aster salicifolius,* a flood plain plant

The Bee Pastures.— The Mississippi hills of the Iowa shore during the later part of August and early September showed only foliage traces of the profuse spring flora, as here and there the scarlet berried Ginseng or the blue berried Cohosh, with now and then along a rivulet or hedged about a spring the Jewel weed, spangled with orange or pale yellow cornucopias and encircled by bumble bees buzzing in and out. The only flowering plants were on the surfaces of the slopes exposed to the sun. *Clematis* or *Sicyos* vines lay on the bushes like great white blankets, here and at the damp base of the cliff or in the open spaces about the springs. Polymnia clumps stood out against the green tangle in cream colored patches and along the railway banks ran the low white catnip colonies. Here small bumble bees and honey bees worked briskly in the morning and continuously on through the lengthening shadows of the afternoon, dipping their proboscides into the many flowered heads, then moving with a whirr to the next cluster, or, having filled their baskets with the pollen or their sacs with nectar, straight up from the flowers they circled and flew toward the distant hive. Not seldom the heavy laden worker beaten low from its high line of flight by treacherous currents met its death in the river.

The honey bee seems less efficient in its movement than the small bumble bee, which usually visits only fresh flowers and inserts its proboscis without experiment in the right grove, while the honey bee visits old dilapidated flowers as well as fresh ones, hovers sometimes before it makes a decision as to which flower to visit and occasionally finds difficulty in making entrance.

Again when a dull, warm, blue-haze-wrapt day blended the vivid colors in a soft mosaic scheme, a sudden shower drove the large bumble bee to shelter. Heels upward it clung to the under surface of a flower cluster, its back fur coat protected from the drops; yet its small velvet coated collaborator diligently and even more vigorously beseiged the trembling rain-pelted flowers. The honey bee laboriously persisted for nearly half an hour then somewhat reluctantly disappeared, as finally, but more slowly did the small bumble bee, leaving the soundly sleeping big bumble bee swinging in the steady drip under the rain-buffeted flowers.

SUMMARY

The abundance of limestone and sandstone products as constituents of the soil and the abundant water supply affords a desirable environment for a wide range of flora.

The light of the forest is sparse in the height of summer and though water is abundant in the deep interior, the flowering plants appeared in the greater light period of early spring and summer, hence the deep forest in midsummer affords few nectar producing plants.

The open borders of the forest slopes and margins of open springs are the only habitats occupied by flowering plants. These plants are principally deep throated *Lobelia siphilitica, L. cardinalis, Impatiens bi-flora* and *I. pallida,* bumble bee pollinated plants.

The evenly watered, amply lighted, broad expanse of flood plain and island are the flower gardens of midsummer. The flowering plants are largely composites whose many flowered heads, closely arranged in flat, corymbose panicles, afford an easily accessible surface and copious pollen as well as nectar. The conservation of space in the arrangement of the composite flowers per unit area allows a valuable economizing of time by an insect.

The large bumble bee, the small bumble bee and the honey bee were the only insects whose activities were observed. The small bumble bee seemed to be a more efficient worker than either the honey bee or the large bumble bee. The greater length of its proboscis permits the small bumble bee to visit corollas having a wide range of tube lengths and to effect an entrance to flowers more readily than can the honey bee, while it has the advantage of more rapid movements than the large, slow moving bumble bee, thus enabling it to visit more flowers in period of time than the large bumble bee.

A uniform water supply is essential to copious flower production, on which nectar flow is dependent. Since most midsummer flowers are found in the open forest or prairie, the factor light may be regarded as quite as important as water.

Department of Botany,
Iowa State College.

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COMPARISON OF ABSORPTION OCCURRING IN CORN STALK TISSUE AND IN PREPARED BIOCOLLOIDS

L. E. YOCUM AND A. L. BAKKE

Growth, an important function of the plant, is characterized by being possible under a wide range of temperature, moisture, available plant food, and other limiting factors. It is a hydration of the colloidal material (protoplasm) of the plant to which, later in the life of the plant, matter is added. This added matter, of course, increases the dry weight. Protoplasm has been found to adhere so closely in its actions to the laws of artificially constructed biocolloids that many attempts are being made to construct a biocolloid whose behavior agrees with the observed behavior of protoplasm and in that way to determine more definitely its detailed structure and composition. The present study is an attempt to set forth the rate of hydration in corn stalk tissues and in artificially prepared biocolloids.

MacDougal and Spoehr [1] have carried on extensive work along the line of growth as related to increase in size of plant parts. Spoehr [2] has determined the constituents and their arrangement in the cell and MacDougal and Spoehr [3] have investigated the rate of hydration in many biocolloids. MacDougal [4] has compared their absorption with that in joints of *Opuntia.*

MacDougal [5] and Shull [6] show that increases in temperature cause increases in absorption according to definite ratios. MacDougal has found that the maximum swelling of agar and protein takes place at about 40° C., but that the higher the temperature, the greater the early hydration, with a consequent earlier state of complete saturation. He also noted that above 18° C. water is absorbed by *Opuntia* more rapidly than are acid or alkaline solutions.

Material and Methods.— Corn stalk tissue was taken from

[1] MacDougal, D. T., and H. A. Spoehr. Growth and Imbibition. Proc. Am. Phil. Soc., vol. 56, p. 289. 1917.

[2] Spoehr, H. A. Carbohydrate economy of cacti.

[3] MacDougal, D. T., and H. A. Spoehr. The effect of acids and salts on biocolloids. Science N. S., vol. 45, p. 484. 1917.

[4] MacDougal, D. T. Imbibitional swelling of plants and colloidal mixtures. Science N. S., vol. 44, pp. 502-505. 1916.

[5] MacDougal, D. T. Hydration and growth. Carnegie Inst. Wash. Pub. No. 297. 1920.

[6] Shull, Charles A. Temperature and rate of moisture intake in seeds. Bot. Gaz., vol. 69, pp. 361-390. 1920.

vigorously growing volunteer corn which was collected when in flower, October 8th, three days before a killing frost. The fourth to the seventh internodes were selected, split lengthwise, and cut to a length at which they would weigh ten grams. These were dried, and lost about 90 per cent of their weight. The dry tissue was stored in the laboratory until used.

The colloidal mixtures were made up according to the general method for making media. One and five-tenths grams of egg albumen were added to nine hundred cc. of agar after cooling to 40° C. These media were poured on porcelain plates which had been greased with just enough vaseline to show a "grain" when rubbed with the finger. Two hundred cc. were used in each case. After the prepared colloidal material was poured into the plates, it was allowed to remain in the laboratory for some time. Drying was hastened by blowing air over the plates by means of an electric fan. The colloids were later cut into pieces of the desired size, 30 square mm. Further drying was resorted to by placing the preparations in an electric oven held at 70° C. The squares after being trimmed off by means of a sharp pair of scissors were allowed to come to an equilibrium with the air before being used. The average thickness of the dry pieces was 0.145 mm. Throughout the work three solutions were used, namely, distilled water, 1/100 N solution of citric acid and 1/100 N solution of sodium hydroxide. The experiment was carried on at room temperature which was about 24° C.

The colloids were placed in a 7 cm. petri dish without cover which was placed in a 10 cm. petri dish. These were kept in the laboratory locker from which they were taken for weighing. The corn tissue was weighed and put in 100 cc. wide mouthed bottles. Four sections of each colloid and corn tissue were treated with distilled water, sodium hydroxide and citric acid.

The increase in absorption was ascertained by weighing. The weights were taken over a period of 39 days for agar and agar with egg albumen in the acid and sodium hydroxide solutions; 81 days in water was needed to bring the corn stalk tissue to its absorption maximum. The weighings were however, continued until there was a distinct loss in weight or the pieces began to break up so that accuracy could no longer be secured. For the first week the extent of absorption was determined daily but after that weighings were made once a week since excessive handling was not desirable. Before being weighed each piece or section was carefully dried between sheets of filter paper.

Since most of the measurements upon absorption in similarly prepared colloidal mixtures have been upon the basis of an increase in thickness, it was thought that as long as the weighing method was used in the present study, it would be desirable to see how the two forms would correspond.

In Table I, a summary is given of a number of determinations. It will be noticed that there is a comparatively close agreement.

TABLE I. *COMPARISON OF THE PERCENTAGE OF ABSORPTION BASED UPON AN INCREASE IN THICKNESS AND UPON AN INCREASE IN WEIGHT*

Time Immersed	2 Days		9 Days	
	Weight	Thickness	Weight	Thickness
Agar water	3022	3011	3463	3338
Agar NaOH	1392	1613	1966	2270

The data given in Table II show the diferences in the total absorption.

TABLE II. *THE TOTAL ABSORPTION IN PERCENT FOR CORN, AGAR, AGAR AND EGG ALBUMEN*

	Water	Sodium Hydroxide	Citric Acid
Corn	863	851	583
Agar	4072	2105	1706
Agar and egg albumen	3921	2002	3457

The accompanying graph, (Fig. 25), shows the comparative rate of absorption. The first weight was taken after four hours and cannot be distinctly shown on the diagram. The early increase in weight cannot be entirely attributed to absorption. This early increase is greater and continues for 20 hours in the constructed colloids while for the corn tissue it is much less. It is a rather striking feature that the maximum point of swelling for each medium is reached at about the same time in the different solutions. For example, the maximum amount of swelling of agar, agar and albumen, and corn tissue in sodium hydroxide is practically reached in 39 days. The curves show many similarities in the rate of absorption, as for example in sodium hydroxide the rather rapid hydration ends in four days. After 19 days there is very little gained. The same general close relation holds true with water. Agar and albumen in citric acid is a notable exception in correlation. This shows a rapid, nearly equal rate of absorption so near as to fall within the range of

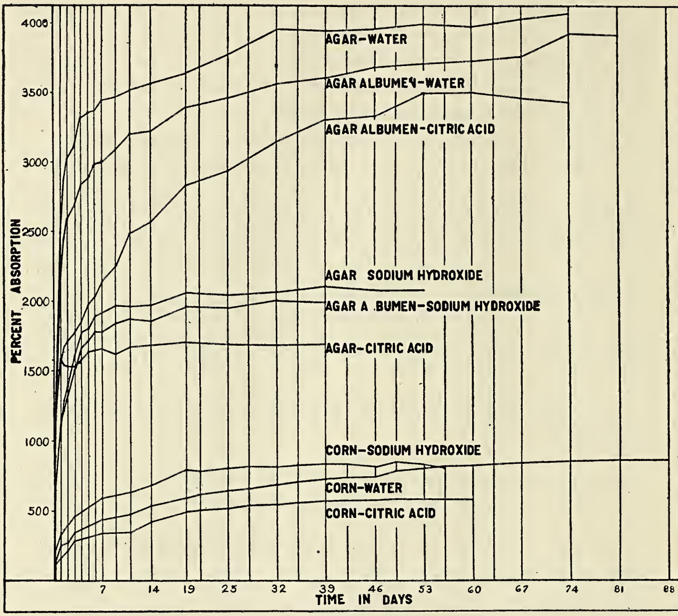

Fig. 25. Graph showing the progress of absorption occurring in corn stalk tissue and in colloidal mixtures.

experimental error. The greatest change in absorption is caused by the addition of albumen to agar, when immersed in citric acid, which for the first day is the same as plain agar in citric acid.

Discussion.— Direct comparison of percentages with other investigators cannot be definitely made because there is such a variation in the conditions under which the work was done. The results as far as their physical nature is concerned, are much the same.

MacDougal has found that in *Opuntia* young tissue absorbs least; mature, most; and old, between the two extremes. We considered this corn tissue to be young and it is likely that mature plants would show a much greater amount of swelling. This might bring the maximum swelling more nearly up to that of agar in acid or alkaline solution. MacDougal has been able to greatly reduce the absorption of water and bring it more nearly equal to that of acid and alkaline solution by the addition of any gum. If this were possible in this case the correlation would be very close. The proportion of swelling in corn tissue and MacDougal's *Opuntia* joints is remarkably similar in that the effects of water and sodium hydroxide are nearly equal and acid solution causes two-thirds as much swelling. It is expected that different plants will vary in their hydration capacities. This would be especially likely if Dachnowski [7] is right in assuming that chemical and enzymatic actions are important factors.

Conclusions.— The comparative rate of absorption of these constructed colloids is quite similar to that of corn tissue, which is, however, much lower.

Plain agar has a very high rate of absorption. This could likely be reduced by the addition of a gum.

Albumen added to agar greatly increases the absorption of acid, and reduces somewhat the absorption of water.

Young corn stalk tissue has a water relation similar to that found for *Opuntia* joints.

Department of Botany,
Iowa State College.

[7] Dachnowski, Alfred. Effects of acid and alkaline solutions upon plants. Am. Jour. Bot., vol. 1, pp. 412-440. 1914.

THE MECHANICAL PENETRATION OF THE SWEET CORN PERICARP

BY R. A. RUDNICK AND A. L. BAKKE

Hawkins and Harvey,[1] Rosenbaum and Sando,[2] and Hawkins and Sando [3] have used a modified Joly balance fitted with a puncturing needle to determine the force necessary to puncture the cells of the potato tuber, tomato, and certain smaller fruits. For the penetration of these tissues a relatively small force is necessary.

However, it occurred to the authors that a similar mechanical penetrating device might be of service in determining the relative puncturing force of the pericarp of sweet corn. Inasmuch as the pericarp of the sweet corn is tough, it became necessary to employ a device where a greater pressure could be obtained than in the usual form of Joly balance.

For this work then, the pulley and stand of a Ganong auxanometer apparatus was fitted with scale pans of a chemical balance by means of braided linen cord of sufficient length to give a free uniform movement. To one of the stirrup hooks was attached firmly a glass needle having a diameter of 0.5 mm., this dimension being obtained by grinding a needle slightly larger with emery. The features described are apparent on examination of figure 26.

The portion of the pericarp used was the part back of the germ taken as far back from the tip as was possible. This layer was glued to a cork having a hole bored through it. Later a small piece of glass tubing having a diameter of 3.5 mm. was securely sealed with sealing wax. The matter of fastening each membrane to a cork naturally consumed considerable time as a new cork would have to be used for each test. To obviate this, the pericarp layer was placed between two pieces of glass tubing which had had their edges ground so that they would fit. This jointed

1 Hawkins, L. A., and Harvey, R. B. Physiological study of the parasitism of *Pythium debaryanum* Hesse on the potato tuber. Jour. Agr. Research, vol. 18, pp. 275-297. 1919.

2 Rosenbaum, J., and Sando, C. E. Correlation between size of the fruit and the resistance of the tomato skin to puncture and its relation to infection with *Macrosporium tomato* Cooke. Amer. Jour. Bot., vol. 7, pp. 78-82. 1920.

3 Hawkins, Lon A., and Sando, Charles E. Effect of temperature on the resistance to wounding of certain small fruits and cherries. U. S. Dept. Agr. Bull. 830. 1920.

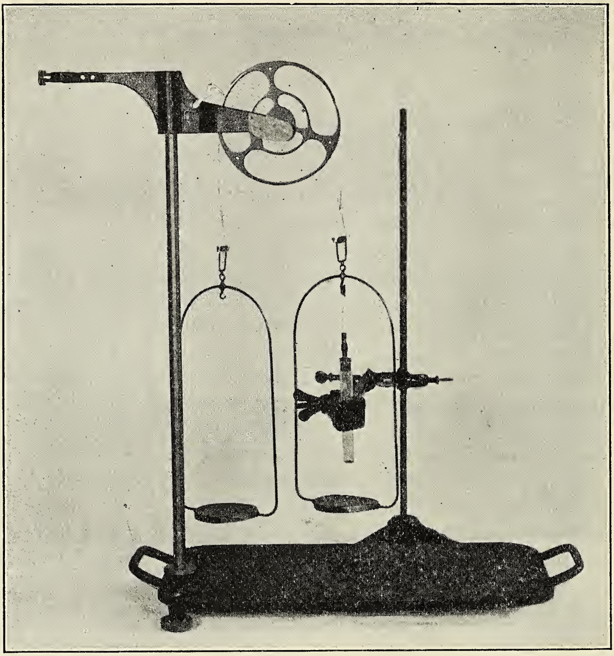

Fig. 26. Machine to determine the force necessary to puncture the pericarp of sweet corn.

glass tube was inserted into a cork and it in turn was securely placed in a vial supported by a clamp attached to a support. By such an arrangement it became an easy matter to centralize the pressure exerted by the glass needle. Weights were then added until the pericarp layer was punctured. The pans used plus the friction of the attached corn represented a weight of 32 grams.

The variety of sweet corn used was the well known Stowell's Evergreen. The corn came originally from Connecticut but had been grown in Iowa for varying periods, one, two and three years. The corn was carefully selected from the plots so that the three stages, canning, dented and mature were typical for such designation. The number of grams necessary to cause penetration of the first series, that which has been grown in Iowa for one year, is given in the first column of Table I. The effect of soaking the seed for varying periods at room temperature upon the physical penetration was also a part of the proposition and is shown in the remaining columns. In practically every case there were at least four readings taken. In the data only the averages are given.

TABLE I. *DATA SHOWING THE NUMBER OF GRAMS NECESSARY TO PENETRATE THE PERICARP OF "STOWELL'S EVERGREEN" SWEET CORN WHEN DRY AND WHEN SOAKED FOR VARYING PERIODS. THE CORN HAD BEEN GROWN IN IOWA FOR ONE YEAR (1919)*

	Dry	8 Hrs.	12 Hrs.	24 Hrs.	36 Hrs.	48 Hrs.	72 Hrs.
Canning stage	103.75	88	121	93.5	93.6	89	70.8
Dented	111.75	89.5	93	90.2	92.6	90.25	107.7
Mature	134	80.3	83	72.7	54	53.8	51.2

In the canning stage the number of grams necessary for the penetration is a little less than for the dented and consequently smaller than for the mature. On soaking the penetration force of the pericarp of the mature fruit is much less than in the corn selected at the canning period. This same relation is also apparent when comparing the mature and dented kernels.

TABLE II. *DATA SHOWING THE NUMBER OF GRAMS NECESSARY TO PENETRATE THE PERICARP OF "STOWELL'S EVERGREEN" SWEET CORN WHEN DRY, AND WHEN SOAKED FOR VARYING PERIODS. THE CORN HAD BEEN GROWN IN IOWA FOR TWO YEARS (1918 AND 1919)*

	Dry	8 Hrs.	12 Hrs.	24 Hrs.	36 Hrs.	48 Hrs.	72 Hrs.
Canning stage	92	82.3	121	97.8	69.4	98.2	68.2
Dented	121.5	93.5	93	95.7	70.5	65.4	89
Mature	172.75	85	94	90.2	64.75	67.6	87.2

In the same variety of sweet corn grown in Iowa for two years the pericarp when dry is punctured by 92 grams, as compared with 103.75 grams at the canning stage; the dented requires 121.5 and the mature, 172.75 grams. There is a wide difference between the three stages of development. Soaking the seed for varying periods from 8 to 72 hours gives results that are somewhat diversified.

In Table III, the differences in the penetration force between the different stages — canning, dented, and mature — is practically as well marked as in the previous citations. Soaking the

TABLE III. *DATA SHOWING THE NUMBER OF GRAMS NECESSARY TO PENETRATE THE PERICARP OF "STOWELL'S EVERGREEN" SWEET CORN WHEN DRY AND WHEN SOAKED FOR VARYING PERIODS. THE CORN HAD BEEN GROWN IN IOWA FOR SEVERAL YEARS*

	Dry	8 Hrs.	12 Hrs.	24 Hrs.	36 Hrs.	48 Hrs.	72 Hrs.
Canning stage	116.7	75	89.25	73.5	64.7	72.7	63.2
Dented	119.5	83	92.75	94.2	71.8	57.4	58.5
Mature	147.5	74	82.75	99.2	58.7	80.2	65.8

kernels for different periods gives results that are at variance with each other.

Considering the dry pericarp itself it is evident that there is much variation throughout. Knowing that plant tissues are modified considerably by the environmental conditions which affect the plant, it is only natural to expect variations in the three sets. The weather conditions of 1918 and 1919 were much different, the former being characterized by periods of very intense evaporation. The present study does not concern itself with the evaporating power of the air and its effect upon the balance between the forces of transpiration and absorption. The province of this publication is simply to show how the proposed mechanical device can serve as a measure of the toughness or mechanical resistance of the pericarp layer.

Recognizing the fact that the data herewith submitted are meager yet the following conclusions are fully substantiated:

(1) There is a considerable variation in the force necessary to penetrate the pericarp of sweet corn in the canning, dented and mature states: — the more mature requires the greater force.

(2) Soaking sweet corn seed for varying periods from 8 to 72 hours does not give a commensurate reduction in the force necessary to penetrate the pericarp.

Department of Botany,
Iowa State College.

THE DOWNY BROME GRASS IN IOWA

H. E. JAQUES

Our state has a number of troublesome weed grasses, worst of which at the present time is, likely, the Squirrel-tail Grass (*Hordeum jubatum* L.) which is now to be found almost everywhere within the state and is very annoying in crowding out better grasses and in injuring livestock. Only a few decades ago is was scarce within our borders. While theoretically it is easily controlled and though it is hated by farmers everywhere it thrives and extends its area every year. If the loss duè to it could be computed it would doubtless prove to be heavy.

This mention of the Squirrel-tail has been made because of its similarity in habits to the Downy or Awned Brome Grass (*Bromus tectorum* L.) which this article discusses. Thirty years ago, the Squirrel-tail did not seem to promise as much as a weed pest as does the Downy Brome today. Both have been introduced from Eurasia; both are winter annuals; and both could be readily exterminated if cut early enough in the year to prevent the maturing of seeds.

The plant is of slender erect leafy growth, with softly pubescent leaves and open nodding panicles the spikelets of which are tipped with long silky awns. It grows from six inches to two feet high and while thriving in cinders, sand or other poor soil where it approximates its minimum size, it does well on good soil and makes a much larger plant.

The date and means of its introduction into the United States and into Iowa seem uncertain but do not appear to date back many decades. In Iowa it is most abundant along the railroad tracks and in only two or three cases have we failed to find it around elevators and stockyards.

The railroads have had much to do with its introduction and spreading. In some regions it grows in unbroken strips along miles of track. It is thus practically continuous along the Burlington tracks from Mount Pleasant to Fairfield, a distance of twenty-three miles.

There is, of course, the question as to whether or not this weed can establish itself in pastures and meadows as has the Squirrel-

Fig. 27. Downy Brome Grass, about one-third natural size.

tail. In a few places it has been observed running out into thickly sodded areas and apparently thriving in the face of the competition of blue grass and timothy. It matures its seed even earlier than Squirrel-tail, and the seeds are disseminated long before one thinks of cutting weeds. This early seeding which has made Squirrel-tail such an obnoxious weed permits the Downy Brome to extend its area unchecked.

As late as 1912 Doctor Pammel gave in the "Weed Flora of Iowa" only five counties in which it was known to exist. During the recent seasons we have been observing it and while in many cases the record has been neglected it has been identified and record made for the following towns within our state: Monroe, Pella, Keota, Washington, Glendale, Lockridge, Beckwith, Cantril, Donnellson, Mount Pleasant, Delta, Rose Hill, Oskaloosa, Osceola, Allison, Belle Plaine, Center Junction, Oakville, Fairfield, Rockwell City, Sherwood, Yetter, Ells, Denison, Villisca, Corning, Afton Junction, Clark, Malvern, Council Bluffs, Minden, Neola, Avoca, Havelock, Harlan, Kirkman, Ames, Irwin, Botna, Manning, Glidden, Halbur, Carnarvon, Wall Lake, St. Charles, Fremont, Hedrick, What Cheer, Kirkville, New Sharon, Lacey, Bernhardt, County Line.

Iowa Wesleyan College,
Mt. Pleasant, Iowa.

THE RELATION OF THE SMALLER FOREST AREAS IN NON-FORESTED REGIONS TO EVAPORATION AND MOVEMENT OF SOIL WATER

IRWIN T. BODE

The importance of the climatic and edaphic relations of forests has been the basis for wide discussion and study. The scope of this field is shown in a condensed way in a report of the Sub-Committee on Forest Investigations to the Fifth National Conservation Congress,[1] which discusses studies undertaken up to the time of the report (1913) and presents in general results obtained. Recently, Zon,[2] in a paper, "Forests and Water in the Light of Scientific Investigation," has presented a much more comprehensive view of the subject and the literature. He has attempted to bring together "all the well established scientific facts in regard to the relation of forests to the water supply." The work includes an extensive bibliography.

It is not necessary in the present discussion, therefore, to attempt to review the whole field or all of the literature with reference to these edaphic and climatic relations. Such citations are made as are pertinent to the particular phases of the present studies.

In connection with the management of the timber-lands in the Southwest, Pearson [3] has presented considerable data as the result of studies to determine the influence of forest cover upon local climate. The effects upon air temperature, soil temperature, precipitation, atmospheric humidity, and wind are included. Only meager information, however, is presented as to the relation of forests to soil moisture and evaporation. With regard to evaporation, Pearson states that the influence of the forest in decreasing the same is 30 per cent greater in Europe than it was found to be in his studies for New Mexico and Arizona.

1 The relation of forests to water, Rept. Sub-committee on Forest Investigations to Fifth National Conservation Congress. November, 1913.

2 Zon, Raphael, Forests and water in the light of scientific investigation, Final Rept., National Waterways Commission, Appendix V.

3 Pearson, G. A., A meteorological study of parks and timbered areas in the western yellow-pine forests of Arizona and New Mexico. Reprinted from Monthly Weather Rev., 41, 1615-1629. 1913.

Hall and Maxwell,[4] Toumey,[5] Bray,[6] and Schwartz [7] have confined their studies more particularly to the influence of forests upon stream flow, although Bray includes studies concerning the general influence upon climate and the relations of various plant associations to soil moisture. Hall and Maxwell present very interesting information regarding the flood problem along the courses of various streams in the United States. They show that, with certain exceptions, the tendency is toward increased floods and that this has a relation to the forest cover especially on the slopes of the drainage area, which slopes are considered by them as making up the vital part of a water-shed. Zon arrives at a similar conclusion.

None of these writers, however, has dealt to any great extent with direct measurements of soil moisture in forested areas, to determine specifically the extent to which forests control the movement of soil water after the surplus has passed on as run-off, and the effect that this influence may have as regards the water table throughout a region in general. It is true that Zon does present extensive information to show that there is a direct relation between forests and stream flow, seepage into the soil, flow of springs, etc., and he establishes further that there is an important relation existing between forests and the water table.

The importance of this latter problem has been more fully presented by McGee.[8] He shows that the level of the water table throughout the United States has lowered appreciably within the past fifty years, having dropped 12.5 feet in Iowa. He shows also the importance of forested areas in connection with this lowering.

It was with these considerations in mind that the studies here discussed were undertaken. It is recognized that the work done is of more or less preliminary nature, and that the results of various phases at least are to be interpreted as indications of certain deductions rather than as permitting final conclusions.

The work consisted of two lines of investigation: first, the determination of the rate of evaporation for forested and open

4 Hall, Wm. L., and Hu Maxwell, Surface conditions and stream flow: U. S. Dept. Agric., Forest Service, Circular 176, January, 1910.

5 Toumey, James W., The relation of forests to stream flow: Reprinted from U. S. Dept. of Agric., Yearbook for 1903.

6 Bray, Wm. L., The timber of the Edwards Plateau of Texas; its relation to climate, water supply, and soil: U. S. Dept. Agric., Bur. Forestry, Bull. 49, 1904.

7 Schwartz, G. Frederick, The diminished flow of the Rock River in Wisconsin and Illinois, and its relation to the surrounding forests: U. S. Dept. Agric., Bur. Forestry, Bull. 44, 1903.

8 McGee, W J, Wells and subsoil water: U. S. Dept. Agric., Bur. Soils, Bull. 92, 1913.

sites and for sites representing a stage between these two; second, soil moisture determinations for forested and open sites.

THE AREA

The area chosen for these tests was in the "Backbone" State Park in northwestern Delaware county, Iowa. It is in a section of the state which was covered by the older continental glaciers, where there is still a large portion of native timber growth and where conditions do not approximate so nearly the prairie conditions of other parts of the state. The park area itself is rough in topography and typical of much of that country, which is not valuable for agriculture other than for grazing.

Description of Sites.— Four main sites were selected upon which to locate the various stations as described in Table A. All of these were at one time covered with heavy timber growth. This has been entirely cleared from sites 1 and 3. Site 1 has been continuously grazed since the removal of the timber, while site 3 has been grazed only occasionally and is now reproducing a timber stand. A good layer of litter and decaying vegetable matter covers the soil on sites 2 and 4, both of which still carry a heavy stand of timber growth.

EVAPORATION

Column 1 Table A shows the location of all the various stations.

Evaporation readings were made at stations as follows:

TABLE A. SITE AND DESCRIPTIONS AND STATION LOCATIONS

Site No.	Location of Stations and Exposure	Soil			Description	Chief Timber Species	Undergrowth Species	Ground Cover
		Surface	Subsurface	Subsoil				
1	X—Top	Silt loam	Light clay loam, some sand	Light clay loam, some sand	Open; heavy grass sod, wide scattered red cedar; formerly timbered; no brush growth; slope steep; pastured since cutting	Juniperus virginiana		Bluegrass; clover; scattered Achillea millefolium
	XI—Middle (south)	Very fine sandy loam	Silt loam, some sand	Silt loam, some sand				
	XII—Foot (south)	Very fine sandy loam	Very fine sandy loam	Fine sandy loam				
2	IX—Middle (east)				Timbered; no sod; trees forming full stand, complete canopy; slope steep, protected by ridges to north and south	Quercus ellipsoidalis, Quercus macrocarpa, Populus deltoides, Populus grandidentata, Ostrya virginiana, Ulmus americana, Tilia americana		Adiantum pedatum, Pteris aquilina, scattered grasses (very light)
3	V—Top IV—Middle (south) VI—Middle (north)				Not timbered; formerly timbered; dense stand of brush and timber reproduction; slope moderate; not continuously pastured	Populus tremuloides, Populus grandidentata, Populus deltoides, Quercus rubra, Quercus ellipsoidalis, Quercus alba, Juniperus virginiana	Rhus typhina, Rhus glabra, Corylus—(40 to 50 per cent of cover)	Heavy grass sod wherever openings occur
4	II—Top	Very fine sandy to silt loam	Very fine sandy loam	Very fine sandy loam, some clay	Timbered; dense stand with nearly complete canopy; moderate growth of underbrush and ground cover; slope steep	Quercus macrocarpa, Quercus rubra, Quercus ellipsoidalis, Acer saccharum, Ostrya virginiana, Ulmus americana, Carpinus caroliniana, Populus tremuloides, Populus grandidentata	Cornus alternifolia, Cornus asperifolia, Cornus circinata, Cornus paniculata, Physocarpus opulifolius, Viburnum acerifolium	Adiantum pedatum, Pteris aquilina, Pellæa atropurpurea, Asarum canadense, scattered grasses
	Ia—Foot (south)	Very fine sandy to silt loam	Sandy loam	Coarse sandy loam				
	Ib—Middle (south)	Very fine sandy loam	Sandy loam	Sandy loam				
	III—Middle (north)							

Timbered site: Station II (top of slope); station I b (middle of south slope); station III (middle of north slope); station IX (middle of east slope).

Brushy site: Station V (top of slope); station IV (middle of south slope); station VI (middle of north slope).

Open site: Station X (top of slope); station XI (middle of south slope).

The stations at the top of the slopes especially were located with respect to uniformity of exposure to the action of the wind from all directions, so that the only mitigating influence in this regard would be that offered by the vegetation.

Evaporation readings were taken morning and evening of alternate days, at 6 A.M. and 6 P.M. For these determinations the standardized cylindrical form of the Livingston atmometer was used.

Results of Evaporation Studies

These results have been brought together in tables B and C and in the form of a chart, figure 28.

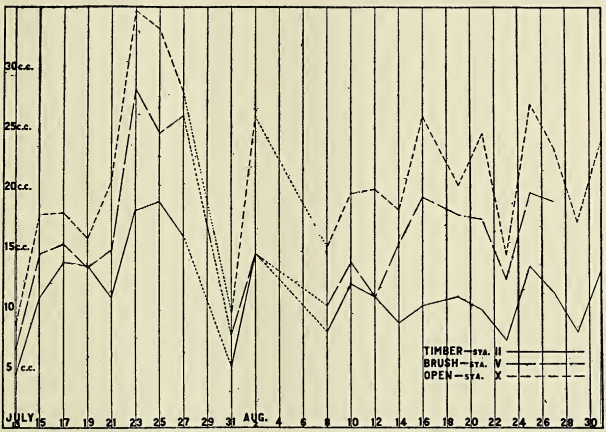

Fig. 28. Evaporation at top of timbered, brushy and open slopes. Readings for period 6 A.M. to 6 P.M. Fine dotted lines indicate points where readings were affected by precipitation.

In consulting table B it is found that the average daily rates of evaporation for the period of the tests for the stations at the top of the slopes are as follows: 11.24 c.c. in the timber; 15.83 c.c. on the brushy site; 20.25 c.c. in the open. Again, for the stations at the middle of the slope, the average daily rate is 7.12 c.c. for the timber, 12.87 c.c. for the brush and 18.69 c.c. for the open. Furthermore, the rate of evaporation for each individual day shows the same ascendency as the above averages. This comparison is shown diagramatically in figure 28.

TABLE B. EVAPORATION IN C. C. AT THE TOP AND MIDDLE OF SLOPE FOR TIMBERED, BRUSHY AND OPEN SITES

	Location—Top of Slope			Location—Middle of Slope		
Date	Timbered Slope (Sta. II)	Brushy Slope (Sta. V)	Open Slope (Sta. X)	Timbered Slope (Sta. 1a)	Brushy Slope (Sta. IV)	Open Slope (Sta. XI)
July 13	4.32	6.48	8.50	2.88	4.32	
15	10.80	14.40	17.64	5.76	8.64	
17	13.68	15.12	17.68	9.36	11.52	
19	13.32	13.24	15.64	6.94	13.68	
21	10.80	14.76	20.40	5.40	12.24	
23	18.00	28.08	34.68	14.40	19.44	
25	18.72	24.48	33.12	12.96	20.16	
27	15.84	25.92	27.88	12.24	21.60	30.24
31	5.04	5.76	9.52	2.16	5.04	7.20
Aug. 2	14.40	14.40	25.84	9.36	14.40	23.04
8	7.92	10.08	14.96	5.04	10.80	12.24
10	11.88	13.68	19.38	7.92	12.96	18.00
12	10.80	10.80	19.72	7.20	8.64	18.00
14	8.64	15.12	18.00	3.96	9.52	18.00
16	10.08	19.08	25.84	6.48	14.40	23.76
19	10.80	17.64	20.06	6.84	14.40	19.44
21	9.72	17.28	24.48	5.04	12.96	20.16
23	7.20	12.24	14.28	4.68	9.36	15.12
25	13.32	19.44	26.86	7.92	18.00	21.60
27	11.16	18.72	23.12	7.92	15.48	20.52
29	7.92		17.00	5.04		14.40
31	12.96		23.80	7.20		18.72
Total	247.32	316.12	425.38	157.70	257.56	280.44
Aver. for season	11.24	15.83	20.25	7.12	12.87	18.69

The results obtained here agree closely with data presented by Fuller [9] as the result of comprehensive studies carried on for three seasons in the sand dune region near Lake Michigan. He showed that in this region there exists a direct relation between the rate of evaporation and the succession from pioneer cottonwood to climax beech-maple associations. The average daily evaporation rates for the three seasons in this region were found by Fuller to be as follows: Cottonwood dune, 22.3 c.c.; edaphic prairie, 12.5 c.c.; Oak dune, 11.0 c.c.; Pine dune, 10.4 c.c.; Oak-hickory forest, 8.8 c.c.; beech maple forest, 7.0 c.c. Transeau [10] in connection with studies made near Cold Springs Harbor, Long Island, New York, has presented similar facts. Likewise, Weaver [11]

9 Fuller, G. D., Evaporation and soil moisture in relation to the succession of plant associations: Bot. Gaz. **58**, 193-234, 1914.

10 Transeau, E. N., The relation of plant societies to evaporation: Bot. Gaz. **54**, 424-426, 1912.

has found the same decrease of evaporation with succession of plant associations in Washington and Idaho. In Minnesota and Nebraska, Weaver and Thiel[12] found the same relation to exist.

Gleason and Gates[13] have studied the influence of the various types of vegetation in Central Illinois. They have presented facts to show that here, as in other regions, the differences in the amount of evaporation in various associations are due chiefly to the nature of the vegetation, and that the more primitive types have the higher rates of evaporation, while those most nearly like the climax types have the lowest rates.

In comparing the daily rate of evaporation at the top of the slope with that at the middle, the averages are found to be:

	Top	Middle
Timber	11.24 c. c.	7.12 c. c.
Brush	15.83 c. c.	12.87 c. c.
Open	20.25 c. c.	18.69 c. c.

Thus it will be observed that in each case the average daily rate is less at the middle than at the top of the slope, and reference to table B shows again that this is uniformly true for each day.

Again, comparing the rates for the north and south slopes as shown in table C the following averages are obtained:

	North	South
Timber	5.58 c. c.	6.79 c. c.
Brush	9.64 c. c.	12.26 c. c.

However, while the averages in this case are lowest for the north slopes it is not true that the readings for each individual day show the same relation. For example, on July 15, the evaporation was 1.44 c.c. higher on the north than on the south timbered slope. The same is true in several other instances. It is important to note in this connection that, in the cases where the evaporation of the north slope exceeded that of the south slope, the direction of the wind was northwest, northeast or westerly.

The lowest minimum evaporation for the season occurred on July 13 on the north timbered slope, being only 1.44 c.c. The lowest maximum (11.52 c.c.) occurred on the same slope on

11 Weaver, J. E., A study of the vegetation of Southeastern Washington and adjacent Idaho: Reprint from Univ. Studies, Univ. Neb., XVII, No. 1, January, 1917.

12 Weaver, J. E., and Albert F. Thiel, Ecological studies in the tension zone between prairie and woodland: Bot. Sur. Neb., New Series, No. 1, April, 1917.

13 Gleason, H. A., and F. C. Gates, A comparison of the rates of evaporation in certain associations in Central Illinois: Bot. Gaz., **53**, 478-491, 1912.

TABLE C. EVAPORATION IN C. C. FOR NORTH AND SOUTH SLOPES IN TIMBER AND BRUSHY SITES

		Site—Timbered Slope		Site—Brushy Slope	
Date		Direction of Slope		Direction of Slope	
		North (Sta. III)	South (Sta. 1a)	North (Sta. VI)	South (Sta. IV)
July	13	1.44	2.88	4.32	4.32
	15	7.20	5.76	10.80	8.64
	17	5.04	9.36	8.64	11.52
	19	4.68	6.94	5.40	13.68
	21	8.28	5.40	13.68	12.24
	23	7.20	14.40	15.48	19.44
	25	7.20	12.96	13.68	20.16
	27	8.64	12.24	15.12	21.60
	31	2.88	2.16	4.32	5.04
August	2	9.36	9.36	10.08	14.40
	8	5.04	5.04	9.36	10.80
	10	5.04	7.92	7.20	12.96
	12	3.60	7.20	5.76	8.64
	14	2.88	3.96	7.92	9.52
	16	7.20	6.48	12.96	14.40
	19	4.32	6.84		14.40
	21	3.60	5.04	12.24	12.96
	23	2.52	4.68	6.48	9.36
	25	11.52	7.92	15.84	18.00
	27	9.36	7.92	13.68	15.48
	29	5.76	5.04		
Total		122.76	149.50	192.96	257.56
Aver. for season		5.58	6.79	9.64	12.26

August 25th. The range from minimum to maximum for the various sites is shown in the following table, taken from the records of the stations at the tops of the respective slopes.

	Minimum	Maximum	Range
Timber	4.32 c. c.	18.72 c. c.	14.40 c. c.
Brush	5.76 c. c.	28.08 c. c.	22.32 c. c.
Open	8.50 c. c.	34.68 c. c.	26.18 c. c.

It is interesting to compare the data in this connection with observations made by Shimek[14] near Missouri Valley, Iowa, and by Weaver[15] in the mountains of northern Idaho. Shimek found, with cup evaporimeters, an average evaporation of 21.07 c.c. for the prairie as against 10.07 c.c. for the groves. Furthermore, in a series of curves he shows a direct increase in evaporation with increase of wind velocity and temperature; also, in his discussion, he presents facts bearing out the results obtained above relative to the evaporation on sites with north and south exposures, and relative to the effect of topography on evaporation. Weaver

14 Shimek, B., The prairies: Lab. Nat. Hist., Univ. of Iowa, **6**, 169-240, 1911-13.

15 Weaver, J. E., Natural reforestation in the mountains of Northern Idaho: Plant World, **18**, 31-47, 1915.

found the average daily evaporation to be 19.0 c.c. on north slopes as compared with 27.7 c.c. for south slopes.

Summary

The results obtained from the present studies in northern Iowa may be summarized briefly as follows:

Forest cover exerts a direct influence in checking evaporation.

There is a regular decrease in the rate of evaporation with the succession from open to brushy sites, and in turn to timbered sites.

The evaporation is uniformly greater at the top of the slopes than at the middle for all the sites.

The evaporation is greater on south than north slopes, except as influenced by the direction of the wind.

Topography and wind direction, therefore, both have a direct influence on the evaporation rate.

Forested areas have a distinct effect in equalizing the rate of evaporation as shown by the low minimum and maximum rates and the small margin or range of fluctuation throughout the season in the timbered area.

SOIL MOISTURE

Relation to Plants and Plant Associations

It has long been recognized that the amount of moisture in the soil is an important factor in all plant growth and distribution. Fuller,[16] Weaver,[17] Weaver and Thiel,[18] and other writers have shown that soil moisture content bears a direct relation to the type of vegetation found in various regions and to the succession of plant associations.

On the other hand, it is recognized that all the moisture present in the soil is not available for plant growth, and that plants wilt before the entire moisture content becomes exhausted. In work by Clements,[19] Livingston,[20] Briggs and McLane,[21] and Briggs and Shantz,[22] the point at which this wilting occurs is shown further to be by no means constant for the various soil types. Briggs and McLane compared the moisture retaining power of

16 Fuller, G. D., Bot. Gaz., **58**, 213-233.
17 Weaver, J. E., Univ. Studies, Univ. Nebraska, XVII, No. 1, 21-37.
18 Weaver, J. E., and A. F. Thiel, Bot. Sur. Nebraska, New Series, No. 1, 15-26.
19 Clements, F. E., Research methods in ecology, p. 334, 1905.
20 Livingston, B. E., The relation of desert plants to soil moisture and to evaporation: Carnegie Institution of Washington, Publ. No. 50, p. 78, 1906.
21 Briggs, L. J., and J. W. McLane, The moisture equivalent of soils: U. S. Dept. Agric., Bur. Soils, Bull. 45, 1907.
22 Briggs, L. J., and H. L. Shantz, The wilting coefficient for different plants and its indirect determination: U. S. Dept. Agric., Bur. Plant Ind., Bull. 230, 1912; Bot. Gaz., **51**, 210-219, 1911; and **53**, 20-37, 229-235, 1912.

different soils by subjecting them to centrifugal force, and have called the percentage of moisture retained the *moisture equivalent.* Briggs and Shantz have worked out the method which has come to be most generally used in comparing the available moisture supply of various types of soils. They have called the percentage of water remaining in soils when wilting occurs the *wilting coefficient.* Fuller has termed the amount of moisture contained in soils above the wilting coefficient *growth water.* Again, it has been shown that the wilting point of plants is not constant for the same plants and soil types. Brown,[23] has studied its relation to the evaporating power of the air and has found that the wilting point is reduced with reduction in evaporation. Briggs and Shantz [24] have found in another study that it varies also, although to a less degree, for the same soil with different types of plants. Therefore, a comparison of the total amounts of moisture contained by various soils is not a criterion of the ability of those soils to maintain plant growth.

It is necessary to recognize the above facts in view of the data presented here. The wilting coefficients have not been determined. The chief purpose is a study of the water holding capacity of the various soils and the relation of the movements of the soil water. It is evident that an increase in the total moisture content of an ordinary soil would make it more nearly capable of sustaining plant life without regard to the wilting coefficient.

Relation of Forests to Water Table

McGee [25] in his work explains how the general level of the water table of a region affects the total soil moisture content, and also the resultant effect that its recession has upon the amount of moisture available for the growth of plants in the upper soil layers. This, of course, in turn affects the ability of the vegetation to withstand periods of excessive drought and evaporation. He discusses further the causes for this recession, as does also Schwartz,[26] and it is not necessary to review the field here. A matter of especial note, however, is the general statement at which McGee arrives, namely, that it is clear that the lowering of the ground level of water is due mainly not to consumption of the accumulated stock, but to the cutting off of the natural source

23 Brown, Wm. H., The relation of evaporation to the water content of the soil at time of wilting: Plant World, **15**, 121-134, 1912.

24 Briggs, L. J., and H. L. Shantz, Bot. Gaz., **53**, 229-235, 1912.

25 McGee, W J, U. S. Dept. Agric., Bur. Soils, Bull. 92, pp. 7-11, 1913.

26 Schwartz, G. Frederick, U. S. Dept. Agric., Bur. Forestry, Bull. 44, pp. 13-15, 1903.

of supply — to the waste of storm waters through floods in lieu of compelling them to pass into the soil and enter the normal circulatory system through which alone the waters of the earth can be fully utilized. Thus, McGee concludes that so far as may be estimated, at least 80 or 90 per cent of the lowering recorded in 31 typical states is due not to excessive removal of water from the subsoil, but to failure to get a normal supply into the soil and on into the subsoil beneath.

Now, Zon [27] shows clearly that the effect of forest growth on soil water, in the immediate area of the forest at least, and in a level country with a minimum of run-off differs greatly from that in a mountainous or hilly country with maximum run-off. That is to say, in the former forests tend to act as drainers of the soil moisture and hence would apparently tend to lower the water table in their immediate vicinity. In the latter, because of the interception of run off, they have the opposite effect, namely, that of increasing the water content and of prolonging the period during which the water of the soil is depleted. He states further that observations carried on in forests over broken topography, where the geological strata are not horizontal, and the ground water therefore is in motion, and where there is a surface run-off, have failed to establish any lowering of the water table under the forest; also, that Hartman, hydraulic engineer for the State of Bavaria, found the water at Mindelheim (altitude 2000 feet) to be nearer the surface in the forest than outside.

Hall and Maxwell in their work relating to stream flow and floods bring out the same facts. Hence, upon first thought, the inference might be drawn that in an essentially level state like Iowa the general effect of forest areas with respect to the water table would be to operate to the detriment of general agriculture. However, in view of the many other influences which already have been established, the question arises as to what part forests really may have in governing the soil moisture content of a region in general and the direction or tendencies of water movement in the soils. In other words, how great a conservator of moisture is a forest in an essentially level region?

In this connection, the conclusions drawn by Shimek [28] are pertinent, namely, that the question of sufficient soil moisture in a region such as Iowa is one of conservation of the precipitation, that the claim that forests have no effect on precipitation has

27 Zon, Raphael, Rept. National Waterways Commission, Appendix V, pp. 238-245.
28 Shimek, B., Lab. Nat. Hist., Univ. Iowa, 6, 207-208.

no significance in connection with the forest as a conservator of moisture, and that both moisture of the air and of the soil will be conserved by protection against evaporation, which may be accomplished by topography or by groves.

Area and Site Descriptions for Soil Moisture Studies

The area on which the present studies were made comprises the hillsides and banks bordering both sides of the Maquoketa river near its headwaters. Lying in a section of the state which has not been glaciated for a long time, it has drainage fairly well established. The stream in this section depends for its regular flow largely upon underground waters which come out as springs all along both banks of the river. Part of these emerge from the immediate borders of the stream, while others break forth at considerable distances from the banks. The soils of which the tests were made are for the most part sandy, especially in the surface and subsurface layers, and the movement of water in them is apt to be well defined.

In choosing the sites an attempt was made to have the soil layers as nearly similar as possible, and also, to have the slopes nearly alike in elevation, degree of slope and exposure, so that the run-off in all directions would be approximately uniform except as checked by absorption into the soil. A study of table A shows, however, that the soils on the open slope are apt to contain less sand than those for the timbered slope, especially in the subsoil layer.

Methods

Soil moisture determinations were made for stations on open and timbered slopes as follows:

Timbered site: Station II, top of slope; station Ib, middle of slope; station Ia, foot of slope.

Open site: Station X, top of slope; station XI, middle of slope; station XII, foot of slope.

Soil samples were taken at these stations at three day intervals for depths as follows: surface (0 to 7 inches), subsurface (7 to 20 inches), and subsoil (20 to 36 inches). These samples were immediately placed in screw-cap containers and taken to camp where the moisture content was determined. This was calculated in per cent of air-dry soil.

Care was taken to have the various soil borings at each station not closer than six feet. The top of each hole was filled with a grass plug and mulched over. Thus the borings already made affected to a minimum degree the drying out of the soil and the normal water content.

Results of Soil Moisture Studies

The most direct comparison of the soil moisture content can be made by reference to the accompanying tables and charts. It becomes at once apparent that, on the whole, the curves which represent the timber soils, plotted on the charts with solid lines, are higher throughout the season than those for the respective soils in the open. The exact difference between these curves is shown in the following comparison of the averages for the period of the tests.

Location on Slope	Soil	Average in Timber	Average in Open
Top of slope	Surface	15.25	5.96
	Subsurface	16.23	10.66
	Subsoil	14.65	21.80
Middle of slope	Surface	13.39	7.03
	Subsurface	15.13	8.13
	Subsoil	13.20	17.38
Foot of slope	Surface	15.88	8.10
	Subsurface	18.00	6.16
	Subsoil	17.12	18.86

It will be noted that an exception to the generally higher average of the timber soils occurs in the subsoil layers. Here the subsoil of the open slope is 7.15 per cent above that of the timber at the top, but only 4.18 and 1.74 per cent higher at the middle and foot respectively. The reason for this becomes clear in considering the physical composition of the soil as shown in table A. With similar composition in all soils there would be every reason to expect a uniformly high average for all the timber soils. It is interesting, however, to note in this connection, how very little higher are the averages for the subsoils of the open, especially at the middle and foot, in spite of their greater clay content.

As shown in table E the maximum moisture contents with the exception of the subsoils, range from 19.45 to 28.3 per cent for the timber as against 14.75 to 27.85 per cent for the open. The minima range from 6.4 to 11 per cent as against 1.55 to 5.05 per cent, respectively. Here again exceptions must be made of the subsoils for reasons already stated. An important consideration, however, with respect to the minima in these latter is that, notwithstanding the uniformly higher content of these soils, the

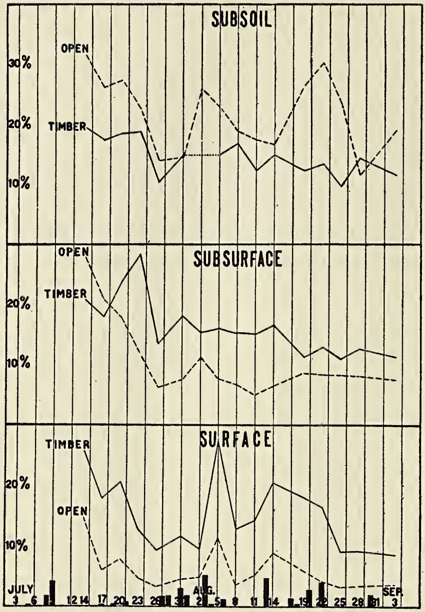

Fig. 29. Soil moisture content in per cent of air-dry soil for the top of timbered and open slopes — stations II and X, respectively. Rainfall, shown in solid columns at bottom, was approximately as follows:
For July: 5, .01 in.; 8, .43 in.; 9, 1.05 in.; 17, .01 in.; 19, .02 in.; 21, .16 in.; 27, .40 in.; 28, .42 in.; 30, .73 in.; 31, .43 in.
For August: 3, 1.30 in.; 4, .04 in.; 6, .30 in.; 13, 1.17 in.; 17, .30 in.; 18, .10 in.; 20, .75 in.; 22, 1.0 in.; 30, .40 in.

minima fall to points ranging only from .95 to 3.05 per cent above those for the timber soils.

Another interesting observation is the deficiency of moisture toward the latter part of the season in the subsurface layers of the open slope, especially at the middle and foot. These soils show the lowest constant average of any of the soils, after the general drop in July, while the corresponding timber soils show averages approximately the same as or higher than the normal for the others.

These considerations, in view of the character of the rainfall during this period, are undoubtedly significant, in that the precipitation was almost entirely in the form of heavy showers, tending to produce rapid run-off except as the precipitation was absorbed into the ground.

TABLE E. MAXIMUM AND MINIMUM SOIL MOISTURE CONTENT IN PER CENT OF DRY WEIGHT OF SOIL FOR OPEN AND TIMBERED SLOPES

Location of Station	Soil Depth		Timbered Slope		Open Slope	
			Moisture Content	Diff.	Moisture Content	Diff.
Top of Slope	Surface	Maximum Minimum	27.40 8.70	18.70	14.75 3.25	11.50
	Subsurface	Maximum Minimum	28.30 11.00	17.30	27.85 5.05	22.80
	Subsoil	Maximum Minimum	19.45 9.65	9.80	31.60 11.45	20.15
Middle of Slope	Surface	Maximum Minimum	26.05 6.40	19.65	19.85 1.55	18.30
	Subsurface	Maximum Minimum	25.00 8.00	17.00	16.50 3.35	13.15
	Subsoil	Maximum Minimum	20.10 7.60	12.50	31.55 8.55	23.00
Bottom of Slope	Surface	Maximum Minimum	24.80 9.95	14.85	25.15 1.70	23.45
	Subsurface	Maximum Minimum	29.00 9.45	19.55	21.90 1.85	20.05
	Subsoil	Maximum Minimum	23.50 8.25	15.25	28.25 11.30	16.95

Response of Moisture Content to Precipitation

Following the more or less clearly defined periods of precipitation it is possible to trace a rather definite response in the various soils.

After the showers of July 21, on the open slope there is no rise in the curves for the soils at the top. In all probability this is due to the high evaporation between the time of precipitation and the time of taking the soil samples on July 23, the effect of which would be the greatest at these stations. On the timber slope, however, there is apparent at the top a rise in the subsurface and subsoils. At the middle of the slopes no rise appears in either timber or open. At the foot the response is evident in the subsurface and subsoils of the timber slope but not of the open.

The rainfall of July 27 and 28 produced a general increase throughout the soils at the top of the slopes, this being the more marked in the timber. In the open at the middle and foot the increase is apparent in all the soils except the middle subsoil. In the timber, on the other hand, the curves remain approximately level or show a slight decrease. This might easily be the case in view of the character of the precipitation, which was in the form of showers of short duration, and further in view of the fact that just previous to this period the open soils showed a content equal to or very near the minimum reached for the season. Since these soils also show a finer texture they might be expected

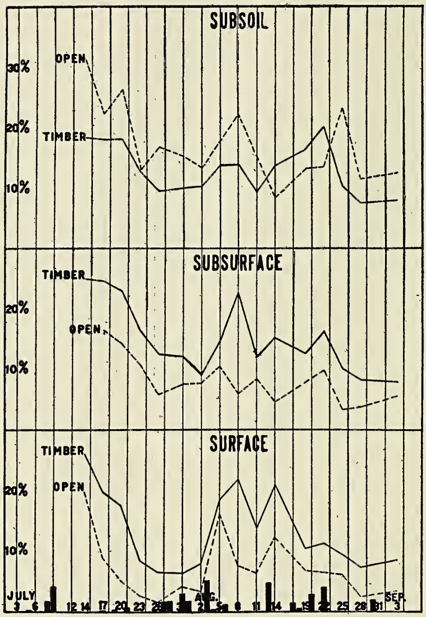

Fig. 30. Soil moisture content in per cent of air-dry soil for middle of timbered and open slopes — stations Ib and XI, respectively. For amount of rainfall see note, fig. 29.

to be more retentive of moisture, and any light precipitation would be apt to make itself more manifest here than in the timber soils, which latter may exhibit a more rapid permeability but showed more nearly a normal content before the showers occurred. It is important to observe here, however, that the content of the open soils does not reach that of the timber soils.

Following the rains which fell from July 30 to August 6, all the soils at the *top* of the timbered slope show a fluctuation with a decided rise in the surface soil. The rainfall was evidently sufficient here to maintain the moisture content in the lower layers and to add a considerable surplus to the surface. In the open, on the other hand, the rise is apparent in all the soils immediately and is greatest in the subsoil. It continues to August 5 in the surface but begins to drop in the subsurface and subsoil after August 2. Apparently then, there is in this case a more rapid gravitational movement and a greater influence of evaporation in the open than in the timber. This is particularly evident when the tendency of the curves following August 6 is considered.

At the *middle* of the slopes for the same period there appears a well marked continuous rise in all soils. This is greatest for the surface of both timber and open slopes and for the subsurface of the timber. Furthermore, the rise in the timber continues until August 8 in all soils, while in the open there occurs a drop after the 6th, except for the subsoil. The rains were heavy and the

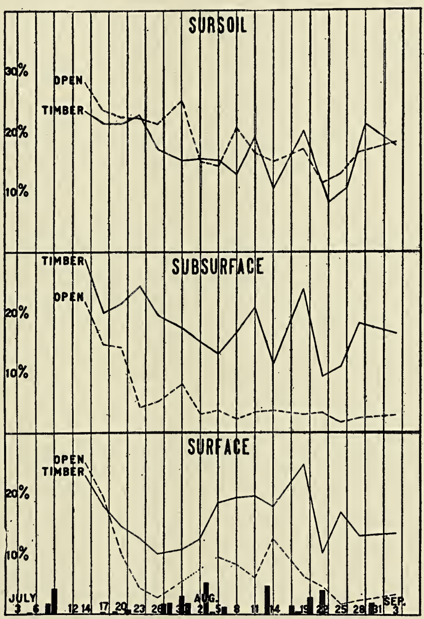

Fig. 31. Soil moisture content in per cent of air-dry soil for foot of timbered and open slopes — stations Ia and XII, respectively. For amount of rainfall see note, fig. 29.

run-off was rapid unless hindered. The subsurface of the timbered slope shows almost as great a gain as the surface, while in the open the corresponding gain is only a slight one. This would indicate again the greater power of obstructing run-off in the timbered slope, with the resultant benefit to the lower soil layers.

At the *foot* of the slopes the surface in both open and timber shows a distinct increase, but the subsurface and subsoils drop. This drop is the more rapid on the open slope. An important observation to be made at this point is that there is a marked increase lagging over into the dry period of August 6 to 11. This is decidedly more marked for the timber than for the open. The surface soils during this period show practically no increase in the timber and a decrease in the open. Then too, the subsoil of the open begins to show a drop following August 8, while in the timber there is a rise until August 11. Thus, there is further evidence of the gravitational movement toward the lower soil layers as well as toward the foot of the slopes, and also further evidence of the delaying or prolonging of the response to rainfall over a longer period in the timber soil, especially on the lower part of the slope.

The rain of August 13 was of a character which would produce moderate run-off. As a result, the response is manifested in general in all the timber soils except those at the foot of the slope. At the foot the effect of the rainfall is apparently delayed until after the 14th. In the open, however, there is evident very little or no rise in subsoils or in the subsurface soils at the middle and foot of the slope. Here, as before, the timber soils show clearly the greater amount of precipitation absorbed.

Moreover, consideration of the curves for the period subsequent to August 14, bears out other observations previously made. No precipitation is recorded until the 17th, but there is an increase in moisture content as follows:

For the Open Slope: Top of slope; in subsurface and subsoil. Middle of slope; in subsurface and subsoil. Foot of slope; in subsoil.

For the Timbered Slope: Top of slope; no increase. Middle of slope; in subsoil. Foot of slope; in surface, subsurface and subsoil.

With the exception of the foot of the timbered slope these increases for this period are accompanied by decreases in the respective surface soils. Furthermore, the increase in the timber soils is much greater than that in the open soils, this being particularly true for the lower parts of the slopes, and the increase at the foot of the timber slope extends into the subsurface and surface layers. There is in this case as in previous cases an evident gravitational movement, not alone from surface to subsoil, but also from the top to the foot of the slope. This is apparently in greater volume in the timber soils and becomes manifest at the foot of the slope much nearer the surface than in the open.

The showers during the period of August 17 to 20 were accompanied by intervening periods of comparatively high evaporation. They were neither heavy nor of long duration. As a result almost without exception the surface soils show a loss during this period except at the foot of the timbered slope. The subsurface and subsoils on the whole show a gain. This gain tends to become apparent earliest in the open soils, the timber soils again showing a tendency to lag behind. Also, with the exception of the clay subsoil at the top of the open slope, the timber soils show the highest gains. In the subsoils the moisture content remains approximately level at the top of the timbered slope but shows a decided rise at the middle and foot.

The rains of the 22d and 30th affected the soil moisture curves as did the previous periods of precipitation, and here again one of the outstanding facts is the delayed rise in the lower layers, especially at the middle and foot of the slopes, and the decidedly greater rises of the timber over the open soils.

SUMMARY

The comparative results of these studies are in many respects less clearly defined than those for the evaporation studies. A cursory consideration appears to indicate rather irregular results, with less clearly defined relationships of forest cover to soil moisture and especially to the movement of ground water than is the case with evaporation. It is true that the results obtained and the deductions made here should form the basis of further study, and they are presented as indications of existing relationships. However, certain rather direct influences are apparent.

On the whole, the timber soils used in this study show greater sand content and therefore would be expected to show, from the standpoint of physical composition alone, a more rapid rate of permeability and a lower moisture holding capacity than the finer textured soils of the open. This is of especial interest since it undoubtedly explains the relatively high moisture content of the subsoils of the open slope. Moreover, it emphasizes the importance of the influence of forest cover, in that actual comparison shows the coarser forest soils used in these studies to be capable of maintaining the higher moisture content in all instances but in the subsoil, and here there is found almost a clay soil in the open.

The average content of the timber soils as well as both maximum and minimum contents are above those for the open soils, with an exception made of the heavier subsoils of the open slope. This is most clearly emphasized toward the latter part of the season. The fact that, in the open, in spite of the greater retentive power of the heavier subsoils, the minimum drops to a point almost equal to or lower than that for the timber soils, is important, since, as has been shown by Fuller and by Briggs and Shantz and others, the wilting coefficients of such soils are higher than for the sandier soils. Furthermore the wilting coefficient of these soils would be expected to be above that of the timber soils, because as Brown and others have shown the wilting coefficient rises with increased evaporation of the air.

Throughout all of the above the greater absorptive power of the timber soils is apparent, as well as the influence this has upon the moisture content of the various soil layers. This is perhaps most strikingly manifested at the middle of the slopes where precipitation with rapid run-off has the least opportunity to penetrate into the subsurface and subsoils. It is found that on the open slope the subsurface soils at the middle and foot show the lowest constant averages of any of the soils, while the same relation does not exist in the timber.

The run-off is, therefore, without question the greatest on the open slopes. The result of this is especially marked in the subsurface and subsoil regions where we frequently find little or no response to rainfall in the open but a decided upward tendency of the curves for the timber areas. This difference seems more marked as the season progresses.

There is apparent a distinct gravitational movement of soil water from upper to lower soil layers and from the top toward the foot of the slopes. The lower soil areas rather uniformly show a continued increase in moisture content after the surface layers have begun to exhibit a drop. The difference in the rate at which gravitational movement takes place is not finally established, but every indication points to its being most rapid on the open slope following precipitation, and to its being in greater quantity, steadier, and distributed throughout a longer period in the timber soils. Furthermore, in these latter soils there is evidence of the increased volume of gravitational moisture and the delayed increase, during a period without precipitation, of the moisture content of the subsurface and even surface layers at the lower part of the slope.

Consequently, these general results all lead directly to a recognition of the close relationship between forest cover and soil moisture content in regions like the one under consideration here. They lead to the further recognition of the influence of forest areas of even small extent in maintaining greater quantities of moisture in the upper soil layers, and to their ability to prolong the period of gravitation of moisture, both from surface to lower soil strata and from upper to lower elevations on a slope. This, it is evident, would have a direct bearing upon the source of streams such as exist in the area discussed, where this source is largely in underground waters or springs.

Since in even a limited area, as was included in the present studies, the removal of the forest cover from one of the slopes has had the marked effect shown, indications point strongly to the final influence of forests in maintaining a higher water level throughout the region in general as being an exceedingly important one.

The writer desires to express his thanks to Dr. L. H. Pammel and Dr. A. L. Bakke for suggestions and criticisms in conducting the experiment and in preparing the manuscript.

Department of Forestry,
Iowa State College.

NITROGEN AND OTHER COMPOUNDS IN RAIN AND SNOW

JACOB E. TRIESCHMANN AND NICHOLAS KNIGHT

The importance of regularly analyzing the rain and snow for nitrogen and other compounds is widely recognized, both for its agricultural and hygienic significance. Messrs. F. T. Shutt and R. L. Dorrance of Ottawa, Canada, carried on a systematic investigation of the rain and snow through a period of ten years, 1908 to 1917, the results of which study have added much to our knowledge of the importance of the nitrogen compounds as an agricultural factor.

Our purpose has been to determine the amounts of the different nitrogen compounds, the chlorine, sulphates, and phosphates in the rain-water and snow of this locality — a continuation of the work which has been carried on here for a number of years, the results of which have appeared in the *Chemical News* from year to year.

The work was carried out in the Cornell College Laboratory under ordinary laboratory conditions. It covers a period of eight and one-half months, October 1, 1918, to June 15, 1919. The samples were collected in granite pans on an open spot near the center of the town, which has a population of about 2500. The town is without manufacturing industries, which eliminates excessive smoke contamination of the air. Every precaution was taken to prevent contamination. Samples were collected on the morning following the precipitation and analyzed as soon thereafter as was possible.

Altogether, 46 samples were analyzed, of which 36 were rain-water, and 10 were snow. There were 45 inches of snow and 18.50 inches of rain. This represents 22.25 inches of rain, considering 12 inches of snow equivalent to one (1) inch of rain. There have been furnished during the period 511.74 pounds of chlorine, 1.509 pounds of sulphates (as SO_3), and 5.2790 pounds of nitrogen per acre. The phosphates (as P_2O_5) supplied only .0086 pound per acre.

The tables appended do not include the sulphates and phosphates, as only fifteen samples produced sufficient sulphates for determination, and only eleven other samples showed a slight trace. The largest yield, from a sample collected on February 28, was only .262 parts per million. The average for the period is .03 parts per million. An unduly mild winter, with the atmosphere comparatively free from smoke and soot, no doubt accounts for this low average.

Five samples showed a trace of phosphates, while only four supplied a sufficient quantity for determination. The largest amount, on March 4, was only .03 parts per million. The average is .002 parts per million.

Table I gives the parts per million of the several nitrogen compounds and the chlorine content; the total for each precipitation; and the number of pounds supplied per acre.

The chlorine content averages 11.12 parts per million. It varies from 6.10 to 25.70 parts per million. Its presence in the atmosphere has been ascribed by Doctor Knight to salt particles carried in the air from the Atlantic ocean. No increase was experienced due to wind preceding or accompanying a precipitation.

The average of total nitrogen supplied for each precipitation is 1.046 parts per million. The totals for the 46 precipitations are fairly constant. Strong winds and severe electrical discharges on May 6, and on June 1 and 3, did not increase the amounts of nitrogen, but the total amount of nitrogen supplied on those dates is unusually high, especially on May 6 and 7 — the highest of the period.

The average parts per million for Free Ammonia is .407; for Albuminoid Ammonia, .366; for Nitrates, .255; and for Nitrites, .018.

Of the total nitrogen supplied during the period, 38.85 per cent is in the form of Free Ammonia; 34.99 per cent, Albuminoid Ammonia; 24.42 per cent, Nitrates; and 1.74 per cent, Nitrites.

The amount of the precipitation determines largely the total number of pounds of nitrogen supplied per acre. But an examination of the pounds of nitrogen supplied per acre by each of the 46 precipitations reveals a remarkable uniformity. When reduced to pounds per acre for one inch of rain, 43 of the 46 precipitations come within the narrow limits of .15 to .40 pounds per acre. The wide variance in the amounts of rain — .05 to 2.00 inches — indicates a marked degree of concentration in the smaller showers. The same standard reveals the fact that during continued precipitations, such as occurred June 1 to June 6, the total

TABLE I. NITROGEN AND CHLORINE IN RAIN AND SNOW

Parts per Million, Total for Each Precipitation and Pounds per Acre

Precipitation			Nitrogen in Parts Per Million						Chlorine	
Date	Kind	Amount in Inches	Free Ammonia	Albuminoid Ammonia	Nitrates	Nitrites	Total	Pounds Per Acre	Parts Per Million	Pounds Per Acre
1918—October 27....	R	.50	.450	Trace	.900	.007	1.357	.1539	21.40	2.4268
November 7...	R	.05	.450	.350	.800	0.50	1.650	.0187	21.40	0.2427
November 16..	R	.05	.925	.685	.500	.025	2.135	.0242	25.70	0.2914
November 17..	R	.34	.450	.275	.200	.002	0.927	.0701	10.20	0.7711
November 28..	S	.83	.500	.215	.300	.005	1.020	.1927	8.65	1.6283
December 8....	R	.40	.450	.600	.600	.010	1.660	.1506	10.20	0.9253
December 12...	R	.50	.475	.350	.240	.008	1.073	.1217	6.10	0.6917
December 13...	R	.10	.450	.365	.220	.005	1.040	.0236	8.65	0.1962
December 22...	R	.10	.450	.365	.140	.005	0.960	.0218	10.20	0.2313
December 24...	S	.67	.500	.365	.100	.004	0.969	.1464	8.65	0.1314
December 31...	S	4.00	.340	.275	.100	.007	0.722	.0545	6.10	0.4565
1919—February 2....	R	.10	.765	.525	.700	.045	2.035	.0562	No test	No test
February 13...	R	.70	.450	.215	.150	.010	0.825	.1410	8.65	1.3732
February 14...	R. & S.	.30	.515	.100	.150	.014	0.779	.0630	10.20	0.6940
February 15...	S	4.00	.195	.115	.100	.004.	0.414	.0413	9.00	0.6736
February 20...	S	4.00	.190	.110	.180	.020	0.500	.0478	10.20	0.7630
February 22...	S	4.00	.090	.040	.120	.028	0.278	.0310	15.13	1.1301
February 24...	R. & S.	.10	.300	.095	.120	.030	0.545	.0223	16.00	0.3629
February 26...	S	2.00	.210	.095	.230	.007	0.542	.0305	10.90	0.4201
February 28...	S	2.00	.215	.090	.300	.006	0.611	.0331	12.00	0.4627
February 28...	S	4.00	.120	.090	.250	.003	0.463	.0447	11.90	0.8906
March 4.......	S	3.00	.090	.750	.200	.002	1.042	.0691	6.10	0.2075
March 13......	R	.10	.450	.300	.500	.030	1.280	.0394	10.20	0.2813
March 14......	R	.25	.445	.090	.280	.007	0.822	.0566	10.20	0.6283
March 16......	R	2.00	.210	.275	.070	.001	0.556	.2522	8.87	4.1694

TABLE I—*Continued*

Precipitation			Nitrogen in Parts Per Million						Chlorine	
Date	Kind	Amount in Inches	Free Ammonia	Albuminoid Ammonia	Nitrates	Nitrites	Total	Pounds Per Acre	Parts Per Million	Pounds Per Acre
April 7	R	.50	.340	.350	.200	.009	0.899	.1018	17.75	4.1697
April 9	R	.75	.340	.340	.150	.005	0.835	.1521	10.15	1.7765
April 11	R	.10	.380	.400	.300	.028	1.108	.0351	14.20	0.4221
April 15	R	.90	.340	.250	.190	.004	0.784	.1700	17.75	3.6731
April 16	R	.13	.460	.400	.400	.007	1.267	.0461	10.15	0.2992
April 22	R	.20	.380	.430	.400	.010	1.220	.0653	7.10	0.3220
April 23	R	1.00	.320	.300	.260	.007	0.887	.2112	7.10	1.6602
May 1	R	.60	.575	.687	.110	.006	1.378	.1075	11.36	1.5459
May 3	R	1.80	.242	.320	.150	.005	0.717	.3027	11.36	4.6368
May 4	R	.80	.320	.200	.150	.002	0.672	.1319	10.15	1.7325
May 6	R	.20	.510	1.420	.150	.015	2.095	.1050	13.49	0.6119
May 7	R	.70	.850	1.500	.150	.001	2.501	.4070	7.10	2.2540
May 22	R	.30	.420	.365	.020	.009	0.814	.0654	11.36	0.7729
May 23	R	.34	.365	.320	.150	.006	0.841	.0736	7.10	1.0948
June 1	R	.15	.240	.320	.500	.020	1.080	.0467	14.20	0.4830
June 2	R	1.75	.650	.540	.130	.150	1.470	.5934	11.36	4.5080
June 3	R	.27	.550	.420	.480	.200	1.650	.1110	11.36	0.6955
June 4	R	1.10	.300	.300	.200	.002	0.822	.2151	7.10	1.8260
June 6	R	.50	.500	.610	.150	.010	1.270	.1540	7.10	0.8300
June 6	R	.65	.610	.285	.040	.001	0.936	.1480	17.75	2.6167
June 6	R	.18	.320	.365	.035	.004	0.724	.0396	10.15	0.4123
Totals		22.25	18.717	16.875	11.765	0.836	48.175	5.2790	511.74	46.0334
Averages		.48	.407	.366	.255	.018	1.046	.1147	11.12	1.0007
Percentages of total Nitrogen			38.85	34.99	24.42	1.74				

TABLE II. MONTHLY RECORD OF PRECIPITATION AND AVERAGE NITROGEN CONTENT

Month	Precipitation in Inches				Average Nitrogen in Parts per Million					
	No. of Precipitation	Snow	Rain	Total	Free Ammonia	Albuminoid Ammonia	Nitrates	Nitrites	Total	Pounds per Acre
1918—October	1	—	.50	.50	.450	Trace	.900	.007	1.357	.1539
November	4	10	.43	1.27	.581	.381	.450	.020	1.432	.3057
December	6	12	1.10	2.10	.444	.386	.233	.007	1.070	.5186
1919—February	10	20	1.20	2.87	.305	.147	.230	.017	0.699	.5109
March	4	3	2.35	2.60	.298	.354	.262	.010	0.925	.4173
April	7	—	3.58	3.58	.365	.362	.271	.010	0.998	.7816
May	7	—	4.73	4.73	.469	.687	.126	.006	1.288	1.2832
June	7	—	4.60	4.60	.455	.405	.219	.055	1.134	1.3078
Monthly average				2.78	.434	.339	.336	.017	1.113	0.6599

nitrogen supplied gradually diminishes — in this case from .40 to .20 pounds per inch of rain.

Table II is a monthly record of precipitation and it presents a few noteworthy features.

There is a gradual increase in the number of inches of precipitation from October, with .50 inches, to June, with 4.60 inches for the first half of the month.

Beginning with February, there is a gradual increase of total nitrogen in parts per million — .699 to 1.134. This, with the increased amount of rain in inches, furnishes an increasing supply of nitrogen per acre to the soil during the main growing season. The increase in pounds per acre during this period is from .3057 in November to 1.3078 in June.

The 45 inches of snow supplied 13 per cent of the total 5.2790 pounds of nitrogen per acre, or .6911 pounds. The rain supplied 87 per cent, or 4.5879 pounds per acre. The rain is thus found to be richer in total nitrogen content than the snow.

The work of Messrs. F. T. Shutt and R. L. Dorrance, mentioned above, has been of assistance in summarizing results.

Department of Chemistry,
Cornell College.

SOFT WATERS OF CENTRAL NEW YORK

NICHOLAS KNIGHT AND J. B. SHUMAKER

Sample No. 1.— The sample of water was taken from a well in the town of Sangerfield, Oneida county, New York, about a mile and a half south of the village of Waterville. It is located on the flat land in the bottom of the Sangerfield valley near the head-waters of Chenango river.

The well is forty-three feet in depth and was sunk in the early eighties. The top soil of the land in the locality is a clay loam and in boring the well the first twenty-seven feet encountered was hard clay. Underneath the clay was a dark coarse sand, entirely different from any other formation in the neighborhood. This is an artesian well and it flows continuously. The figures in the table below express the amounts of the different substances in a million parts of water.

Total solids	186.80
SiO_2	13.20
Fe_2O_3	00.00
Al_2O_3	3.20
$CaCO_3$	113.20
$CaSO_4$	4.00
$MgCO_3$	42.80
NaCl and KCl	11.80
Free ammonia	0.00
Albuminoid	0.00
Nitrogen in nitrates	0.00
Nitrogen in nitrites	0.0003

The water is pure and likewise unusually soft for the particular locality.

Dr. A. P. Brigham, Professor of Geology in Colgate University, in a private communication says: — "The bed rocks at Sangerfield for any moderate depth would be sandstone or possibly shaly sandstone of the Hamilton group; but the fact is that most of the well waters and pond waters of the region are very hard owing to the amount of limestone flour which has been incorporated in the local materials of the glacial drift by moving from limestone formations that lie to the northward. However, water of a softer character is sometimes obtained from the valley bottoms under thick beds of clay."

This water affords another good illustration of how the character of the rock and soil determines the quality of the water in the region.

Our thanks are due Dr. Nelson O. Brooks, physician of the board of health of the city of Oneida, New York, for his interest in sending us the sample of water for this analysis.

Sample No. 2.— This is a shallow well, only twelve feet in depth, also from Oneida county, New York, near Fish creek, possibly eighteen or twenty miles distant from the well described in No. 1. The analysis is as follows, in parts per million:

Total solid residue in platinum dish	186.4
SiO_2	2.6
Fe_2O_3 and Al_2O_3	1.8
$CaCO_3$	99.6
$CaSO_4$	27.0
$MgCO_3$	47.40
NaCl and KCl	11.80
Free Ammonia	00.00
Albuminoid ammonia	00.00
Nitrogen in nitrates	0.10
Nitrogen in nitrites	0.002

The water is also pure and soft as would be expected from the locality in which the shallow well is located. It is in the pure white sand about half a mile distant from Oneida lake. The water doubtless comes from the lake and so would have half a mile of a pure sand filter. This would easily account for its freedom from organic contamination and softness and absence of much solid matter in solution.

We desire to express our thanks to James L. Bentley for sending us the sample of water.

Department of Chemistry,
Cornell College.

THE USE OF THE TERMS FLINT AND CHERT

WALDO S. GLOCK

Reference to almost any two text books in geology will show that there are different usages for the terms flint and chert. Perhaps much of the confusion is due to the fact that the origin of these substances is unknown, in which case exact definition at this time would be premature. Whatever the reason it seems advisable to bring out the variability of definition, if for no other purpose than to state a problem without attempting its solution.

Blackwelder & Barrows.— Elements of Geology, 1911, page 39.

Flint is defined as "a very compact, dark grey, siliceous rock." Farther on, chert is said to be "an impure flint, usually of light color;" both occur in limestones.

Chamberlin & Salisbury.— Introductory Geology, 1914, pages 268, 287-289.

"Flints and cherts occur in limestone both as nodules and as distinct beds." Under alterations of rocks it is stated that silica which was primarily deposited as shells is later gathered into nodules or concretions of chert or flint. Concretions of chert (silica) are common in limestone. Preference is given to mode of occurrence, while no distinction is drawn between the two terms.

Chamberlin & Salisbury.— Geology, Advanced course, 1904, Vol. I, page 426.

There is here no essential difference in the use from that in the "Introductory Geology" except that cherts are termed impure flints and that both may occur in limestone and chalk. In a reference list of the more common minerals under which it is admitted that common usage is more or less inconsistent, the definitions are given: chert — "an impure flint, usually of light color and occurring abundantly in concretionary form as nodules in certain limestones;" flint — "a compact dark chalcedonic or lithoid form of quartz." No sharp rules are laid down.

H. F. Cleland.— Geology, Physical and Historical, 1916, page 77.

"Flint and chert are gray to black, translucent to opaque, quartz masses which occur in chalk and limestone."

Grenville A. J. Cole.— Rocks and Their Origin, 1912, pages 38-42, 62-63.

Flint, a form of silica, is described as being the most common substance that replaces calcium carbonate in limestone. For three paragraphs flint is strictly associated with the chalk of the Cretaceous of England. Then comes the information that casts of crinoids are found in the flints of the Carboniferous limestone. "Radiolaria have now been well recognized as flint formers, even in dark 'cherts' of Silurian age." In a discussion of sandstone it is said, "Bands of flint (chert) occur in certain sandstones, — — — —. These are due to the cementing of certain layers of chalcedonic silica." Toward the end the author makes no attempt to conceal the fact that he regards flint and chert as identical.

W. O. Crosby.— Tables for the Determination of the Common Minerals, 1911, page 84.

Flint and chert are described as compact or cryptocrystalline, and not glassy.

J. D. Dana.— Manual of Geology, 1895, pages 83, 480.

Chert is called an impure flinty rock and flint is used in reference to the chalk deposits.

W. E. Ford.— Dana's Manual of Mineralogy, 1912.

Flint is placed under the cryptocrystalline varieties of quartz.

Archibald Geikie.— Textbook of Geology, 1903, page 141.

There is no strict definition. Flint is assigned to chalk but it is held that chert is impure flint most of which occurs in limestone.

A. W. Grabau.— Principles of Stratigraphy, 1913, pages 764-765.

"Flints characterize chalk, and chert layers abound in many limestones. Chert concretions occupy the same relation to limestone that flints do to chalk." Thus flints are assigned absolutely to chalk and cherts to limestone.

A. J. Jukes-Brown.— The Building of the British Isles, 1911.

Throughout scattered pages the term "cherts" is used only in connection with sands and limestones; "flint" is used with chalk.

E. H. Kraus.— Descriptive Mineralogy, 1911, pages 74-75.

Flint,—"Gray, smoky, brown, — — — —, nodular variety (of quartz) closely related to chalcedony. It is usually found in chalk beds and limestone." Chert, — "A more or less general term applied to hornstone, impure flints or jaspers." They are thus described as more or less general terms.

Lake & Rastall.— Textbook of Geology, 1910, pages 151-152.

Cherts are said to be chalcedonic silica that occur in limestone, as in the Lower Carboniferous rocks of North Devon. Flint is "nodular and shapeless masses of black or gray chalcedonic silica — — — — in chalk." The author gives a definite distinction which, of course, would allow a clear usage.

J. Le Conte.— Elements of Geology, 5th Edition, 1903, page 169.

It is specifically stated that flints are siliceous concretions in chalk while in limestone they are called chert.

C. K. Leith.— An article in "Types of Ore Deposits."

"Chert as defined in the textbooks, is an amorphous and hydrous variety of quartz, but in the field the term has been generally applied to siliceous bands such as those found in limestone, with little regard to their microscopic or chemical characteristics. Some of the so-called cherts in limestones are very fine-grained or amorphous. The cherts of the iron formation are similar in every respect to those of the limestones. They show the same irregularity of texture, interlocking of quartz grains, and often very fine grains. However, it cannot be said that any of the so-called chert in the Lake Superior region has been found to be truly amorphous and hydrous." Leith probably had in mind the bands of quartz which with their distinct crystalline properties should not be called cherts. Among the various sources, however, flint and chert appear to be regarded more often as cryptocrystalline than amorphous. Evidently the author would base a definition of chert on microscopic and chemical characteristics.

Sir Chas. Lyell.— Principles of Geology, 11th Edition, 1872.

Flints may occur either in chalk or limestone while chert is only impure flint.

H. A. Miers.— Mineralogy, 1902, pages 373-381.

"Under the microscope chalcedony is found to be crystalline, consisting of minute fibers, — — — — they are therefore quite distinct from true quartz, and chalcedony is not, as was formerly supposed, merely a massive or micro-crystalline quartz — — — —. 'Flint' contains sponge spicules and is of organic origin; it often contains crystallized quartz in its cavities. 'Hornstone' and 'chert' are names given to compact flinty varieties of chalcedony; the latter is generally also of organic origin." He evidently distinguished flint and chert on the basis of composition, crystalline properties and origin.

Moses & Parsons.— Mineralogy, Crystallography and Blowpipe Analysis, 1904.

Flint is put under the jasper varieties of quartz. Flint is "smoky-gray to nearly black, translucent nodules, found in chalk beds."

William H. Norton.— Elements of Geology, 1905, pages 18, 375.

Chert is not mentioned. In referring to the limestone of Missouri it is said to contain nodules of flint that are left on the surface by the decay and removal of limestone. Further on it is remarked that flints were formed in the accumulation of the Cretaceous chalk of England and France. Evidently flint is an ordinary feature of both chalk or limestone and is not to be defined on the basis of occurrence alone.

James Park.— Textbook of Geology, 1914.

Flints are said to occur in chalk and cherts in limestone.

A. H. Phillips.— Mineralogy, 1912, page 361.

"When dark in color and associated with limestone in nodules it (chalcedony) forms flint." There is no mention of chert.

Pirsson & Schuchert.— A Textbook of Geology, 1915.

On page 496 an attempt is made to assign separate origins to flint and chert but at the end an appended reservation concedes that they may be formed in either way. The authors state it has been held that flints are of diagenetic origin and the cherts "develop near the surface in the zone of circulating ground waters during the process of weathering." It is probable also that flints are caused by meteoric water. As to definitions. "Flint (p. 274) is a dark gray to black, very hard and compact substance occurring in irregular nodules, or concretions, in chalk. It is composed of silica, SiO_2, with a little chemically combined water. An impure flint, occurring in a similar way, in limestones, is known as chert — — — —." In the appendix, page 410, flint "is an intimate microscopic mixture of crystallized silica, SiO_2 (quartz), and non-crystalline silica containing some combined water (opal). Its color is dark gray, or black, from organic matter; its hardness is well known and like that of quartz; it cannot be scratched by the knife or by feldspar — — — —. Its occurrence as concretions and masses in chalks and limestones (in the latter often called chert) has been alluded to in this book (page 274)." The quotations speak for themselves. However, the authors do present a possible solution for the lack of a definite term for the great amounts of silica interbedded with iron ore. "Somewhat similar masses of silica, more or less pure, sometimes white or light gray, and often differently colored by iron (yellow, red, or brown) and other substances, in some cases of similar but often of different or uncertain origin, have been variously termed jasper, jaspilite, hornstone, novaculite, etc. In places like the jaspilites of the Lake Superior region, or the novaculites of Arkansas, they may form beds of considerable importance."

H. Ries.— Economic Geology, 1910.

The author considers flint or chert as a single term and calls them nodules in limestone and chalk. However, he does say that our main supplies of flint come from France, England and Norway where extensive chalk deposits occur.

Tarr & Martin.— College Physiography, 1918, page 20.

The whole matter is dismissed by a sentence: "The minerals opal, chalcedony, agate and jasper are impure varieties of silica, as in the rock flint, or chert."

The Americana Encyclopaedia.

Chert: —"A cryptocrystalline variety of quartz closely related to flint. It is found in limestone and other stratified rocks." Flint: —"A subvitreous variety of quartz resembling chalcedony somewhat — — — — and occurs chiefly in the chalk of England and France."

Encyclopaedia Britannica.— Eleventh Edition.

Flint: — A dark gray, or dark brown cryptocrystalline substance which has almost a vitreous luster, a splintery, conchoidal fracture and is opaque. Its specific gravity is 2.6. "Flint occurs primarily as concretions, veins and tabular masses in the white chalk in such localities as the south of England. Chert is a coarser and less perfectly homogenous substance of the same nature and composition as flint. It is gray, brown or black, and commonly occurs in limestone in the same way as flint occurs in chalk." Under concretions: —"Another very important series of concretionary structures are the flint nodules which occur in chalk, and the patches and bands of chert which are found in limestone.

— John Smith Flett.

CONCLUSION

The question resolves itself into two parts: first the distinction, if any, between the terms, and second the present usage or exact meaning of the two.

Is there a difference between flint and chert? Apparently siliceous nodules were found in the chalk of England and called flint while later, and elsewhere, siliceous nodules in the limestone were found and called chert. It appears that authorities such as A. W. Grabau, A. J. Jukes-Brown, Lake & Rastall, J. S. Flett in the Encyclopaedia Britannica, and Pirsson and Schuchert to a certain extent propose to draw a hard and fast line between the two substances, depending on their occurrence in chalk or in limestone. So far as present knowledge is concerned their origin is professedly uncertain. A. C. Trowbridge and E. W. Shaw in the "Geology and Geography of the Galena and Elizabeth Quadrangles" (Illinois State Geological Survey, Bull. 26, 1916, pp. 80-81) state the case by pointing out that the origin of cherts and chert bands is entirely problematical. Therefore it seems altogether out of place and quite confusing to base, simply for the sake of apparent exactness, a precise distinction on mode of occurrence when, in all possibility, flint and chert may be found subsequently to have identical origins and thereby cause the terms to be synonymous.

In the second place come the physical characteristics of flint and chert, their composition and the limitations to surround the use of the terms. Confusion appears to have arisen by attempting to assign minor differences to each. On the whole the color varies from almost white through gray and brown to black, the hardness is that of quartz or slightly different owing to impurities, and the fracture is conchoidal. As to texture the silica has been described as amorphous, or cryptocrystalline, or coarsely crystalline, or a mixture of the first two. Limitations should be applied here since the use of chert for coarsely crystalline silica will infringe sooner or later on the field of quartz itself and will meet obvious difficulties. Such admittedly is its misuse as intimated in the citation from C. K. Leith. Concensus of opinion, however, tends to restrict the terms to cryptocrystalline and amorphous varieties of silica. Another stumbling block lies in the composition as related to texture which relation is given as impure quartz, or crystalline silica, or amorphous and hydrous silica, or a mixture of crystallized silica and non-crystallized silica with a little chemically combined water. Mineralogists, as Dana, Kraus, Miers, Moses and Parsons, Crosby, and Phillips include both flint and chert under the anhydrous varieties of the oxide of silica.

The entire confusion seems to result solely from the uncertainty, warranted no doubt, that envelops the terms. The fact stands out that they are blanket terms which, in the present state of knowledge regarding them, should not be circumscribed by hard and fast rules. On this account, however, they should not be made promiscuous "catch-alls" whose latitude may be unwisely increased by including much more than the simple siliceous nodules and bands in chalk and limestones. Until such a time when investigation shall point out the true origin, and the differences if any, or variations, in mode and place of occurrence, form, composition, texture — in other words point out the real nature, limitations and gradations of the terms flint and chert as applied to their field equivalents — it would be well for the sake of truth to forbear an attempt at exact definition. Under the circumstances precision is at the present premature and probably misleading.

THE DEPARTMENT OF GEOLOGY,
STATE UNIVERSITY OF IOWA.

AGRICULTURAL GEOLOGY

JOHN E. SMITH

During reconstruction, as the present period is frequently termed, many new applications of the principles of pure science to special fields of endeavor are being made. The principles of geology thus applied during recent years have given rise to economic geology, mining geology, engineering geology, oil geology and perhaps to that branch of the subject indicated by the above title, for it is not entirely new. The application of the principles of the science to the solution of the geological problems that are met in agricultural enterprises and pursuits, in brief, the relation of geology to rural welfare may appropriately be considered as agricultural geology.

Such a problem is that of securing an abundant supply of pure water. In regions of copious rainfall it is essential, in those of average to minimum rainfall it is absolutely necessary to consider the properties and the structure of the substrata in their relation to water in order to obtain such a supply. Pursuant to the requirement of this necessity, the United States Geological Survey maintains a branch of service whose work is concerned with the water resources of the entire country. The purity of subsurface water depends chiefly on the filtering power of the yielding rocks. One of the best natural filters consists of residual material of considerable depth. Some rocks below this mantle are sufficiently pervious to contain, transmit, filter and consequently to yield pure water. Certain others are impervious. Another condition is found where the rocks contain joints or cracks along which water moves freely without filtration, conveying to wells or springs contamination from distant sources. This condition is a strong possibility in limestone regions. Artesian water which, in some localities flows from wells, may be found where the properties and structure of the containing rock bear such a relation to a supply of water as will produce it. Under one combination of these conditions, as in areas of jointed igneous or metamorphic rocks in the Piedmont belt, an artesian well may yield a few hundred gallons daily; under another, that of a pervious sedimentary rock overlaid by impervious ones which outcrop in a moist region of higher elevation, as in the Great Plains, the yield may be several hundred gallons per minute.

Among the minerals most useful in agricultural pursuits are coal and other mineral fuels, the mineral oils (kerosene and gasoline), iron, salt, gypsum, lime, the minerals of the soil, and the fertilizer minerals yielding potash, phosphates and nitrates. The nature, quality, distribution and availability of most of these substances bear direct relations to their respective geological occurrences. In order that careful discriminations may be made in their purchase and use, those who have need for them should be familiar with their distinguishing properties and with their relative values.

In numerous localities natural gas is obtained from considerable depth. Gas provides fuel and light for use in buildings and power for machinery. Examples of such uses are common in agricultural districts in gas-producing regions from Pennsylvania and West Virginia via Illinois southwestward to Texas and in other places, where many farmers depend almost wholly on the gas wells for these services. Gasoline for the auto and the tractor is now being extensively made from natural gas. At Anaconda, Montana, the tallest smokestack in the world, 585 feet, was erected to protect vegetation from destruction by smelter gas and soil from ruin by erosion due to this loss of its vegetative cover. Ducktown, Tennessee, and other mining districts afford additional illustrations of these principles. The gases and dust from the smelters, from the blast furnaces of the steel industry and from the flues of the cement mills, through skillfully devised systems of careful collection and concentration, are soon to yield a large proportion of the potash used as fertilizer.

In road building the adaptation of various materials even when only sand and clay are needed is determined by the properties of the minerals and rocks considered for this purpose and by the nature of the base on which the road is to be constructed. In locating a road along or near a slope or in any topographic position where strata outcrop, the drainage and therefore the safety and permanence of the road, or its failure, depend on the kinds of rock involved and on their structural relation. The rapidly growing use of motor vehicles emphasizes the importance of details in regard to road materials and road locations.

From the rocks at the surface or below it, suitable material is obtained for buildings and other structures necessary in agricultural enterprises. Such materials are used in making brick, cement and concrete, in building roads, bridges, dams and retaining walls and in the erection of dwellings and other buildings. A knowledge of the properties and adaptations of structural materials is essential to the intelligent selection of them and to their efficient use. It is also necessary in many localities to understand thoroughly the relations of the substrata to the surface in order to choose safe locations for permanent structures.

The way in which undrained areas were formed has much to do with the solution of the problems that arise when drainage is undertaken and with the kinds of soil reclaimed when the project is completed. Whether an area must be drained by means of surface ditches or whether an exit may be found through a pervious layer of rock below depends wholly on the elevation and on the nature and structure of the substrata. In arid and semi-arid regions the possibility of irrigation as well as the permanence of the aqueduct is dependent also on geologic and topographic factors. Of the sewage disposal plants which are needed on all farms most types can be located with safety in regard to water supply only by considering fully the conditions of geologic structure and materials in the vicinity.

The losses of soil by erosion due to the action of wind or of water and in some localities due to the additional influence of improper tillage and pasturage bear definite relations to the topography of the area affected. Unfortunately the rich, black humus of the top soil, which is the best part of it, is the first to be removed — a fact that makes early prevention imperative. If the losses are permitted to continue a great succession of gullies and barren ravines soon develops and a worthless area is formed where valuable land could have been retained. The water table is perceptibly lowered over large areas by increased depth of drainage channels or removal of protective cover and this is another serious loss. On the other hand proper drainage may change an alkali soil to a fertile one. The chief processes that cause these losses involve the principle that the transporting power of running water varies as the sixth power of its velocity. This means that a current whose velocity is three miles per hour can carry more than eleven times as much sediment as one whose velocity is two miles per hour and that a current of three miles per hour loaded to its capacity will, on being reduced to two miles per hour or less, deposit more than 90 per cent of its load. When a flood current subsides or is checked, an area of rich soil may be covered to a depth of several feet with sand and other worthless material. Prevention and partial restoration of losses may be accomplished as follows: Meandering channels may be replaced by large drainage ditches and with the aid of catchment basins in regions having high rate of rainfall, prevent flooding and erosion of river bottom land. Other losses may be wholly or partly prevented by constructing retaining walls, by the use of tiling or of lined open drains, by contour tillage, by limited pasturage, or by planting trees, shrubs or grasses. Restoration may be partly made by constructing dams or by other means of ponding to check the current and arrest the moving sediment, thereby changing the area from one of erosion to one of deposition.

Soil origin finds its explanation chiefly in the field of geology; soil distribution, largely in that of physiography. Different kinds of soils are produced from different kinds of rock or from the same kind of rock when subjected to different processes during the course of origin. For example, soils originating from a given kind of rock in a warm, wet climate will be very unlike those derived from the same kind of rock in a cool, arid region. A third kind of soil will result if the materials from the same kind of rock are transported and sorted by water before forming the final soil; a fourth kind if transported by glaciation; and a fifth, if deposited by the wind. The various kinds of soil may differ from each other in number of mineral constituents or in the different proportions of each. The development of hills and valleys and other topographic forms by erosion gives rise to a different kind of soil in each topographic location. Kinds of soil arise also in numerous other ways each of which is a response either directly or indirectly to geologic or physiographic processes and conditions.

Classification of soils that they may be subjected to treatment conducive to the greatest production depends chiefly on the accurate use of the principles of soil origin and distribution. The changes recently made by the United States Bureau of Soils in the revision of classification units that were used in mapping a number of years ago afford excellent illustrations of this fact and of its recognition by the Soil Survey. The new divisions formed are based almost wholly on genetic and topographic relations—the principles of geology and physiography being applied to a much greater extent and in greater detail than in the earlier work.

The distribution of vegetation in so far as it is controlled by topography, kind of rock and geologic structure constitutes an important phase of agricultural geology. The distribution of soils, of rainfall, of temperature and of plant and animal life, the location of water courses, of valleys and uplands, of railways, highways and of markets as well as the adaptability of various areas to their respective agricultural uses are, to a remarkable extent, arranged in accordance with the topography and with the kinds and relations of the underlying rocks.

The principles of improvement in domestic plants and animals are found in a diligent study of the geological history of their respective races and are fully illustrated in the development of the present forms of life from the ancient ones. These great changes in form, stature and intelligence make some of the useful stories in the earth's history as they are revealed by the record that is written in the rocks.

By the study of this history man is encouraged in self improvement and in the realization of his responsibility to the world about him; he is inspired to higher ideals in his relations with his fellow man and in the field of intellectual achievement; he is stimulated to a more intelligent understanding of the powerful forces in nature and of their influence on the origin and on the destination of the human family.

In view of the present awakening to the needs of people in agricultural vocations and of the many relations of this science to rural welfare, it seems reasonable to expect that the study of agricultural geology in colleges and elsewhere will be extended until it is shared by all who are preparing to do work in rural improvement and that each will continue this study long enough to be able to apply the subject with intelligence.

Department of Geology,
Iowa State College.

A FIELD OF ESKERS IN CENTRAL IOWA

JOHN E. SMITH

(*ABSTRACT*)

This area is located chiefly in Polk County, one to three miles west of Camp Dodge in a swampy section of the south side of Beaver Creek valley. It is just north of the recessional moraine that extends in an east-west direction across parts of Polk and Dallas counties. Within an area about a mile wide and two or three miles long lying mostly in sections 19 and 20 of Jefferson township, there are a dozen or more eskers which the writer first studied during observations made in this locality in 1910.

The eskers are irregular in size when considered individually and when compared with each other and vary as follows: in width, 10 yards to 100 yards; in height, 15 feet to 40 feet or more; in length, 100 yards to one mile. They contain clay, sand, gravel and coarser material and show some stratification. A few of them are nearly at right angles to the general direction of the moraine in this vicinity, some of them are nearly parallel to the direction of the valley (southeasterly), and some lie in a component of the two directions. Among them a few winding curves are found and some of them end in or near a field of kames. As no good structure sections of the eskers were available for study, no explanation of their origin was given.

During the discussion of the paper, these eskers were compared with those in Worth and Dickinson counties.

Department of Geology,
Iowa State College.

A NOTE ON A SINK HOLE

E. J. CABLE

Most sink holes occur in regions where the underlying rock is dominantly calcareous. They are variously shaped depressions in the surface into which the run-off is carried away as subterranean drainage.

Sink holes are due, (1) to an enlargement by solution of joints and fissures, or, (2) to the caving in of the tops of subterranean caverns. They vary in diameter from a few yards to several miles. Where sink holes are due to the solvent action of meteoric waters along joints or fissures they are more or less round, but where they result from the caving in of the roofs of subterranean caverns, they are more irregular in outline. After their formation many sinks are given dendritic pattern by the erosive work of surface streams which flow into them.

Often sink holes become clogged, due either to a filling up of the joints or fissures, or to a sudden rise of the ground water surface. In such instances lakelets are formed.

Sink holes are common in many parts of Iowa. In the northeastern part of the state where the glacial and residual rock mantle is thin and the underlying rock is highly calcareous, sink holes, in places, are the most conspicuous features of the landscape.

In some parts of the state farmers have attempted to drain small ponds and marshes on their land by boring holes through the more or less impervious rock mantle and thus connecting the surface drainage with the subterranean fissures and joints. In some instances where the sink holes become an asset for surface drainage, farmers direct their tile ditches into these sink holes.

In the spring of 1918, a peculiar sink hole was observed in Pocahontas county. The county is deeply covered with drift except in local areas where the underlying St. Louis limestone is subject to the solvent action of meteoric waters. The sink hole in question is located seven and one-half miles to the south and east of the town of Rolfe.

Instead of proving ready egress for surface waters the sink

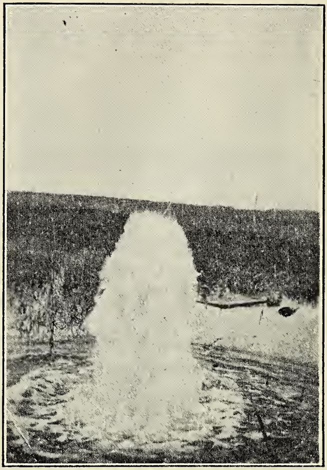

Fig. 32. Sink hole south of Rolfe, Pocahontas county.

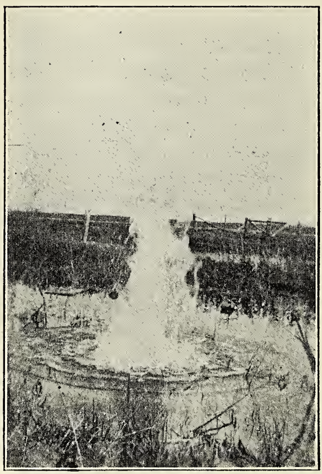

Fig. 33. The same sink in a later stage.

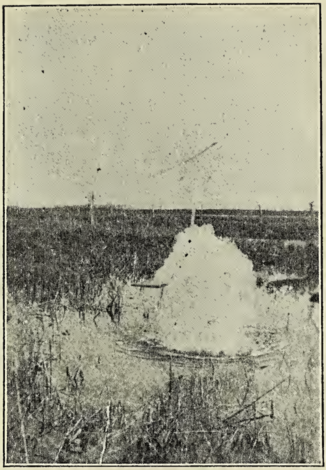

Fig. 34. The same sink in a still later stage.

hole not only filled up with water, but became a spouting spring. A column of water several feet high and several inches in diameter was continuously forced up. The phenomenon was so unusual that its fame spread and people came from considerable distances to witness the novelty. Although the spouting was continuous for three or four weeks the amount of water forced up varied and it was observed that there was a gradual decrease in the flow, until after the heavy spring rains the flow ceased and finally even the lakelet disappeared. Compare figures 32, 33 and 34.

That the water was not the immediate run-off was shown by the fact that the water forced up through the sink hole was clear and free from sediment. The phenomenon may have been due either to tile ditches connected with this particular sink hole, or a natural drainage to this particular joint or fissure. Sufficient underground drainage was directed to the joint to develop the hydrostatic pressure.

Department of Geology,
State Teachers College.

A NOTE OF PROGRESS ON THE STUDY OF THE IOWAN-WISCONSIN BORDERS

E. J. CABLE

During the past year the writer has found some time to continue his investigations of the Iowan and Wisconsin borders.

As stated in a former article,[1] there is a strong field evidence that the Iowan margin in Hardin and Grundy counties will need to be revised, especially in the vicinity of Eldora, Hardin county. Owing to the thinness of the Iowan drift, the high state of its weathering, and its complex relations to the loess, much more detailed work will be necessary before a definite boundary can be determined upon.

There are suggestions that a terminal moraine of Wisconsin age in Cerro Gordo county continues into Worth county, to the east of the Colby moraine, as outlined by Calvin in Cerro Gordo county.

Mr. I. A. Williams in his report of the geology of Worth county,[2] divides the Wisconsin drift into two distinct areas. This division was made upon the field evidence of (1) the freshness of contours, and (2) drainage. The eastern terminal moraine belt is located in the northwestern part of Northwood township, the extreme eastern part of Hartland township and the southern part of Brookfield township, see map, figure 35.

About six miles to the west of this outer moraine is a second irregular belt of drift which Mr. Williams calls the inner terminal moraine. This moraine exhibits its most marked characteristics in Bristol and Fertile townships. In the last named township this inner moraine coincides with the outer moraine.

This same prominent ridge, while making a sharp turn in sections 35 and 36 of Fertile township, continues to the south and west in Cerro Gordo county.

Some work was done on the moraine in Cerro Gordo county in an attempt to determine, if possible, whether two distinct moraines were present in the county. More work will be necessary before definite conclusions can be reached.

1 Iowa Acad. Science, vol. 26, 1919, pp. 399-404.
2 Iowa Geol. Survey, vol. 10, 1900, pp. 320-321.

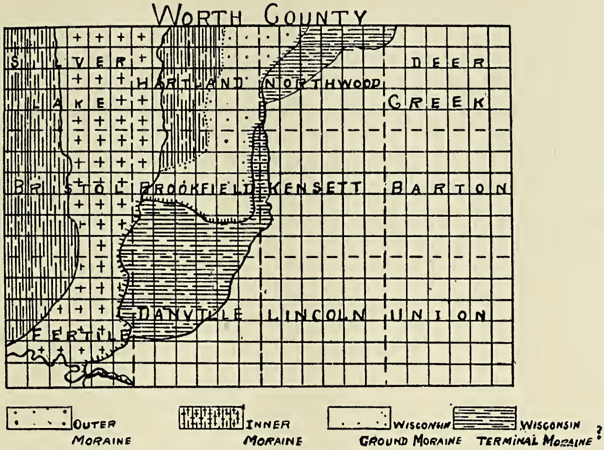

Fig. 35. Map showing the moraine in part of Worth county.

Work done in Worth county has revealed evidence which seems to warrant Mr. Williams' contention for two distinct moraines or advances of the Wisconsin ice-edge. During the summer of 1917, a large drainage ditch was in the process of construction. This ditch, where it cuts through the terminal moraine, sections 3, 10, 14, and 23, Fertile township, was carefully examined in all parts of its course through the terminal moraine and many sections noted. The following section is quite typical of many others that might be given.

	Feet	Inches
5. Black loamy soil	3	6
4. Bluish gray clay, highly calcareous	10	
3. Sand, uniform in texture, rather fine, filled with small pelecypod shells		4-6
2. Vegetable zone, filled with tree trunks, 1 inch to 3 inches in diameter	1	
1. Clay, compact, of bluish color	Base	

It would seem that the animal and vegetable life, should they prove to be interglacial between the first and second advances of the Wisconsin ice, are criteria that may furnish some measure of the time interval between the two advances.

After the first advance and retreat, enough time must have elapsed to permit vegetation to take hold on the surface and life to inhabit the marsh or lake areas. The sand represents probably the outwash from the ice-edge.

It seems highly possible that the drift marked as Wisconsin, located to the east of the outer moraine (see figure 35) is Wisconsin terminal moraine drift and represents the earliest advance of the Wisconsin ice-edge. It is between this drift and the junction of the inner moraines of Williams that the above section was obtained. What is mapped as inner and outer moraine drift material by Williams may prove to be but local oscillations of the same advance, as the ice-edge was, no doubt, very lobate.

Department of Geology,
State Teachers College.

THE CONSERVATION OF UNDERGROUND WATERS

JAMES H. LEES

Importance of Water.— Ranking with the soil and the atmosphere, water is recognized as being one of the absolute essentials of existence. We are all familiar with the fact that where water is absent — or unavailable, which is equivalent — life likewise is absent or nearly so. It is difficult, perhaps needless, to decide which is the most necessary, soil, air, or water, all are so intimately interwoven into the complex relationships of life. Not only is that water which is exterior to the organic creation an essential to the continued well being of that creation but much the greater bulk of animal and vegetable tissue is composed of water. It is estimated that of annual plants, three-fourths of the substance is water; of perennials, three-eighths is water. Eighty per cent of animal tissue is water, and this ratio holds good with regard to the body of man himself. The gray matter of the human brain — the most highly developed and specialized living material on the planet — is said to consist of 83.5 per cent of water, leaving only 16.5 per cent of solid matter, so called (Van Hise).

The amount of water consumed by animals and plants in their growth and nourishment is truly remarkable. "The average man of 150 pounds weight ingests each year about 264 gallons of water or 35 cubic feet, the weight of which is more than a ton" (Van Hise). Do we of Iowa realize that to produce a bushel of our world-famed corn there is necessitated the evaporation from the soil and the transpiration from the plants of ten to twenty tons of water? Or that the pound of beefsteak about whose price we grumble so severely required from fifteen to thirty tons of water in its production (McGee)? Multiply these figures by the beeves grazing today in Iowa pastures and over the Great Plains and by the millions of acres of corn and grain waving in our fields or standing in orderly shocks and you gain some conception of the enormous volume of water that enters into the life of the world.

Source and Distribution of Ground Water.— Of course the source of the water of the earth is the rainfall and it is interesting to note that over the United States this averages about 1500 cubic miles each year, enough to cover the national domain to a depth of thirty inches. In Iowa the rainfall averages a little more — nearly thirty-two inches, ranging from thirty-four inches in southeastern Iowa to twenty-eight in the northwestern portions. This means that on the average upon each of Iowa's 35,575,000 acres there falls annually 116,000 cubic feet of water, a total for the state of twenty-eight cubic miles.

Now what becomes of this vast quantity of water? The experts tell us that substantially one-half evaporates and is returned quickly to the atmosphere. One-third runs into the rivers and back to the sea and hence is known as the run-off. The remaining one-sixth is consumed by plants or, escaping them, goes deep enough to join the permanent body of water beneath the surface, the underground reservoir, the ground water. It is this latter one-sixth that we are to consider just now.

Let it be understood that despite popular conception there are no extensive underground lakes and very few subterranean streams. Such as do exist are gathered chiefly in the relatively rare caverns and devious passageways in the upper portion of the earth's crust. The great body of the ground water is diffused through the pores and crevices and other small openings in the rock and soil of the solid earth. The upper surface of the ground water — the ground water level or water table — is somewhere near the surface of the earth. The lowest extent of the ground water is about six miles, below which depth the pressure of overlying material is so great as to render the subjacent rock impervious. Most of the waters in much the greater portion of this zone must, however, remain permanently inaccessible to man through any means. It is only the water content of the topmost few hundreds of feet which can be counted on to be of any service to humanity or indeed to life forms of any kind.

What then is the amount of available ground water, how may it be best utilized and by what means shall we seek most intelligently to conserve it? These are the questions which most concern us in this inquiry.

Relation to Rock Strata.— Of the stratified rocks of Iowa the Sioux quartzite contains probably less than one per cent of voids, the limestones contain one to five per cent and the sandstones contain five to twenty-five per cent. Doctor McGee has estimated that the amount of water in the outer one hundred feet of the rocks of the United States is sufficient to cover its entire area to a depth of seventeen feet. This is equivalent to the rainfall for seven years. Since Iowa is in the region which receives at least an average amount of the total rainfall of the United States we may accept these figures as being substantially correct for our state. It appears then that there is no lack of ground water, that the total capacity of the reservoir is very large and that rainfall is reasonably sufficient to continually replenish the supply.

If we consider the relation of the various strata of Iowa to her ground water supply we shall find that the glacial formations, the clays and sands and gravels transported and spread out by the great ice-sheets of Pleistocene time, form one of the most important, if not actually the greatest of the aquifers, or water-bearing formations, of our geological column. Leaving out of consideration for the moment the water used by plants, which over most of the state is drawn directly from glacial drift materials, most of our rural population depends entirely or nearly so on the drift for its water supply. This supply is drawn largely from wells, in lesser measure from springs, to some extent from so-called surface waters, which, however, are replenished in part from the underground supplies. Again, many of our cities and towns are supplied from the drift — including here the sands and gravels found as pockets in the clays or lining the valley floors. Notable examples are Des Moines, Council Bluffs and Sioux City in part, Le Mars, Webster City, Chariton, Atlantic, Muscatine and many others. It is doubtless true that more than half of the state's inhabitants depend directly on the drift materials for their supplies of water.

Beneath the drift covering — the mantle rock — lie the great series of the bed rock. All of these strata contain water in different amounts, the shales scantily, the limestones in fair abundance in crevices and fissures and pores, the sandstones in bountiful supply. Hence whenever a sandstone is penetrated by wells it is more than likely to supply a goodly store. The Cretaceous sandstones of western Iowa, the Des Moines sandstones in the central counties, the St. Peter, the New Richmond and the Cambrian sandstones in northeastern and southeastern Iowa, all of these beds yield water in large measure to the wells which are sunk into their depths. The waters from some of these strata are rather heavily mineralized, it is true. And this mineralization is increasingly heavy at greater distances from the regions of outcrop of the strata. But it is nevertheless true that the combined

Jordan-St. Peter field is the greatest artesian basin in the United States. These formations outcrop over 15,000 square miles in Wisconsin, Minnesota and Iowa. The rainfall which they receive is transmitted readily through their porous strata and percolates hundreds of miles beneath the surrounding states. Many of the towns of eastern and northeastern Iowa receive a bountiful and excellent supply of water from these stored-up sources. Among them we may mention McGregor, Dubuque, Sabula, Clinton, Manchester and Charles City. Even points as far distant from the outcrop as Keokuk, Centerville, Stuart and Denison have artesian wells fed from these great aquifers.

The sandstones of the Des Moines stage are quite strongly mineralized and are not much used for municipal supplies although they furnish water to a number of country wells. The Cretaceous sandstones supply a number of wells in the area of their extent, among them being those at Cherokee and Guthrie Center. Possibly also some of the wells at Sioux City are fed from these beds.

The various limestone strata of the state also furnish large supplies of water to many shallow wells, to abundant springs in the areas of their outcrop and to numbers of fairly deep wells which penetrate them for a few hundred feet. Such wells are those at Oelwein, West Union, Cedar Falls, Forest City and elsewhere.

It has been estimated that seventy-five per cent of the population of the United States depends directly on underground waters (Mendenhall) and a review of conditions in our own state would lead to the opinion that an even greater percentage of Iowans use this source, since only a relatively small number of cities and towns depend on surface supplies such as rivers, lakes and impounded waters. The brief discussion here given will show, it is hoped, the importance and value of the ground water for domestic and industrial uses and yet it is estimated that the amount used annually in the United States is equal to only about one per cent of the total flow of the streams of the land for the same period of time.

Use of Ground Waters by Plants.— Turning for a moment to consider the use of ground waters by plants: it takes but little thought to realize the importance of the underground supplies in supporting this part of the living world. Doubtless plants derive a portion of their needful moisture directly from the rain as it falls and from the run-off on its way to the streams. But much the greater part of the water used by vegetation must come from beneath the surface and must be drawn in by the root systems of the plants themselves. During the seasons and periods of abundant rainfall, when the groundwater level is high and the root systems are laved with moisture, the process of keeping each of these miniature waterworks systems in successful operation is a relatively simple one. But during dry seasons, when the water table has dropped down below the reach of the major trunk lines, below even the minor feeders, then the more complex operations of capillarity must come into play.

Capillarity or capillary attraction is the adhesive force by which moisture is held in small openings in opposition to the force of gravity. This force is sufficient to hold capillary water about five feet above the water table in ordinary soils, the actual distances ranging from four feet in coarsely sandy soils to eight feet in finely sandy or clayey soils (Meyer). It is necessary, of course, if life is to be sustained, for connections to be maintained between plants, roots, capillary water and gravity water — the portion below the water table. If this connection be broken for any extensive period, death must ensue. Because of this fact many plants develop root systems several times more extensive than that part which is above ground. Thus some of the grasses in the western arid regions send their roots down five, six and seven feet into the ground in search of moisture, and it has been said that alfalfa has been known to grow roots even longer than these. The amount of water actually used by plants is probably not known, but it must be very great. The amount of transpiration from the foliage of forest trees — that is, the water which passes back into the atmosphere from the pores of the leaves — is stated to vary from 1000 to 20,000 pounds per day per acre during the growing season, while the transpiration from the leaves of maize in the production of a bushel of corn is said to be about 5000 pounds (Van Hise). It is evident then that great quantities of moisture are used by the vegetable life of the land.

Another important use of ground water is in preserving and stabilizing stream flow. While the streams are fed primarily by the run-off, their flow is maintained during periods of little or no rainfall, which with us includes a majority of the days of the year, by springs and by seepage from the rocks and soil. The water which escapes in this way and finds its way back to the sea, amounts to a great deal and must contribute very largely to the eleven or twelve inches of run-off which the upper Mississippi valley furnishes to the great master stream.

Conservation of the Ground Water.— How then may we properly conserve our stores of underground water? Obviously the problem resolves itself into making the most efficient and at the same time the most economical use of the supplies with which Nature has so beneficently endowed us. Not to use them is to waste them. To fail in making them serve to the utmost in the advancement of all material and social welfare is as much criminal negligence as is their wilful or careless dissipation. Hence the question is not, Shall we use them? but rather, What is the best method of utilization? There are two chief lines along which their utilization will proceed, namely domestic and industrial uses and agricultural uses.

For the first of these classes, domestic and industrial uses, the quality of serviceable water is rather severely limited. The amount of water held in solution, either of solid or of gaseous matter, must be relatively small in order not to interfere seriously with its palatability, its effect on the human body, its action in steam boilers and other industrial machinery. These limitations have prevented the use of many supplies which were abundant in quantity and easily accessible, at the same time necessitating greater drafts upon less abundant but more desirable supplies. Thus here the problem is the complex one of securing water that is abundant, is easily put where it is needed and is of the proper quality.

Living plants are less fastidious in their demands than are mere mechanical plants. Provide them with almost any kind of water and they will take from it what they need and reject what is useless for their growth. Here the problem is largely that of keeping a supply of water within capillary reach of the roots. Of course these statements cover only ordinary ground water, not acid waters from mines, or industrial wastes and similar classes.

The Effect of Population Increase.— The rapid growth of population in the upper Mississippi valley, as elsewhere in the United States, has made necessary increasingly heavy drafts upon the water supply. So long as the population was largely rural or in small towns the supply of water needed was drawn from the streams or from shallow wells. Furthermore there was relatively little pollution of these sources. With the centralization of population and the rapid growth of large cities there have come not proportional increases in the demand for water but a demand which has grown by leaps and bounds, in geometric ratio. Application of water to sanitary purposes in the home, public sewage systems, enormous manufacturing industries, all these call for usage of amounts of water which to our forefathers would have seemed unbelievable. The ordinary shallow well in the back yard is not only insufficient, it is inefficient, incapable and unsanitary. The great system of galleries, the battery of large wells, the deep bores piercing the aquifers far underground, these have taken its place. The shallow well of our fathers, the clear sparkling streams and ponds of our childhood are gone or, what is worse, are polluted beyond use or are in danger of contamination.

The Effect of Agriculture.—Paralleling this enlarged demand for water there has come a change in surface conditions which has diminished the supply or at least has tended to interfere with its replenishment. Agriculture, either by carelessness or by wrong methods or in part perhaps by necessity, has caused an increase in the run-off, thus lessening the amount which should seep into the ground, while at the same time filling the stream channels with the richest of the surface soil. The breaking up of the sod which held back the rain as it fell so that it might be absorbed instead of washing gullies in the soil; the cutting away of the forests from the steep slopes, permitting the gullying and gashing of the hillsides; all of these have acted counter to the needs of the state — they have wasted and lessened its available water-supply when it should have been conserved and increased.

Doctor Beyer stated in his Presidential address before the Iowa Academy of Science that "The records show that the average lowering (of the water table) for the entire country is about nine feet and for Iowa some twelve and a half feet during the fifty years preceding 1910." Happily he stated further that "The rate of lowering was highest during the early stages but appears to be proceeding at a diminished rate." I firmly believe that this lowering is due to the practical loss of so much rainfall because of the increased run-off mentioned above as much as to the increase in the use of water. If some means can be found to check what is practically a waste of water an important step will have been taken in the conservation of the ground water supply.

Most of the water that is used by plants is returned to the atmosphere and is useful in maintaining atmospheric humidity and rainfall. Most of that used for domestic, civic or industrial purposes ultimately joins the run-off and is of little further immediate direct service. Hence a more conservative use of water by man will go far toward reducing this alarming lowering of the water table which is such a vital factor in the preservation of all life. If as has been stated, "the upper level of the ground water is not far from the limit of its availability for crop growth" (Beyer) it is evident that the condition is really alarming and must be remedied. It is not only the crop grower who is concerned. The crop consumer is equally vitally concerned. He too must take steps to retard and if possible prevent the catastrophe that seems to be impending.

Another element which, although necessary, has assisted in lowering the water level, is artificial drainage. Doctor Beyer, in the address to which reference has been made, urges strongly the abandonment of the open ditch as it both increases the run-off and wastes valuable land. Tile drainage, on the other hand, equalizes the run-off while reducing the wastage of the land. Furthermore by the very act of lowering the water table a few feet it reduces the losses through evaporation. Probably the greatest part of the work of drainage, with its consequent lowering of the water table, has been completed, so that it will not be a serious factor in the future.

It is clear that agriculture must be made to conserve soil moisture rather than dissipate it. How shall it be done? The details are for the trained agriculturist; only a few principles can be given here. Soil wastage must be stopped. Soil conservation must be enforced. Deforestation must cease or at least be very intelligently practiced and furthermore it should be accompanied by reforestation and even by the enlargement of the forests and groves. Proper treatment of the soil in plowing and in cultivating of crops will go far to preserve the water which is brought up by the great centrifugal pump, capillarity, and to prevent its excessive evaporation. Keeping the surface of the soil of the field loose and fine, fall plowing, allowing a field to lie fallow for a time; these all help in increasing percolation and reducing run-off. In spite of the great amount of transpiration from vegetation a cover of plants reduces the amount of evaporation from a given surface in a large degree. Let me cite the following relative rates of evaporation as given by Meyer. He says: "Considering the rate of evaporation from the bare ground surface at a given mean temperature as 1.0, the rate of evaporation of free moisture from the ground in grain fields may tentatively be taken as 0.8; for grass land 0.7; for light forests, brush and second growth 0.6; and for dense forests with abundant herbaceous vegetation from 0.2 to 0.4."

From our cities and towns in all quarters the cry is going up: "Our water supply is diminishing, our wells are going dry!" What does it mean? What are we going to do about it? From newspaper items and from official correspondence it is evident that everywhere the situation is becoming acute. At the present moment at least three of the important cities of Iowa which have depended on deep well supplies are looking anxiously for other sources, namely Mason City, Fort Dodge and Waterloo. The heads of the wells have fallen so low that it is becoming out of the question to depend on them much longer. Towns with large shallow wells are being forced to dig more wells or use surface waters. Towns dependent on impounded waters are finding difficulty in maintaining necessary reserves. We cannot increase the rainfall; we cannot find a substitute for water, although many establishments for that purpose are insistently thrusting their wares upon our notice. We must then adopt the only remaining recourse — conservation. The writer recalls listening while a graduate student at the State University to a paper on the water supply of Buda-Pesth, Hungary, in which the speaker said that that system furnished two gallons a day per inhabitant. The head of the engineering department of the University in commenting on the paper stated that the consumption in Iowa City was eighty gallons per capita. The daily average consumption for Des Moines is eighty-one to eighty-five gallons per person. Does this point a moral or adorn a tale? In the flowing well district of the artesian basin wells are left flowing from year end to year end. We of central Iowa are suffering for this wastefulness.

The way in which agriculture may help in conservation has already been discussed. In addition our forests are an important factor. It is a proven fact that nothing aids more in the retention and stabilizing of ground moisture than do the forests. In addition to all their other attractive features they rank as one of the great conservers of our water reserves. This they do by checking the run-off, by lessening evaporation, by preventing soil wastage with all its attendant evils. They not only stabilize the stream flow, maintaining it when the run-off fails; they increase the supply of ground water and yield it when it is most sorely needed. The advocate of forest preservation can advance arguments to appeal to every class, whether the so-called practical man, the idealist, the nature lover, the artist, the technical expert or the mere pleasure seeker. To all there is some feature which will carry weight. And to none is the movement to establish a great system of forest preserves, of parks big and little, of more importance than to those whose concern it is to see that the supplies of pure, healthful, life-giving water do not fail. Therefore it is well that we give thought to the careful and timely consideration of every plan that will tend to the betterment of living conditions by bringing Nature closer to Man and making her serve him more completely.

Iowa Geological Survey.

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THE TAXONOMY OF ALGEBRAIC SURFACES

R. P. BAKER

The problems of taxonomy are problems of order. Any discrete set can be arranged in linear order but it does not follow that any linear order is satisfactory. The separation of natural neighbors may be inevitable. Examples are Linnaeus' botanical classification, or the arrangement of logical classes (*abcd*, $\bar{a}bcd$, ----) where a natural arrangement applies in general surfaces of connectivity greater than one, or *n*-dimensional space. Any number of interrelations of a discrete finite set can be indicated by a three dimensional model where the elements are points and the relations say colored lines, as in a Cayley color group abstracted from a surface.

When the set of elements is infinite the only apparent arrangement is in a space of *n* dimensions. For the cubic surfaces every real point in a space of nineteen dimensions corresponds to a real cubic.

To condense this two fundamental schemes are used, either a classification by projections (real or complex) or by a birational reduction.

The literature of the cubic surface contains three different projective attacks. For the 'general form' Cayley [1] gave a four parameter form (*lmnp*) having in general twenty-seven lines rational in (*lmnp*). Schläfli [2] reduced the set to a four parameter double trihehedral form. Rodenburg [3] took the reduction to sum of five cubes and classified by the coefficients.

The comparison of these forms is rendered difficult by the fact that one of two algebraid equations (neither of which has been explicitly written) is encountered: a quintic for the pentahedron of the five cubes, discussed by Clebsch [4] and the well known equation of order 27 for the lines.

The groups are in general of order 120 and 51840 respectively. By a theorem of Jordan the adjunction of the quintic roots is ineffective as to the resolution of the line equation, and the ad-

1 Phil. Trans., 1869.
2 Phil. Trans., 1863.
3 Math. Ann., 14.
4 Crelle, 59.

junction of the lines is similarly ineffective as regards the pentahedron.

The desirable connection would be given by a four parameter form which has rational lines and rational pentahedron in a domain as simple as possible.

In discussing this problem the question of a group of transformations of the surface into itself is met at the outset. Some easily attainable results are: —

1. If the group is continuous of non-multiplicative type the surface is ruled.
2. If continuous of multiplicative type is is singular. A list can be made and the examples correlated with Schläfli's classes.
3. For the general case, since the pentahedron must transform into itself there must be equalities among the coefficients of Rodenburg or the group is the identity. In this case we should have the truly general form.

The possible groups are of order 120 as in Clebsch's diagonal surface, 24, 12, 6 or 2. The Clebsch surface is not contained in Cayley's form nor are some of the others, the trouble being that Cayley's reduction of the general quadric is a special one. The diagonal surface is rational in the domain ($\sqrt{5}$) for both lines and pentahedron.

Since Klein[5] takes small distortions of the diagonal surface as the general type, whereas Cayley's form is finitely removed, some doubt may be expressed as to the equivalence of the forms thus obtained with the general one. Further his remark that a model should be symmetrical is unfortunate since the general cubic has no transformation into itself and hence it is in no way symmetrical.

The problem may be attacked by assuming the pentahedron and a triangle which involve the adjunction of cubic and quadratic irrationalities. The reduction of Schläfli's form requires adjunction of the roots of a quartic and cubic.

These adjunctions are possible by rationalizing conics and cubics. The detailed formulæ are naturally complicated and restrictions arise which differ according to the group of transformations into itself. Finally a complete exploration of the four dimensional space is required to show that the forms approach every point.

State University of Iowa.

5 Math. Ann. 6.

VACUUM TUBE CIRCUITS AS A SOURCE OF POWER FOR CONDUCTIVITY MEASUREMENTS

H. A. GEAQUE AND F. PAUL RALSTON

At the present the possible sources of current for conductivity measurements are limited to the induction coil, the high frequency generator and the Vreeland oscillator. In the first two the oscillating current is produced mechanically and the noise from the mechanism is apt to interfere with the accurate balancing of the bridge when measuring the resistance of the conductivity cell. This may not be the greatest objection in the case of the induction coil as it has been shown that the current has an undirectional value. The Vreeland oscillator is the only apparatus in use which produces a tunable oscillating current by means of a rectifier and controlled by the capacity of the condenser and the inductance of the coils in the circuit. This circuit gives an oscillating current whose intregal value is zero, and there are no overtones or mechanical noise to interfere with accurate work.

The advantages of such a system led to the development of a similar circuit using the vacuum tube as an oscillator. Several circuits were found which would give an oscillating current of a degree most favorable for conductivity measurements, but it was difficult to control the frequency and to get the current in the secondary circuit of sufficient strength to be of practical value.

The circuit shown in figure 36 was found to be the most satisfactory. The bulb consists of the grid (G), the plate (P) and the filament (F). The filament was lighted by a six volt storage battery (A) and 0.6 ampere was necessary. The "B" battery (B) has a voltage of 25 to 70 volts, the latter giving a stronger current, and is made by connecting thirty flash light batteries in series. The inductances L_1 and L_2 have values of 100 and 1.3 millihenrys respectively. The variable condenser (C) has a capacity of .0005 micro-farad as a maximum and is shunted by a high ("grid leak") resistance of several megohms. The primary (P) and secondary (S) coils were put within the inductance coil L_1 which substantially increased the secondary current. The positive pole of the "B" battery was connected to the plate of the vacuum tube and in parallel with this the inductance L_2, the

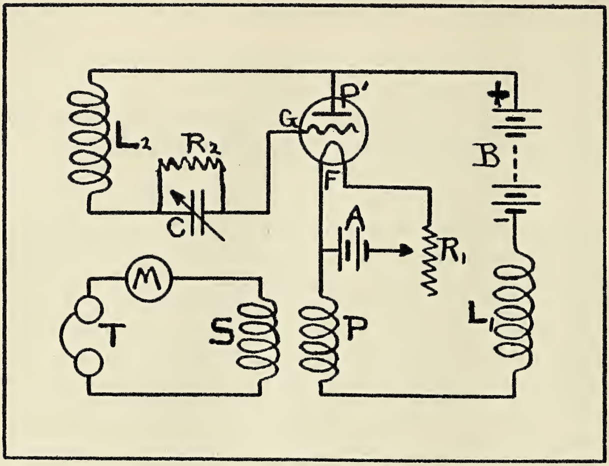

Fig. 36

condenser and the grid were connected in series. The negative pole was connected to the inductance L_1, the primary coil and the filament in series.

To measure any electrolysis due to any unindirectional component that the current might have, the secondary circuit was closed with a silver coulometer (M) in series with telephones (T). The current was passed through a 0.1 normal silver nitrate solution for a total of fifteen hours and there was no change of weight of the electrodes.

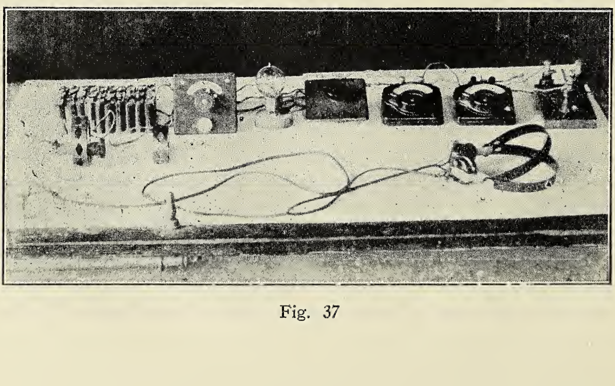

Fig. 37

The frequency of the current was found to increase by decreasing the capacity of the condenser, decreasing the inductance L_2, increasing the inductance L_1 and as the filament current approaches the most favorable value for the filament.

Several makes of vacuum tubes were used. Only those where the plate is very close to the filament gave oscillations.

SUMMARY

The vacuum tube circuit shown in figure 36 will produce an oscillating current of sufficient frequency for conductivity measurements.

The advantages of the apparatus are:

1. The elimination of the noise accompanying mechanically produced oscillations.

2. The elimination of the heat developed by the mercury rectifier.

3. The simplicity of the apparatus.

The disadvantages of the apparatus are:

1. The changes of frequency due to external capacities and changes in the filament current.

2. The small current obtained by using the ordinary vacuum tube.

The work is being continued with the hope that the strength of the current can be increased.

In conclusion the authors wish to thank Dr. John L. Tilton whose coöperation made possible this work.

Chemical Laboratory,
Simpson College.

THE HALL EFFECT AND THE SPECIFIC RESISTANCE OF THIN SILVER FILMS

G. R. WAIT

ABSTRACT

1. The Hall Effect of ordinary metals may be expressed by the equation $E = HIa/e$ where $E =$ the Hall Effect, $I =$ the primary current, $e =$ the thickness of the conductor and $a =$ a constant whose value in silver lies between .00083 to .00090. In the present investigation the above equation was found to hold in thin silver films, and that a has a value of .00084.

2. In thin films the specific resistances have by many investigators been found to be abnormally great at a critical thickness. In the case of silver, this critical thickness lies between 15×10^{-7} cm. and 50×10^{-7} cm. Various theories have been advanced to explain this increase in resistance. The films upon which the Hall Effect was measured were first measured for specific resistance. The results together with the results for Hall Effect are plotted against thickness in figure 38.

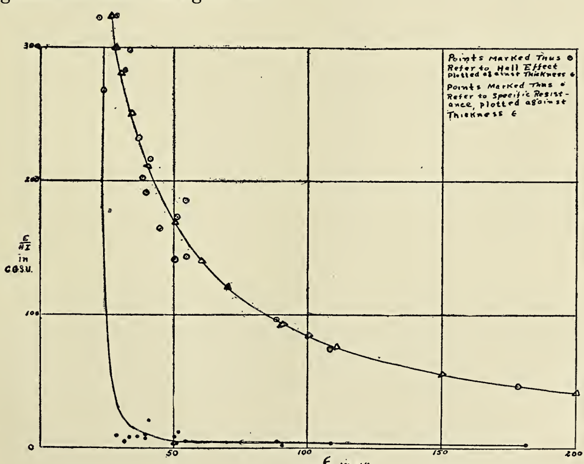

Fig. 38

3. The results upon Hall Effect will aid in explanation of the abnormal rise in specific resistance of silver films.

Department of Physics,
State University of Iowa.

THE DEPENDENCE OF THE RESISTANCE OF SILVER FILMS UPON THE METHOD OF DEPOSITION

G. R. WAIT

ABSTRACT

1. Most observers investigating the specific resistance in thin metallic films have found that it decreases rapidly with time. In the present investigation Brashear's process of obtaining silver films was followed. Figure 39 shows how the resistance of a typical film changes with time.

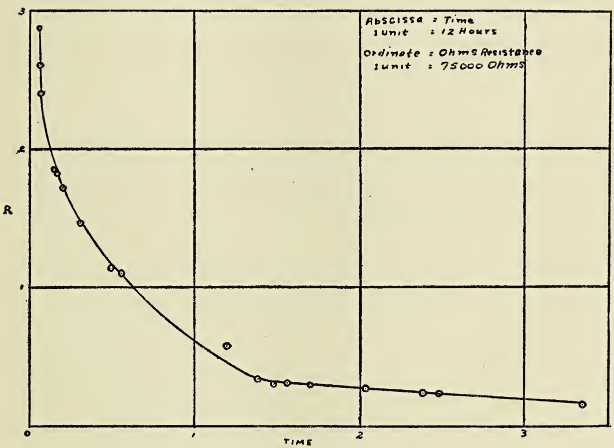

Fig. 39

2. The method mentioned above was modified somewhat; (a) by the addition of double the amount of sodium hydroxide stipulated; (b) by going over the surface of the glass upon which the film is to be deposited, after it is in solution, with a glass brush, thus freeing the surface of small air bubbles; (c) by keeping the temperature of the solution below 60° F.

3. Figure 40 shows films obtained by Brashear's process unmodified (points marked .), and films obtained by the process

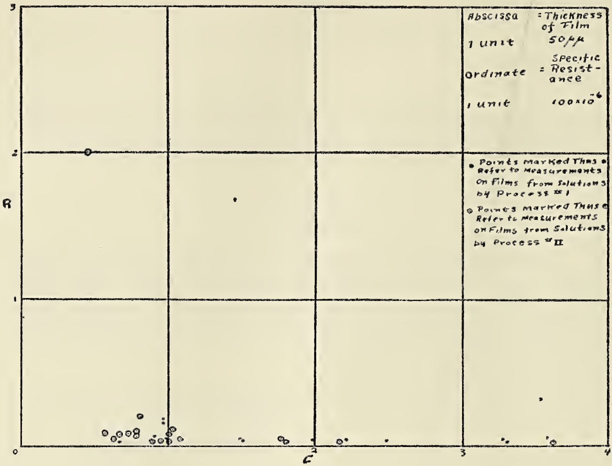

Fig. 40

modified as explained above (points marked ⊙). It will be seen that for those films obtained by the unmodified process, the resistance is not only much higher than that of the others, but the variations are much greater.

A PHOTOGRAPHIC DETERMINATION OF THE FORM OF AN AIRPLANE LOOP, AND THE DYNAMICS OF THE LOOP

L. P. SIEG

Introduction. During a greater part of the years 1918 and 1919, the writer was engaged at Langley Field, Virginia, on experimental work connected with the determination of bomb trajectories. The work was under the direction of Dr. A. Wilmer Duff, as Engineer-in-charge, and the writer as assistant engineer. The credit for the development of the photographic method, described below, is due to Doctor Duff. The details connected with this paper, have been worked out by the writer as an interesting and important side issue of the main problem.

Method and Apparatus. In order to gain information as to the actual path of an airplane during any manoeuvre, for example the loop, it is necessary to have some method of accurately surveying its positions in space as a function of the time. Whatever method could be used for accurately surveying the path of a falling bomb, could obviously be used for the present problem. If the flying is done at night, if there is a light on the airplane sufficiently bright to affect a photographic plate at a distance of, say two miles, and if, to record the path of this light, there are two cameras which are situated at the ends of a measured base line, are raised to known elevations, and are pointing in known directions; then it is possible to reduce the two plates so as to give the X, Y, and Z co-ordinates of the path of the plane, referred to any arbitrary origin. If in addition one has a means of obscuring the camera lenses simultaneously at regular intervals, say every second, he has in addition the necessary time element to completely define the path of the plane as a function of the time. Such apparatus was installed at Langley Field for the regular program of trajectory determinations, and it served of course equally well for the present problem. There is neither space nor occasion for an elaborate description of this apparatus, nor of the labor involved in meeting the practical difficulties one by one until accurate results were possible. But the briefest description, therefore, will be given of the apparatus and method.

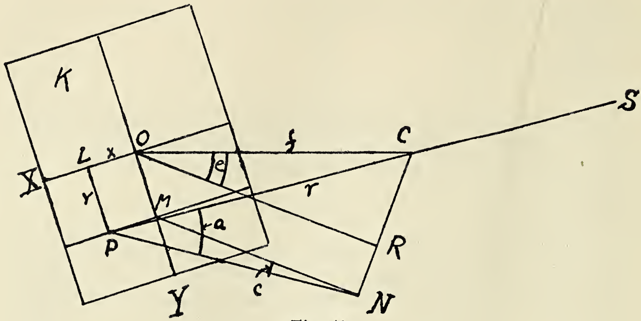

Fig 41

In figure 41 let K be the plate in the tilted camera. Let P be the image of a point on the path of the loop, the ray coming from the direction S, through the center of the lens C. The focal length f is given by the distance CO. Take the horizontal line OX and the line OY perpendicular to it as axes of reference. CRN is a vertical line through C. OY is in the vertical plane through OC. Horizontal lines OR and MN in this vertical plane intersect CRN in R and N respectively. The angle MNP, called c, is the angle which a vertical plane through SCP makes with the vertical plane through the axis OC. This angle is the azimuth of the ray SP referred to the horizontal direction MN. The angle CPN, called a, is the elevation of the ray SCP above the horizontal plane. Letting $CP = r$, then

$$r^2 = x^2 + y^2 + f^2 \qquad (1)$$

$$CN = CR + RN = f \sin e + y \cos e,$$

where e is the elevation of the axis of the camera above the horizontal plane. Then

$$\sin a = \frac{y \cos e + f \sin e}{r} \qquad (2)$$

and since

$$PN = r \cos a$$

$$\sin c = \frac{x}{r \cos a} \qquad (3)$$

We thus have formulas for determining, as viewed from one camera the elevation of a given point on the path of the airplane above the horizontal plane, and its azimuth with reference to a fixed direction from the base line. A great deal is here omitted in regard to the problem of choice of camera, plates, camera adjustment, lens distortion, determination of focal length, determination of the azimuth of the camera axis, etc. One also has results for the azimuth and elevation of the *same* point on the airplane's path as measured from the plate of the other camera. Call these angles c' and a', respectively.

We have now to find the co-ordinates of the point of the path of the airplane from these four angles, and the length of the base line. In figure 42, let L be the length of the base line (in

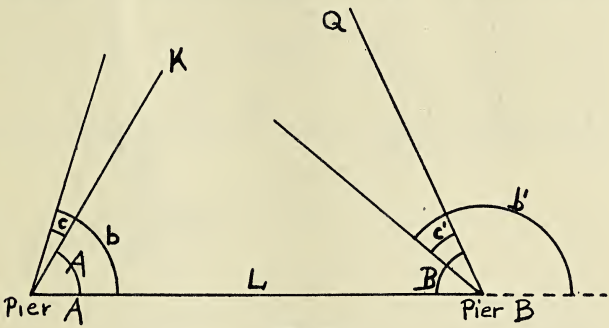

Fig. 42

our work, about one-half mile) between the two piers A and B. Let the line K to pier A be the projection of the axis of camera A, and Q to pier B, be the projection of the axis of camera B. Let the angle b be the azimuth of the ray in question from camera A, referred to the base line, and b' the azimuth determined from camera B. Then

$$b = A + c \qquad (4)$$

$$b' = 180° - B + c' \qquad (5)$$

where the angles A and B have previously been accurately surveyed. We have given then (see Fig. 43) the angles a, b, a' and b', and the length L of the base line. S is the point to be determined, and X, Y, and Z referred for convenience to pier A as origin, its co-ordinates. Then

$$X = R \cos b \qquad X = R' \cos b' + L$$
$$Y = R \sin b \qquad Y = R' \sin b'$$
$$Z = R \tan a \qquad Z = R' \tan a'$$

and if we eliminate R and R' from these equations, we obtain,

$$X = \frac{\cos b \sin b'}{\sin (b' - b)} \qquad (6)$$

$$Y = X \tan b \qquad (7)$$

$$Z = X \frac{\tan a}{\cos b} \qquad (8)$$

$$Z = Y \frac{\tan a'}{\sin b'} \qquad (9)$$

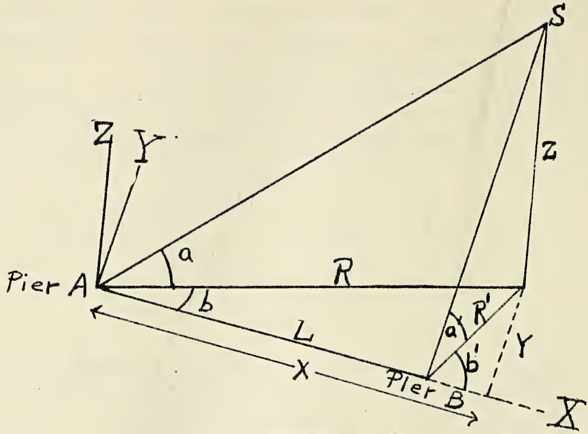

Fig. 43

Equations (1) to (8) are sufficient to determine X, Y, and Z. Equation (9) is a valuable check equation for the latter quantity.

The original plate measurements, corrections, etc., that were employed to obtain the *X*, *Y*, and *Z* of the loop will not be given here. In the actual determination there was a wind blowing transversely to the loop, which carried the airplane out of a plane. By appropriate methods the wind was determined, and the path of the plane reduced relative to the air. Lastly the *Y*-co-ordinate was eliminated by rotating the plane of the loop into the *X-Z* plane.

In figure 44 is drawn the resultant loop referred to the *X-Z* plane. The distances are in feet. The numbers beside the various points of the curve represent the time in seconds from the beginning, arbitrarily chosen at a given point as zero. The loop is executed from right to left.

Forces Involved in Looping. At any given point in the loop there are the following forces to consider: the weight of the airplane (taken as 2000 lbs.), the centrifugal force, the engine thrust, the air lift on the wings, and the resultant of all these, yielding tangential acceleration in the path of the plane. Any other forces, such as parasite resistance, are merged into the above forces. The weight vector is simply obtained by drawing a fixed vector downward at each point to a scale representing 2000 pounds. The engine thrust is taken as 450 pounds when

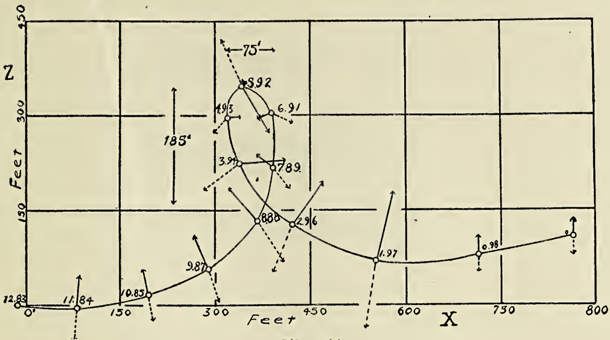

Fig. 44

the r.p.m. are 1400, and the speed of flight 70 miles per hour. For higher speeds, with the same r.p.m., the thrust is less. Near point 5.92 the engine was cut off and not turned on again until near point 10.83. The centrifugal force and the tangential acceleration at each point were obtained by a method of graphic differentiation, as follows. First, with dividers the length of the curve was determined, and platted as a function of the time. Then for the various points the linear velocities $\frac{ds}{dt}$ were found from the slopes of the tangent to the curve at these points. Next these velocities were platted as functions of the time, and the slopes of this latter curve, $\frac{dv}{dt}$, or $\frac{d^2s}{dt^2}$ at these various points yielded the tangential accelerations. These were sometimes positive, and sometimes negative. The centrifugal force was determined from Wv^2/gr, where r the radius of curvature was determined graphically from the original curve. The tangential force was determined from $W/g(dv/dt)$, and lastly the air pressure vector was determined as the difference between the vector for the tangential acceleration and the resultant vector of weight, centrifugal force, and engine thrust. On the curve (Fig. 44) are drawn to scale the air pressure vectors in solid lines, and the vector resultant of weight, centrifugal force, and engine thrust as dotted lines. The resultant of these two at each point represents the tangential accelerating force on the airplane. The details of these various forces are given in table I.

TABLE I

$W = 2000$ lbs.

Point	Total Dist. s (ft)	$ds/dt = v$ (ft/sec)	$dv/dt = a$ ft/sec^2)	$Wa/g = f$ (lbs.)	Radius of Curv. $= R$ (ft)	WV^2/gR (lbs.)	Engine Thrust $= T$ (lbs.)	(Vector Sum) $T + W + WV^2/gR$ (lbs.)	Direction N through E (degrees)	Air Lift (lbs.)	Direction N through E (degrees)
0.	0	150	+4	+250	Inf.	0	0	2000	180	1980	353
0.98	145	153	0	+10	Inf.	0	0	2000	180	2000	0
1.97	307	148	—8	—510	270	5040	10	7500	189	7500	13
2.96	455	137	—17	—1040	320	3640	100	5470	203	5330	35
3.94	580	103	—46	—2860	180	3660	410	4650	235	4930	88
4.93	657	59	—25	—1550	165	1310	450	2100	223	1450	88
5.02	715	56	+13	+810	25	7790	off	5550	338	5670	150
6.91	778	75	+17	+1060	145	2410	off	2450	115	1600	250
7.89	865	90	+13	+810	295	1700	off	2820	142	2300	307
8.88	957	100	+8	+520	180	3450	off	4920	147	4780	320
9.87	1069	107	+4	+240	370	1920	off	3720	162	3660	338
10.85	1172	107	+1	+90	745	950	off	2900	171	2850	350
11.84	1287	110	+1	+60	500	1500	350	3600	184	3550	3

Results and Conclusions.— It will be noted first that the loop is far from circular, contrary to the opinions of many pilots I have interviewed on this matter. This is to be expected, since the velocity of the airplane decreases toward the top of the loop. To create a sufficient centrifugal force here, then, a smaller radius of curvature is required. The dimensions of this loop are, as noted from figure 44, 75 feet broad by 185 feet high. The time consumed in making the loop proper is a trifle over five seconds. The greatest stresses involved are at point 1.97 where the air pressure is nearly four times the normal, and at point 5.92 where it is nearly three times the normal. It is thus evident that a large factor of safety is required in this manoeuvre. In fact in these airplanes, the J.N.4 H., the factor of safety is supposed to be in the neighborhood of ten to twelve. It will be noted further that the greatest stresses in this present case occur before the loop proper is executed. These stresses follow always when an airplane, following a steep dive, is too suddenly leveled out, or directed again upward. In the present case a velocity of about 100 miles per hour was attained. The high stress at point 1.97 came from the high velocity, while at point 5.92 it came from the small radius of curvature.

No two loops are ever alike as, for example in the present case, a close inspection of the figure reveals that the angle of attack varies rapidly from point to point. This is in the pilot's control, and he can never operate his controls with perfect uniformity.

Altitude is invariably lost on a loop; in this case about seventy feet as shown in figure 44, but more was lost actually as the first part of the approach is not recorded.

This method of survey, while somewhat laborious, is capable of yielding very accurate results. In the present case there was but one light on the airplane, and so only the path of the plane as a whole was determined. If three lights were mounted, one would have exact information as to the angle of attack, and other matters, all of which information would be of the utmost value. A great deal of stress has been, and is being laid on tests of airplane performances. This method would in the end yield more accurate results with far less labor than would many of the methods which have hitherto been pursued.

Physical Laboratory,
The State University.

A NEW HIGH FREQUENCY TONE GENERATOR

C. W. HEWLETT

ABSTRACT

Ordinary telephone receivers will respond satisfactorily to alternating currents at frequencies as high as ten thousand vibrations per second, but above this frequency so much of the electrical energy is absorbed in hysteresis and eddy current loss that it becomes impracticable to supply enough energy to the receiver to enable it to serve as a satisfactory source of sound waves.

There are a number of interesting applications for a generator of sound waves of frequency above ten thousand vibrations per second. For instance the sensitiveness of the ear for sounds of definite intensity has not been satisfactorily investigated between the frequency of ten thousand and the so called upper audible limit. Another use is that such short waves will enable the phenomena of interference, diffraction and shadows to be demonstrated by the use of sound waves. There are other less obvious applications, and on the whole it seems to be worth while to try to develop a generator for high frequency sounds.

If the generator is to be driven electrically it is obvious from the foregoing statement in regard to the ordinary telephone receiver that some method must be adopted in which hysteresis and eddy currents are eliminated as far as possible. With this in mind a generator of the following design has been constructed and used:

Two flat pancake coils, each built of concentric coils with air spaces between are mounted facing each other with a thin aluminum diaphragm between. The coils and diaphragm are held in place by a framework of hard fiber or other insulating material. The method of connecting up the instrument and using it is shown below:

A three element vacuum tube is used in a circuit forming an oscillation generator. L_1 and L_2 are the coils of the tone generator and form part of the inductance of a tuned circuit of which C forms the variable capacity. The capacity C_1 allows the alternating current to pass through the coils without going through the 15 volt battery. This battery sends a direct current through the coils of the generator in such a way that

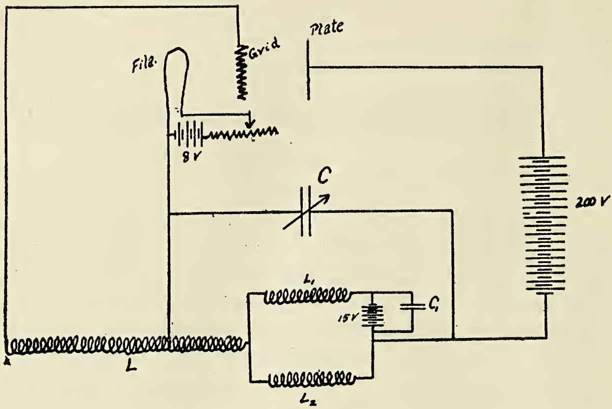

Fig. 45. L = Auto-transformer for feed back. L_1 and L_2 = Receiver coils. C = Tuning capacity. C_1 = Large capacity (2 m. f.) as path for high frequencies to avoid 15 V. battery.

the magnetic fields owing to this current oppose each other, and produce a radial field in the aluminum diaphram. The alternating current produces a magnetic field which is axial and hence induces circular currents in the diaphragm which react with the radial field due to the direct current producing vibration of the diaphragm of frequency equal to that of the alternating current. The air spaces between the concentric cells forming the pancake coils are for the purpose of allowing the sound waves to leave the diaphragm. With this arrangement sounds from 5000 to 26000 vibrations per second have been produced. With intensity the sound may be altered by changing the value of the direct current flowing through the coils. With this apparatus a beam of sound may be reflected in any direction by a mirror made of a flat piece of board about a foot square.

Mr. C. E. Lane, a senior in this university, has worked with me throughout this piece of work and has been of much assistance with valuable suggestions and efficient and careful experimenting.

Physical Laboratory,
State University of Iowa.

THE PERCEPTION OF BINAURAL PHASE DIFFERENCE NOT CAUSED BY AN INTENSITY EFFECT

G. W. STEWART

ABSTRACT

It is becoming well known that it is possible to perceive a difference in phase at the ears by a displacement of the phantom image from the median plane. Attempts have been made to explain this effect by bone conduction and the effect of intensity, for it is also well known that a difference of intensity will also cause a displacement. But the only published explanation of this character has been shown to be not satisfactory. Yet, since a large group of psychologists believe that sensation depends entirely upon the mode of response of the end organ and not upon the character of the stimulus, it is difficult to secure convincing evidence that the character of the stimulus, i.e., phase, does produce an apparent displacement of the phantom source.

If, however, it can be demonstrated that intensity does not indirectly produce the effect of phase, there remains but one conclusion, i.e., that there is direct perception of phase difference.

Such a proof has been found provided one accepts an obvious proposition, e.g., that if, for a given frequency, the observer does not respond to a difference of intensity at the ears by a displacement of the phantom sound, then intensity cannot, by bone conduction and consequent variation of intensity at one ear by variation of phase externally, produce such a displacement of the phantom sound.

In the test of five individuals for the intensity effect and the phase effect, three of the five are found to have the phase clearly defined in the region of frequency when *the intensity effect does not exist at all.* Indeed, the phase effect is just as clearly defined at a frequency where the intensity effect exists as at a frequency where the intensity does not exist. This would seem to be convincing evidence that the phase effect cannot be explained by terms of intensity.

Physical Laboratory,
State University of Iowa.

THE FREQUENCY LIMITS OF THE BINAURAL PHASE DIFFERENCE AND INTENSITY EFFECTS

G. W. STEWART

ABSTRACT

The variation in localization of a phantom source with phase difference only at the ears and the variation with intensity differences only at the ears are here called the binaural phase difference effect and the binaural intensity effect respectively. That these variations follow according to law, the former linearly and the latter logarithmically, is not discussed.

Individual	Limit of Phase Effect	Lapses in Intensity Effect. Observations from 100 to 1000
EMB	1360 D. V.	None
AETF	1335	850-1250
CICK	1119	None
HMH	1474	Over entire range
ML	1767	1450-2000
IK	1249	None
ES	1392	1450-1850
CRB	1333	850-1250 and 1550-2000
SC	1161	None
ERK	1146	1150-1250
CEL	1058	1450-2000
RK	1145	None
BWS	1248	850-1150
EGR	1151	None
ACR	825	1750-2000
GRW	1393	950-1850

The above table shows the results of experiments upon sixteen individuals. It is to be noted that the limit of the phase effect, or the frequency at which the phase effect ceases is approximately the same in all of the observers and that the lapses in the intensity effect seem to have no similarity. Experiments covered the range from 100 to 2000 d.v. Scattered experiments up to 4000 d.v. show no return of the phase effect but additional lapses in the intensity effect.

Physical Laboratory,
University of Iowa.

A TABLE OF THE TOTAL NUMBER OF STROBOSCOPIC VELOCITY CURVES FOR ANY OF THE NATURAL NUMBERS FROM 1 TO 500 INCLUSIVE TAKEN AS A LIMITING VALUE OF n AND m

L. E. DODD

The stroboscopic velocity equation [1] is

$$v_s = (A - n/m \cdot B) D_0,$$

where n/m is a fraction at lowest terms. Since there are as many stroboscopic velocity curves as there are different values of n/m this fraction may be referred to as the "stroboscopic parameter."

A question of importance in the study of stroboscopy is, what is the total number of stroboscopic velocity curves for all possible values of the stroboscopic parameter up to and including a given limit determined by the condition,

n not greater than m not greater than p,

where p is the limiting natural number.

This total number, Q, of the stroboscopic velocity curves for each of the values of p from 1 to 500 inclusive has been calculated, and the Q values are given in the appended table.

TABLE

p	Q	p	Q	p	Q
1	1	61	2323	121	8991
2	3	62	2383	122	9111
3	7	63	2455	123	9271
4	11	64	2519	124	9391
5	19	65	2615	125	9591
6	23	66	2655	126	9663
7	35	67	2787	127	9915
8	43	68	2851	128	10043
9	55	69	2939	129	10211
10	63	70	2987	130	10307
11	83	71	3127	131	10567
12	91	72	3175	132	10647
13	115	73	3319	133	10863
14	127	74	3391	134	10995
15	143	75	3471	135	11139
16	159	76	3543	136	11267
17	191	77	3663	137	11539
18	203	78	3711	138	11627

1 See Proceedings Iowa Academy of Science, vol. 24, 1917, p. 221.

TABLE — *Continued*

p	Q	p	Q	p	Q
19	239	79	3867	139	11903
20	255	80	3931	140	11999
21	279	81	4039	141	12183
22	299	82	4119	142	12323
23	343	83	4283	143	12563
24	359	84	4331	144	12659
25	399	85	4459	145	12883
26	423	86	4543	146	13027
27	459	87	4655	147	13195
28	483	88	4735	148	13339
29	539	89	4911	149	13635
30	555	90	4959	150	13715
31	615	91	5103	151	14015
32	647	92	5191	152	14159
33	687	93	5311	153	14351
34	719	94	5403	154	14471
35	767	95	5547	155	14711
36	791	96	5611	156	14807
37	863	97	5803	157	15119
38	899	98	5887	158	15275
39	947	99	6007	159	15483
40	979	100	6087	160	15611
41	1059	101	6287	161	15875
42	1083	102	6351	162	15983
43	1167	103	6555	163	16307
44	1207	104	6651	164	16467
45	1255	105	6747	165	16627
46	1299	106	6851	166	16791
47	1391	107	7063	167	17123
48	1423	108	7135	168	17219
49	1507	109	7351	169	17531
50	1547	110	7431	170	17659
51	1611	111	7575	171	17875
52	1659	112	7671	172	18043
53	1763	113	7895	173	18387
54	1799	114	7967	174	18499
55	1879	115	8143	175	18739
56	1927	116	8255	176	18899
57	1999	117	8399	177	19131
58	2055	118	8515	178	19307
59	2171	119	8707	179	19663
60	2203	120	8771	180	19759
181	20119	241	35567	301	55299
182	20263	242	35787	302	55599
183	20503	243	36111	303	55999
184	20679	244	36351	304	56287
185	20967	245	36687	305	56767
186	21087	246	36847	306	56959
187	21407	247	37279	307	57571
188	21591	248	37519	308	57811
189	21807	249	37847	309	58219
190	21951	250	38047	310	58459
191	22331	251	38547	311	59079
192	22459	252	38691	312	59271
193	22843	253	39131	313	59895
194	23035	254	39383	314	60207
195	23227	255	39639	315	60495
196	23395	256	39895	316	60807
197	23787	257	40407	317	61439

TABLE — *Continued*

p	Q	p	Q	p	Q
198	23907	258	40575	318	61647
199	24303	259	41007	319	62207
200	24463	260	41199	320	62463
201	24727	261	41535	321	62887
202	24927	262	41795	322	63151
203	25263	263	42319	323	63727
204	25391	264	42479	324	63943
205	25711	265	42895	325	64423
206	25915	266	43112	326	64747
207	26179	267	43463	327	65179
208	26371	268	43727	328	65499
209	26731	269	44263	329	66051
210	26827	270	44407	330	66211
211	27247	271	44947	331	66871
212	27455	272	45203	332	67199
213	20503	273	45491	333	67631
214	27947	274	45763	334	67963
215	28283	275	46163	335	68491
216	28427	276	46339	336	68683
217	28787	277	46891	337	69355
218	29003	278	47168	338	69667
219	29291	279	47527	339	70115
220	29451	280	47719	340	70371
221	29835	281	48279	341	70971
222	29979	282	48463	342	71187
223	30423	283	49027	343	71775
224	30615	284	49307	344	72111
225	30855	285	49595	345	72463
226	31079	286	49835	346	72807
227	31531	287	50315	347	73499
228	31675	288	50507	348	73723
229	32131	289	51051	349	74419
230	32307	290	51275	350	74659
231	32547	291	51659	351	75091
232	32771	292	51947	352	75411
233	33235	293	52531	353	76115
234	33379	294	52699	354	76347
235	33747	295	53163	355	76907
236	33979	296	53451	356	77259
237	34291	297	53811	357	77643
238	34483	298	54107	358	77999
239	34959	299	54635	359	78715
240	35087	300	54795	360	78907
361	79591	408	101283	455	126143
362	79951	409	102099	456	126431
363	80391	410	102419	457	127343
364	80679	411	102963	458	127799
365	81255	412	103371	459	128375
366	81495	413	104067	460	128727
367	82227	414	104331	461	129647
368	82589	415	104987	462	130887
369	83059	416	105371	463	130811
370	83347	417	105923	464	131259
371	83971	418	106283	465	131739
372	84211	419	107119	466	132203
373	84955	420	107311	467	133135
374	85275	421	108151	468	133423
375	85675	422	108571	469	134215
376	86043	423	109123	470	134583

TABLE — *Continued*

p	Q	p	Q	p	Q
377	86715	424	109539	471	135207
378	86931	425	110179	472	135671
379	87687	426	110459	473	136511
380	87975	427	111179	474	136823
381	88479	428	111603	475	137543
382	88859	429	112083	476	137927
383	89623	430	112419	477	138551
384	89879	431	113279	478	139027
385	90359	432	113567	479	139983
386	90743	433	114431	480	140239
387	91247	434	114791	481	141103
388	91631	435	115239	482	141583
389	92407	436	115671	483	142111
390	92599	437	116463	484	142551
391	93303	438	116751	485	143319
392	93639	439	117627	486	143643
393	94159	440	117947	487	144615
394	94551	441	118451	488	145095
395	95175	442	118835	489	145743
396	95415	443	119719	490	146079
397	96207	444	120007	491	147059
398	96603	445	120711	492	147379
399	97035	446	121155	493	148275
400	97355	447	121747	494	148707
401	98155	448	122131	495	149187
402	98419	449	123027	496	149667
403	99139	450	123267	497	150507
404	99539	451	124067	498	150835
405	99971	452	124515	499	151831
406	100307	453	125115	500	152231
407	101027	454	125567		

Bureau of Standards,
Washington, D. C.

ON FINDING THE EQUATION OF THE CHARACTERISTIC BLACKENING CURVE FOR A PHOTOGRAPHIC PLATE

P. S. HELMICK

In 1890 Hurter and Driffield [1] proposed the following equation for the density [2] "D" of a photographic plate exposed for a time "t" to light of constant intensity:

$$D = 1/a \ \mathrm{Log}_e(b - [b-1]e^{-ct})$$

where "a", "b", and "c" are parameters.

This equation has since been quite generally employed by other investigators,[3] but its one great disadvantage lies in the difficulty of finding numerical values of the parameters for an experimentally determined plate-curve. Sheppard and Mees [4] give methods of approximating values of "b" and "c" only when "a" equals 1.

This contribution points out two ways of obtaining values of the constants from an empirical curve which has the form of the equation given above by (1) an algebraic and (2) a graphical process.

Assuming that the experimental curve is of the form above, and selecting four points (t_1, D_1), — —, (t_4, D_4), so that $t_2 = t_1 + \Delta t$, $t_3 = t_1 + 2\Delta t$, and $t_4 = t_1 + 3\Delta t$, by elimination it can readily be shown that

$$(e^{aD_2} - e^{aD_3})^2 - (e^{aD_1} - e^{aD_2})(e^{aD_3} - e^{aD_4}) = 0.$$

$$c = \mathrm{Log}_e (e^{aD_1} - e^{aD_2})^{\frac{1}{\Delta t}} - \mathrm{Log}_e (e^{aD_2} - e^{aD_3})^{\frac{1}{\Delta t}}$$

and $$b = \frac{e^{aD_1} - e^{-ct_1}}{1 - e^{-ct_1}}$$

so the parameters are thus determined in terms of D_1, — —, D_4, and Δt.

The graphical method, superior to the algebraic method in actual practice, can be very conveniently established.

[1] Journn. Soc. Chem. Ind. 9, 455; 1890.

[2] Density of a plate equals logarithm to the base 10 of the ratio of the incident light to the light transmitted by the plate.

[3] See, for example, "Theory of the Photo. Process." Sheppard and Mees, p. 288; 1907.

[4] *Loc. cit.*

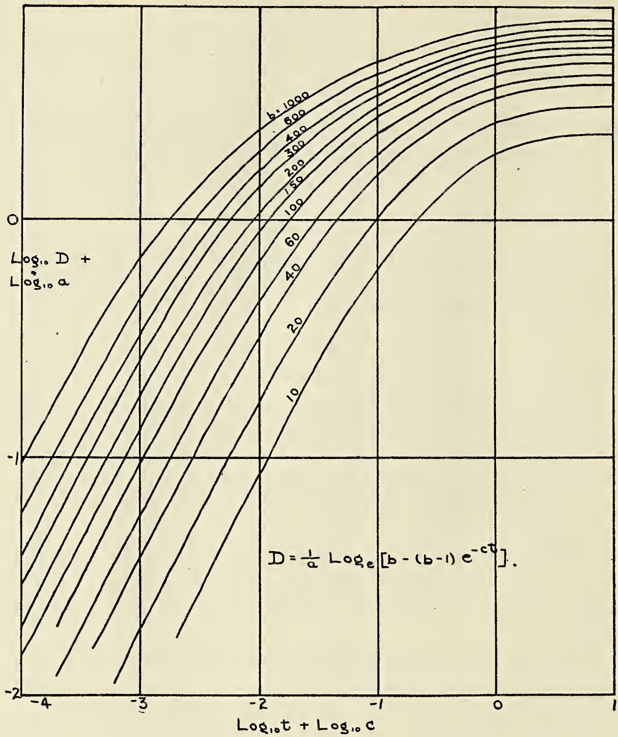

Fig. 46

A family of curves is plotted, as in the figure, with ordinate and abcissa Log aD and Log ct respectively, with "b" a parameter. The experimental curve is plotted upon tracing paper with Log D and Log t as ordinate and abcissa respectively. The tracing paper curve is now shifted over the family of curves,—preserving parallelism of axes,— until it coincides with a part of one of the family. The "b" is determined by the particular curve of the family chosen for coincidences, and the "a" and the "c" are given by the intercepts of the axes of the experimental curve upon the axes of the family of curves.

Physical Laboratory,
The State University of Iowa.

THE COMPARATIVE STABILITY OF COLORS IN WALLPAPER

J. M. LINDLY

The salesman of wallpaper is frequently asked if such a sample will fade, or is confronted with the bold assertion that such a specimen will do so. Usually, he is unable to answer the question definitely, or to deny the charge. Not having noticed any observation on the subject of the stability of colors in wallpaper, the writer was prompted to make a few tests or experiments.

Forty-six samples of wall paper, no two alike, representing as many colors, shades and tints, were exposed to the bright sunlight during the middle of the day for two days, making a total exposure of eight hours. This was done in the early part of August.

The results are classified into eleven groups, averaging about four samples to each group.

According to the average resistance of the samples of each group to the influence of the sunlight, the groups have been arranged in the following order of permanency:

1. The whites were unchanged.
2. The drabs were unchanged.
3. Buffs. Half the samples were unchanged; the others, being the darker, were slightly lightened.
4. Dark Blues. The darkest specimen was unchanged; the others were slightly changed but not sufficiently to attract attention.
5. Yellows. One, a high priced sample, showed no change; three showed slight change; the fifth, an ingrain, was much faded.
6. Dark greens. The two darker were slightly dulled. One of the lighter was apparently unchanged, while the fourth was much faded.
7. Dark browns. Half of these samples exhibited very little change, while the remainder betrayed a noticeable alteration.
8. Light browns. Two showed marked change; the third only slight.

9. Light greens. All showed change; a few very much.

10. Reds. All showed great change, the light ones and pinks having faded nearly white.

11. Light blues. All faded nearly white.

The foregoing is offered as the rule for the stability of colors in wallpaper, to which, like most rules, there are evident exceptions. These exceptions are probably due to a difference in the chemical material composing the coloring matter. It was observed that the light shades were more prone to fade than dark ones. The higher priced papers were more permanent than the cheaper ones, with a few exceptions. Gilts and micas were apparently unchanged. Red, pink, green and purple decorations, on any background, faded.

The question may arise as to the colors that were assumed in fading, that is, the colors resultant from fading. Specimens of the same papers were exposed during the spring, each for several days, to the strong light of the show window, and sometimes in the direct rays of the sun. The dark or deep reds became a dark purple, some of them of pinkish purple hue; the light reds became a light pink. The dark greens assumed a genuine slate color; the light greens approached white, some of them with a yellowish tinge. The drabs became lighter, approaching white. The browns assumed a dark reddish drab. Even the whites assumed a cream tint, which is, probably, the ultimate color into which a majority of all the other colors would finally fade.

When colored glass was placed over a light blue paper, the paper faded least under the green glass and most under the purple glass. When a red paper was treated in a similar manner, it faded least under the red glass and most under the green glass.

It is doubtful if there is any color used in wallpaper that is absolutely permanent. However, the gilt and mica, or the gold and silver, on the specimens subjected to the long-time exposure, showed no alteration.

Perhaps, the most permanent wallpaper would be that with a white or buff background with gilt and mica decorations.

WINFIELD, IOWA.

SYMPOSIUM: SOME RESULTS OF CURRENT RESEARCH IN THE PSYCHOLOGICAL LABORATORY OF THE STATE UNIVERSITY OF IOWA

INTRODUCED BY C. E. SEASHORE

Investigations at the psychological laboratory are at the present time centering upon two general fields which are more or less closely related; namely, the Psychology of Music, and the Psychology of Basic Motor Capacities. The former is represented essentially by the first six titles, and the latter by the last six.

The work in our laboratory has for a number of years been characterized by team work shown not only in the unit coöperation represented in this program, but also by team work reaching backward in that several of the problems here represented are merely the present link in the chain of previous investigations by other persons on the same subject in this laboratory. Our aim is to put one man after another upon a problem that has once been taken up until the cumulative results reach a satisfactory state.

This team work has great advantages in that it enables those who direct the research to concentrate their energies, not only for one year but for a series of years, upon the same problem, and, as we cannot employ research specialists for life, this dovetailing together of apprentice periods of research students is found to be a very happy procedure. Furthermore, research students, like certain plum trees, grow best in bunches, and the shoulder to shoulder coöperation upon related problems is a stimulus to achievement.

THE TALENT SURVEY IN OUR MUSIC SCHOOL

ESTHER ALLEN GAW

The forty-six students who are majoring in music have been given a series of psychological tests during the year 1919-1920. The tests for sense of pitch, sense of intensity, sense of time, sense of consonance, and tonal memory were given not only to those majoring in music, but also to the large groups in harmony and history of music, by means of the phonograph disks. The large groups were also given the army intelligence test and the auditory imagery group test. Those specializing in music were measured for their motor ability by means of eight motor tests; first, a series of motor tests showing the general reponse of the fingers, hands and arms. These four are motility tests — the test for rapidity of tapping described by Mr. Ream; free action, a test of the ability to mark time at a uniform rate; timed action, a test of the ability to keep time with a sound recurring every second; rhythmic action, a test of the ability to mark a complicated rhythm; and visual serial action, a test of the ability to react to visual stimuli, described by Mr. Hansen. The second series of motor tests are those given on the tonoscope. They measure (1) ability to sing the keynote D, 290 v.d., (2) ability to carry the tune America, and (3) ability to sing a very small difference in pitch. The motor and visual imagery tests were given individually to the forty-six students.

In addition to the seventeen tests we have the ratings of the teachers as to the application, control of rhythm, ability to read music at sight, and progress of each student. This gives us criteria of achievement with which to compare the measurements.

In general the music students are found to be average or above in the discrimination tests. Selection has already taken place before they come to the music school, a selection based upon the sensitiveness of the ear to the factors of musical tone. In the motor tests they vary more. Timed action and the singing tests show the effects of training, for the records are uniformly very high.

In making a talent chart all of the measurements are reduced to percentile rank; i.e., rank on a scale of one to one hundred, one being the lowest rank obtainable in any measurement, 100 the highest and 50 average. The results in all the tests have been reduced to this common basis and are thus comparable. Talent charts, showing characteristic points were exhibited. The first is of a student who is very superior in every measurement but one and who, according to her teacher's ratings, is also very superior in application, control of rhythm, etc. The second shows a superior student who is also superior in achievement. The third shows a student about equal to the second in ability, but who is not achieving what she should. The fourth shows a student of average ability who is also average in her achievment.

THE NORMAL CURVE OF ACUITY IN HEARING

PAUL B. ANDERSON

The speaker reported on the establishment of norms on the basis of records made by Mr. Bunch with the Iowa Pitch Range Audiometer. The normal curve (Fig. 47) of acuity of hearing, based

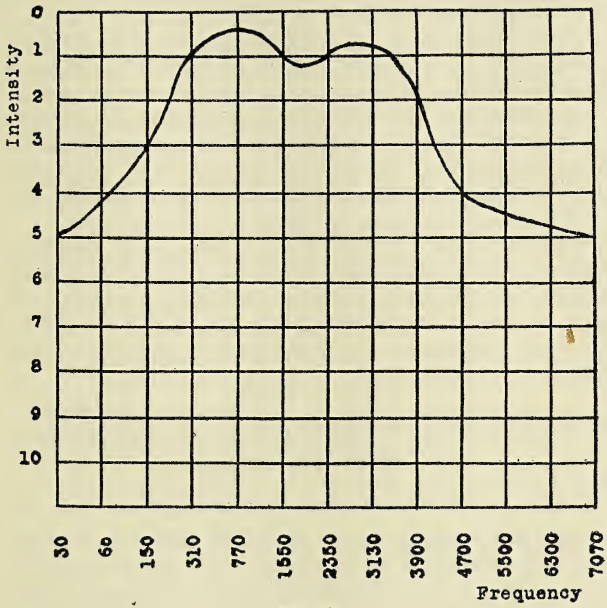

Fig. 47

upon twenty-four cases of music pupils, was exhibited. In this figure the intensity of the sounds are on the scale of 1 to 6 as shown at the left, and pitches are denoted by vibration frequency as indicated by the numbers at the bottom. A graded series of norms is being established showing the norm for the best 10 per cent, the best 25 per cent, and the best 50 per cent of so-called normal ears. Abnormalities are measured in terms of deviation from these norms.

THE IOWA PITCH RANGE AUDIOMETER

C. C. BUNCH

The ideal apparatus for measuring the acuity of the ear should enable one to determine the faintest audible sound at each and every pitch within the tonal range. It should be easily and quickly operated and should be permanently standardized. The Pitch Range Audiometer is an approach to this ideal.

The essential parts of this audiometer are a variable frequency generator having a range of between 25 d.v. and 14,000 d.v., a motor for rotating this generator, a telephone receiver, and an electric tachometer for indicating the pitch of the tones produced. The complete range of tones is produced by varying the speed of the motor. Intensity measurements are secured by means of a small potentiometer with an empirically chosen increasing scale of 400 per cent installed in the circuit.

The practical use of the instrument has been demonstrated and verified in the otological clinic. It was used in the army vocational school in selecting radio operators. Unlimited opportunities are open for its use in the psychology of music, and for the basis of laboratory experiments, and other lines of practical scientific work.

THE LOCALIZATION OF SOUND BY WAVE PHASE IN THE OPEN EAR

HENRY M. HALVERSON

Wave phase localization may be studied under normal conditions; i.e, without the aid of conductors to the ears. Our apparatus consists of two telephone receivers connected in series from the same source. If the receivers are so energized as to produce a pure tone, the observer, by closing one ear and moving the head carefully from one source to the other, (the side of the head parallel to the axis of the receivers) will experience a series of "highs" and "lows" in intensity. These points of maximum and minimum intensity correspond exactly to the points of reinforcement and interference as obtain in the standing wave.

If now the observer, with both ears open, (the aural axis parallel with the axis of the receivers) moves slowly from one source to the other, he will be conscious of a median plane localization for each one-half wave length that he advances. These points in localization we call loops. Midway of these are other median localizations known as nodes. There is a fundamental difference between these nodes and loops. In the loop the phantom sound moves in the same direction in which the observer is moving, while in the node it moves in the opposite direction.

Following are some of the conclusions which we have reached:

1. If a rich tone is used the trained observer may localize, not only the phantom for the fundamental tone, but at least two or more of the overtones the phantoms of which have loops of relatively smaller dimensions may be localized independently of the overtone. This is particularly true of low tones of some 100 v.d.

2. The loops and nodes of any phantom always occur alternately for each one-fourth wave length of the phantom tone in the case of either a pure tone or a rich tone, and may be interpreted in terms of the conditions of the standing wave.

3. Wave phase effects obtain, not only in the line of the receivers, but practically anywhere within the range of audibility. We are as yet unable to say that these changes in phase are everywhere uniform. Present investigations seem to point to the fact that they are not uniform.

4. Wave phase effects are best obtained midway of the receivers. As we draw near either of the sources localization becomes more difficult.

5. The size of the loops varies directly with the wave length of the sounds used. The same is true of the nodes.

6. Wave phase effects in open air are best observed with tones ranging from 300 v.d. to 1200 v.d. This is because (1) tones within these limits present sharper differences in intensity at the nodes and loops; (2) the interaural distance hinders localization with tones of high pitch.

7. The flux in intensity from a loop to its adjacent node has been determined by means of the Seashore audiometer. Hence the differences in intensity which we had formerly observed are not at all subjective.

8. The intensity of the two sources may vary widely without affecting the wave phase effect.

9. By means of the standing wave it is possible to predict the relative intensity and localization of the phantom at any point on the line between the receivers.

WHAT CONSTITUTES VOICE?

C. I. ERICKSON

I. General mechanism of voice production —
  A. Physiological
    1. Lungs
    2. Larynx
    3. Resonating Cavities
      a. Ventricles of the Larynx
      b. Lower pharynx
      c. Upper pharynx
      d. Oral cavity
      e. Nasal cavity
      f. Sinuses
    4. Muscles
      a. Ten expiratory muscles
      b. Laryngeal muscles
        (1) Five intrinsic
        (2) Four extrinsic or infrahyoid
      c. Supra-laryngeal muscles
        (1) Five pharyngeal
        (2) Four suprahyoid
        (3) Four maxillary
        (4) Eight lingual
        (5) Ten labial
        (6) Five palatal
        (7) Five nasal
  B. Psycho-physical
    1. Auditory imagery and sensations
    2. Kinaesthetic imagery and sensations
    3. Tonal memory
II. Basic factors —
  A. Pitch — its primary mechanism of control
    1. Physiological
      a. Vocal cords — variable as to weight, length, shape, tension, and condition
      b. Intrinsic laryngeal muscles
      c. Supra-laryngeal muscles
    2. Psycho-physical
      a. Pitch discrimination
  B. Intensity — its primary mechanism of control
    1. Physiological
      a. Lungs variable as to capacity and condition
      b. Resonating cavities — variable as to number used, size, shape, condition
      c. Expiratory muscles
      d. Supra-laryngeal muscles
    2. Psycho-physical
      a. Intensity discrimination
      b. Acuity of hearing

C. Timbre — its primary mechanism of control
  1. Physiological
    a. Resonating cavities
    b. Vocal cords
    c. Supra-laryngeal muscles
    d. Laryngeal muscles
  2. Psycho-physical
    a. Pitch discrimination
    b. Intensity discrimination
    c. Timbre discrimination
D. Volume — its mechanism of control
  1. Physiological
    a. The general mechanism of voice production
  2. Psycho-physical
    a. Intensity discrimination
    b. Timbre discrimination
    c. Extensity discrimination
E. Time — its mechanism of control
  1. Physiological
    a. The muscular mechanism of voice production
  2. Psycho-physical
    a. Time discrimination

THE PERSONAL EQUATION IN MOTOR ABILITY

MARTIN L. REYMERT

In order to try out experimentally the common notion, that an individual will show a constant behaviour as to speed and accuracy in all kinds of motor performance — within his group — a series of reaction and motor tests were given to sophomores. The tests were: (1) Tapping in group (with pencil). (2) Individual tapping (on telegraph key). (3) Counting numbers orally. (4) Writing numbers. (5) Counting and writing as one combined activity. Simple bodily reactions of (6) the lips, (7) the jaws, (8) the index finger, (9) the head, (10) the elbow, (11) the thumb, (12) the foot. (13) Ergograph test.

Throughout this test series the individual behaviour was judged in terms of speed (time) and variability (mean variation). The raw-correlations (Spearman) have been pooled.

The main results:

1. There is a distinct personal equation as to speed throughout all tests — the intercorrelations here being positive, very high and very reliable (as judged by P. E.).

This result may have the bearing on motor tests for vocational selection, that one or two representative motor tests will suffice as to the placing of an individual in a group — regarding quickness of action.

2. It is impossible to predict from one or two motor tests how a subject will rank in his group as to individual variability (constancy) in other motor tests. At least the M.V. shows up to be a fleeting factor from test to test. Either the M.V. is not a minute enough measure of individual variability or no personal equation exists in this respect. The negative outcome ought to have the greatest bearing on vocational motor testing.

A wealth of other significant general and special results, which lack of space forbids stating in full here, also were evolved from the above investigations.

It may suffice to note, as a matter of general interest, that regarding the highest rate of movement for the different bodily members, we get the following sequence:

(1) lips, (2) index finger, (3) jaws, (4) thumb (grip), (5) elbow, (6) foot, (7) head.

As to the range of different bodily reactions, we may state that the individual's variation from the average of the group is very nearly proportional to the personal range in M.V. for all parts of the body here tested except the jaws. The rate of the quickest bite, then marks out the individual most clearly in the group.

SERIAL ACTION AS A BASIC MEASURE OF MOTOR CAPACITY

C. FREDERICK HANSEN

Motor tests involving "continuous discriminative reactions" or "serial action" are being standardized by the psychologist with the end in view of reproducing, in dealing with his practical problems, the actual conditions of simple daily motor activities more closely than obtained in the traditional reaction time tests. These newer measures of motor capacity recognize the essentially fluid character of stimuli and reactions — their fundamentally continuous interplay, which is apparent not only in simple motor achievements like walking or handling tools, but also in the complex activities of the musician, the telegrapher, the typist, or the expert mechanician. In the analysis, therefore, of motor capacities for clinical, vocational, or industrial purposes, the performance of a subject in a standardized test of serial action may serve as an index of his basic motor capacity, applicable to many problems.

Our program has been:

1. To determine experimentally what kinds of stimuli, associations, and reactions are most natural and basic, thus leading to the measurement of inherent rather than acquired abilities.

2. To secure a simple and practical device which can be transported, set up, and operated without difficulty.

3. To control as far as possible every variable in the procedure, objective and subjective.

4. To measure the performance in this test of certain homogeneous, representative groups of persons.

5. To correlate the results obtained with achievement in the particular vocational or industrial pursuits involved by means of practical criteria.

Suitable apparatus having been devised and the test standardized, we have investigated its value for (1) indicating general motor capacity by a comparison of scores of 158 university sophomores in this test and in seven other motor tests; (2) predicting the probable competence or incompetence of beginners in telegraphy by testing 173 men in the Army Vocational School at this University; (3) the analysis of native capacity of ninety music students for musical action; (4) the prediction of skill in typewriting based on about 280 cases from various commercial courses.

THE MEASUREMENT OF MOTILITY IN CHILDREN

LILLIAN TOW

What we expect and demand in discipline and performance at each age should depend upon a child's development, mental, physical, and functional.

In this laboratory the evaluation for scientific and diagnostic purposes of motor rather than mental capacities is being stressed. The object of this investigation is to find what the motor equipment of children is on entering school. The discovery of the basic motor tests which applied at five and six years of age will give results which are reliable and significant in that they throw light on motor ability. Previous investigations on young children have had for their fundamental purpose the comparison of mental and motor traits. The aim of this study is to investigate the responses of as many different sets of muscles as possible and to compare these responses one with another to see if the nature of one is an index to a corresponding nature in another.

The phases which have been especially studied are:

1. Strength
2. Steadiness of motor coördination
3. Speed and accuracy of voluntary movement
4. Rapidity of movement
5. Quickness of response

The results of such an investigation will help to determine:

1. The movements children can best make
2. The relative ability of children and adults
3. The development of motor control with age
4. The variation of motor control due to sex
5. The variation of motor control in individuals
6. The correlation of motor and mental ability

THE SELECTION OF TALENT FOR STENOGRAPHY AND TYPING

BENJAMIN W. ROBINSON

H. C. Link states that "The application of psychological tests in those fields where their value has been verified, is the only method short of the laborious and costly method of trial and error, which makes it possible to discover the exact ability, both innate and acquired, of an individual. Unless these facts are known, it becomes impossible to assign the individual to the work for which he is best fitted or to give him the training which he deserves. Once the potential and actual ability of an individual has been discovered the vocational selection or training of that individual can be decided with a measurable degree of intelligence."

In our study of measurement of natural capacity and aptitude for stenography and typewriting, the first problem was that of verifying the value of the tests to be used. The mental and motor capacities necessary for a good stenographer and typist were analyzed and two mental and motor tests were selected to be tested as measures of these capacities.

Advanced shorthand and typing students were tested by means of these four tests to determine whether or not the same individual differences were brought out by the tests as those which showed up in the actual work in shorthand and typing. The results in the tests were correlated with the instructor's ranking of the individuals in shorthand and typing as well as with the results of a speed test in typing, and a positive correlation was found to exist.

The problem now remains to find out which of the tests best serves the purpose and to substitute other tests for those which do not serve so well. This done, the aim will then be to standardize the test for use in the eighth grade to assist the vocational guidance of those pupils who expect to elect the commercial course in high school.

A MEASURE OF CAPACITY FOR ACQUIRING SKILL IN COÖRDINATION OF EYE AND HAND

WILHELMINE KOERTH

Because success in many industries and activities depends to a large extent on ability to acquire skill in coördination of eye and hand, a measure of this capacity would prove very serviceable in both vocational guidance and selection. We are now trying to determine whether an apparatus providing a moving target of known size, following a constant predictable path at a uniform rate of speed will give an index of such capacity. This index is to be found by measuring the observer's ability to hold a ringed, metallic pointer on the moving target.

The apparatus consists of a circular target, 1.9 cm. in diameter, mounted flush with the surface of a wooden disc large enough to permit the target to describe a circle 16 cm. in diameter as it revolves. The target is electrically connected with a commutator on the edge of the disc, which records on a Veeder counter the time the observer is able to hold the pointer on the revolving target. The disc is revolved on an ordinary phonograph at the rate of one revolution per second, thereby providing a constant, uniform rate of speed and recording the time in tenths of a second.

After measuring 140 men and women, principally from the sophomore class, the following things were noted: that observers fall into four groups; i.e., those who start low and end low, those who start low and end high, those who start high and end higher, and those who start high and end practically on the same level, that the curve of distribution tends to be normal with the mode at forty and the extremes at five and eighty. The averages of twenty trials for each person were used to establish this curve. The curve for each observer is a typical learning curve, and with continued practice the typical plateaus of organization are well marked. In a ten day practice period the curve of the best observers tends to become a straight line and that of the others tends to remain broken.

As a check on the value of the measure, ten men from the Engineering shops were measured. Each man was given twenty-five trials and the results compared with the rating on mechanical ability given by their instructors. In six cases the two ratings were near enough to be significant, but the other four showed considerable discrepancy. The one case where the difference was most marked was rated by the instructors as being mentally unable to make good in a machine shop. As this measure is not a measure of mental ability the discrepancy is not as alarming as it at first appears.

On the whole, while the results of this investigation are somewhat negative, they are still sufficiently encouraging to continue the work, which is as yet scarcely well started, until a measure of a person's ability to acquire skill in the coördination of eye and hand is eventually evolved.

A STANDARDIZED MEASURE OF MOTILITY

MERRILL J. REAM

In any survey of the fundamental capacities of motor control the factor of speed of simple movement is obvious as one of the basic essentials which underlie all the developed complexities of movement. This fundamental capacity for speed in a simple repeated movement we call motility, and the motion selected is an easy movement of the forearm in which the finger taps a telegraph key. This type of movement is selected because it is one of the most rapid of the voluntary movements; it is clearly developed, is very simple, and requires no learning. It is assumed that the ability shown in this movement is, in general, indicative of corresponding ability in other parts of the body.

The investigation of motility has resulted thus far in a standardized apparatus and method for conducting the test. It was discovered that for most people voluntary movement can not be maintained at its maximum rate for more than five seconds. To measure accurately and easily this short interval of time, an apparatus was devised which eliminates the reaction time of the experimenter and the observer. The apparatus, in addition to the telegraph key, consists of a metronome, a specially reliable electric counter, and a double action shunt key. The metronome is accurately timed to beat seconds and is equipped with a mercury contact during alternate seconds of its oscillation. The recording of the tapping is started and ended by the beating metronome. During the intervening seconds of the five seconds' interval, a short circuit through the shunt key makes the recording continuous. By this method we have an accurate recording and timing instrument which is also compact, portable, and usable outside of the laboratory. Any graphic method of recording the twenty trials, which are the standardized number of a single test, would be exceedingly laborious.

The efforts at standardization have shown that the fastest tapping is done under the following conditions: a natural forearm movement, the arm unsupported, a finger position in which the key is lightly held and a charge to the subject which stimulates him to his best effort.

Most interesting have been the results of a twenty day practice experiment of six normal adults. There is essentially no improvement with practice unless the observer was hampered in his initial performances by difficulties of technique. For this reason two preliminary practice trials are given. Non-improvability is very significant since it indicates that a fundamental motor capacity is being measured.

There are individual differences in regularity of performance as well as in speed. The four combinations of speed and regularity are found, though more often the fast tapper is likely to be regular. A very high irregularity often means that there are difficulties of technique which a little practice or cautioning from the experimenter may overcome.

The testing of children from each grade of an elementary school showed that motility develops consistently with age and physical growth until the adult physique is attained. At each age the boys averaged slightly better than the girls.

Motility has a low positive correlation with other motor tests, but thus far no relation has been found with mental ability. Its future application will be in those lines of activity where speed of movement is an essential specification.

A STUDY OF SOCIALITY IN THE MADREPORARIA

GERTRUDE VAN WAGENEN AND H. J. WEHMAN

The type of sociality found in the Madreporaria is necessarily primitive. While we were making this study two criteria of sociality have been adopted and applied: first, the proximity of one corallite to another; second, organic communication between associated polyps and corallites. As the two criteria indicate, sociality is examined from the sandpoint of morphology of hard parts. This is necessary because of the extent of the field covered, the absence of live specimens, and the inclusion of fossils.

The association in which there is no organic communication between the units may be called non-colonial; the association in which there is organic continuation, colonial. The non-colonial associations include simple corals growing in the same locality, colonies flourishing on the same reef, and groups of larvæ which, because of an especially favorable environment, have settled very near to each other. In the last-mentioned instance, should several of the larvæ survive their hard parts would soon approach each other and coalesce, giving the appearance of a true colony. In such a case there is usually no communication between the adjacent visceral cavities; and the term pseudo-colonial is used. Other than this simple fusion of hard parts the non-colonial and pseudo-colonial associations are of no further interest morphologically.

It is only reasonable to believe that the solitary corals preceded the colonial. The evidence of paleontology, while leaving something to be desired, is definitely in favor of this view. The most ancient of all corals, the *Archaeocyathidae,* occur in the Cambrian. They are solitary, and no trace of a Cambrian colony has yet been found. The family *Archaeocyathidae* is considered to belong to the Hexacoralla and Perforata, but for the most part the Paleozoic history of corals deals with the Tetracoralla. Of eleven genera of Ordovician Tetracoralla listed by Zittel (1913) only two were colonial (ten per cent); of twenty-eight genera from the Silurian nine were colonial (thirty-two per cent); of thirty-one genera from the Devonian eleven were colonial (thirty-five per cent); of sixteen genera from the Carboniferous seven were colonial (forty-five per cent). From these percentages it appears that there was a gradual increase in the number of colonial genera, but there is no doubt that the majority of the Tetracoralla always remained solitary.

There are few known genera of Hexacoralla from the Paleozoic, and the greater number of these, including the *Archaeocyathidae* and several genera in the *Eupsammidae,* were solitary. The sudden extinction of the Tetracoralla at the close of the Paleozoic was followed in the beginning of the Mesozoic by as sudden an increase in the number of Hexacoralla. Paleontology does not show any definite increase in the proportion of colonial to solitary genera among the Hexacoralla; but so far as is known the Hexacoralla have been predominantly colonial from the Triassic, ninety per cent of the Triassic genera listed by Zittel being colonial.

Hence it appears that in the course of geologic time a predominantly colonial type has superseded a predominantly simple type of coral.

Of the five families of Tetracoralla given by Zittel, three (*Cyathaxonidae, Paleocyclidae,* and *Zaphrentidae*) contain solitary forms only. In the *Cystiphyllidae* colonies are rare; hence nearly all the compound Tetracoralla are found within the family *Cyathophyllidae.* In this family a definite progression in colony-formation may be traced.

Heliophyllum may serve as an example of a solitary Tetracorallum; this genus also, though rarely, forms dendroid colonies.

Diphyphyllum forms large colonies, but is composed of discrete columns held in place by intercolumnar braces placed at different levels throughout the colony. Reproduction is by multiple gemmation, and in some species at least the parent polyp dies. Since the columns are separated by a space which may be as great as their own diameter, and since there is no trace of interstitial tissue other than the occasional bridges, it would appear that only a few neighboring polyps were continuous over newly-formed braces.

Cyathophyllum represents a further step toward the formation of a compact colony. Connecting braces are not present, and a fairly distinct progress is traced from species like *C. cespitosum* in which the column walls diverge, through forms such as *Cyathophyllum calvini* in which the perfect cylindrical column walls become flattened where two are in contact, to forms like *C. hexa-*

gonum in which the assumption of a definite hexagonal shape is caused by maximum crowding of calices.

In the species *Lithostrotion canadense*, although the calices have taken on the hexagonal shape, each column remains distinct, the walls of adjacent columns being merely applied to each other. In *Acervularia* and other genera the walls of adjacent columns have coalesced and the common wall brings about the closest union between polyps attainable without actual confluence.

Colonies may arise in two ways: by budding and by fission. Stolonization is to be considered as a type of budding. These two lines of development from solitary corallite to colonial form may be illustrated in the Perforata within the single family *Eupsammidae* by the genera *Balanophyllia, Heteropsammia, Lobopsammia, Dendrophyllia* and *Rhizopsammia.*

The Solitary Phase. *Balanophyllia* may be taken as a typical example of a solitary coral, and this, as well as other solitary forms, is often found in pseudo-colonial groups.

Colonies arising by Fission. An example of a genus that has abandoned the solitary form and is in process of becoming colonial is *Heteropsammia.* One species, *H. michelini,* invariably occurs with two calices, partly imbedded in cœnenchyma. Another species, *H. multilobata,* has made further progress, always having a greater number of calices than two. A further departure along the same line is shown by *Lobopsammia,* in which there is repeated fission, resulting in a cespitose colony.

Colonies formed by Budding. *Balanophyllia* forms new individuals by budding, as do other solitary corals; and it is easy to see that a colony might arise in the first instance by retention of a bud. The genus *Rhodopsammia* shows a primary stage in colony formation by retaining lateral buds which in turn may bud, and the grand-daughter buds being likewise retained, the result is a dendroid colony of a simple type. A more advanced stage is illustrated by the genus *Dendrophyllia,* some species of which on the one hand build up by successive gemmations dendroid colonies of considerable complexity (*D. nigrescens,* etc.); and on the other hand certain species (*D. willeyi, D. diaphana*) form cespitose and finally massive colonies by lateral or sub-basal budding. Stolonization is represented by the genus *Rhizopsammia.*

Aporosa. The Aporosa furnish no single family, the limits of which are undoubted, to illustrate the two lines of development in colony formation, but a fairly complete series may be found within the limits of the suborder as a whole.

Colonies arising by Budding. *Caryophyllia* is an example of imperforate solitary coral, and what has been said about *Balanophyllia* applies also to *Caryophyllia.*

Haplohelia, an Oligocene genus in the family Oculinidæ, stands as an example of primitive dendroid colony, having gemmation from one side only. In *Oculina* the corallites are small and numerous, arranged spirally or scattered irregularly over the branches and imbedded in coenenchyma — obviously an advance over *Haplohelia* in colony-formation.

A reduction in size of corallites and filling in of coenenchyma is to be found in the family Orbicellidæ. *Galaxea* forms a submassive colony with exsert turbinate calices, while in *Orbicella* the calices are smaller and imbedded in coenenchyma; the latter condition must be interpreted as a marked advance over the former in colony-evolution.

Colonies arising by Fission. *Lophohelia* is an example of a primitive dendroid colony. The geniculate branching indicates that the colony results from simple successive unequal fissions, the original turbinate shape typical of the solitary corals being retained by each calice. Other colony-formation by fission is illustrated by the three families *Eusmiliidae, Mussidae,* and *Faviidae. Eusmilia* forms cespitose colonies by dichotomous or trichotomous fission, but the rapid separation of the corallites with upward growth is accompanied by withdrawal of soft parts, leaving the colony complex only as to skeleton. The soft parts are continuous between members of the last division, so as a rule the polyps are confluent in twos and threes. In *Dichocoenia* the same division into two or three calices occurs, but reduction in size of calices and filling of intercalicinal spaces with coenenchyma results in a massive colony in which all soft parts are continuous and the calices are confluent in small groups.

In *Mussa sinuosa* fission results in a meandrine form, but the walls of confluent groups are ununited, leaving the soft parts of the individual groups distinct. In *Diploria* the walls of the adjacent series of corallites are united by the peripheral ends of costae, which leaves a shallow trough, over which, however, the polyps are continuous. In *Meandrina* the fusion of the walls directly into a single colline brings about the highest union between the soft parts of an entire head that is to be found throughout the whole group Aporosa.

Fungida. In the Fungida it was not found possible to follow out the two lines of colony formation because of incomplete data as to the mode of asexual reproduction. However, in the study of hard parts there appears to be a series in increasing complexity, within the family *Fungidae,* exemplified by the genus *Fungia,* which is invariably solitary; and *Herpetolitha,* which has an axial series of calices with several peripheral parallel series of calices, the septocostae being continuous between calice and calice; and *Polyphyllia,* the last step in the series, having calices decreased in size, increased in number, and crowded together.

The genera of the *Agariciidae* are typically compound, but in the Tertiary simple forms appear to have been fairly common (*Microseris, Trochoseris, Palaeoseris,* etc.). *Cyathoseris,* from the Oligocene and Eocene, forms a massive colony by costal gemmation, the young corallites remaining permanently in a circle about the periphery of the mother polyp. Within the family *Agariciidae* it is possible to choose a graded series of genera and species from such forms as *Siderastraea,* in which a definite pericalicular wall interrupts communication between polyps, to certain species of *Agaricia* in which there is no definite pericalicular boundary, the septocostæ and some of the mesenteries being continuous from polyp to polyp. The highest degree of sociality in the Fungida appears to be found in *Pachyseris,* in which the calices are disposed in parallel rows with continuous and parallel septocostae, with continuous columella, and showing no impression in the hard parts of distinct calices.

The most successful corals at the present time are undoubtedly those which have the most intimate union between the individual polyps; for example, *Porites* and *Acropora* in the Perforata, meandrine forms in the Imperforata, and in the Fungida those corals which have lost definite pericalicular boundaries, as for example the family *Agariciidae.* In modern reefs the world over these genera are found to be most numerous in individuals and often also in species and varieties. The communication between the visceral cavities of polyps in the Perforata is accomplished by perforations in the boundary walls, while in the Imperforata and the imperforate Fungida a similar result is brought about by the abolishment of the walls themselves in the line of confluence. In the one case the communication is intraskeletal; in the other, supraskeletal.

The unity and compactness of colonies of the Hexacoralla cannot be paralleled among the Tetracoralla, althought the Tetracoralla shows some progress, from the diffuse *Diphyphyllum* to the compact *Strombodes* or *Acervularia.* Modern species have fairly definite growth-forms; while such diffuse colonies as *Cyathophyllum calvini* and species of *Diphyphyllum* have apparently neither definite shape nor definite size, and one colony of *Cyathophyllum calvini* has been found which is reported as having probably had a diameter of fifty feet or more.

CONCLUSIONS

Two points seem clear: first, there has been progress throughout the geological history of corals from solitary to colonial, and within the colonial corals progress in compactness; second, the most successful of modern corals are those which have the highest degree of colonialism. Since this is so, there must be definite advantages in sociality.

In the animal kingdom there is always an advantage in numbers. The colonial condition supports a greater number of individuals in a favorable environment than is possible in the solitary condition. There is moreover an economy of skeletal tissue, for instance, epitheca. Then too, asexual multiplication, by budding and by fission, is more economical than sexual reproduction because in the former case the young inherit the same environment which has proven favorable for the parent and enjoy the protection of the parent polyp and of the colony. This is the same principle which in higher animals is called care of the young. These advantages are true not only of coral heads entirely covered with soft parts but also of colonies bearing only isolated polyps. In colonies where there is continuation of soft parts, and especially confluence of visceral chambers, there are the further advantages of equal distribution of food and transmission of nerve impulses. Where visceral chambers are continuous food ingested by one polyp will be transmitted to others; and continuity of soft parts means possibility of transmission of impulses from polyp to polyp, so that food and warning-stimuli call forth anticipatory reactions in neighboring polyps.

These advantages — community of food supply, economy of space, protection of young, transmission of warning stimuli, common action against enemies, and protection against extinction afforded by a large number of individuals — characteristic of all social groups in a certain stage of their evolution, are found to be present therefore even in the primitive sociality of the Madreporaria.

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Department of Zoology,
State University of Iowa.

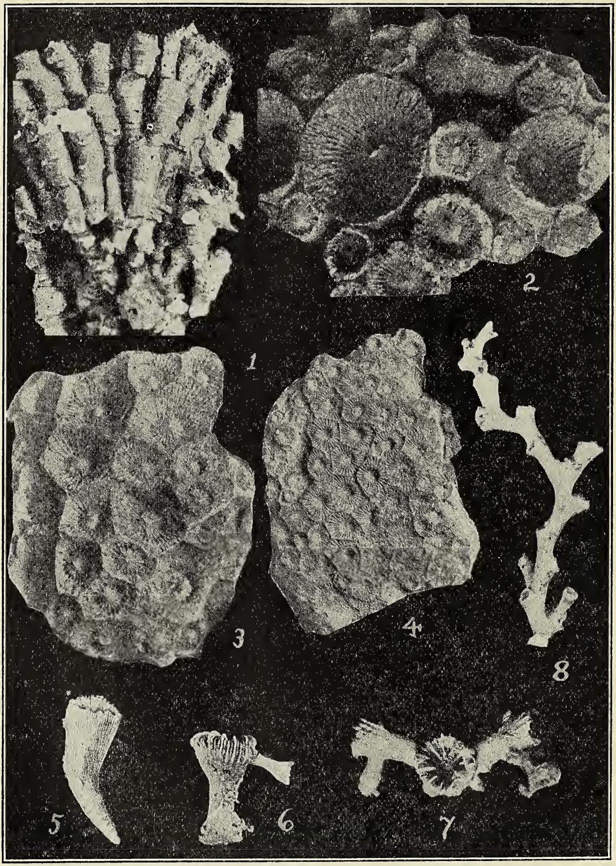
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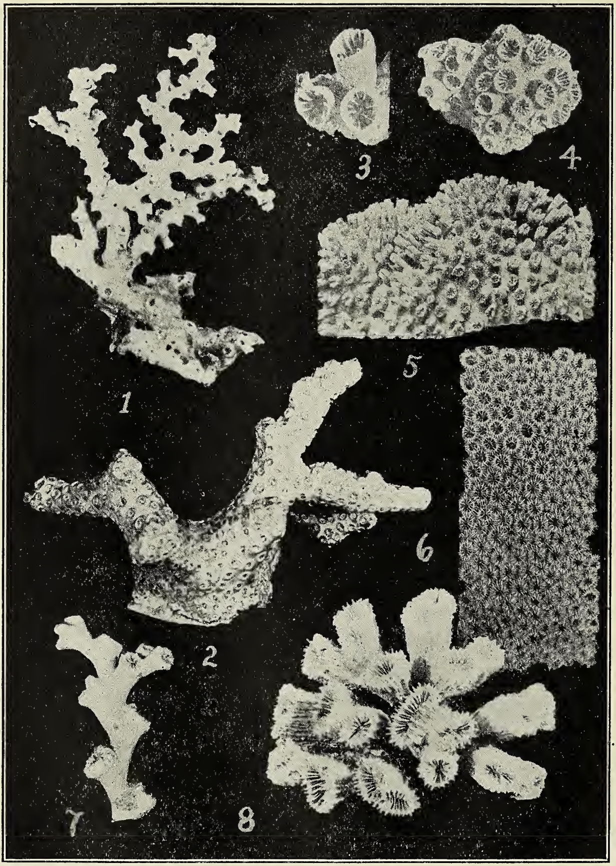
PLATE III

1. A small portion of a colony of *Diphyphyllum eruciforme*, x 1, showing multiple calicinal budding and intercolumnar braces. A diffuse type of colony. Specimen from the Iowa Silurian; furnished by the Geology Department, State University.
2. Portion of colony of *Lithostrotion canadense* var. *proliferum* Hall, x 1, top view. Also a diffuse type but with the columns contiguous and without intercolumnar braces. Specimen from Iowa Mississippian; negative furnished by Geology Department, State University.
3. Portion of colony of *Lithostrotion canadense* Castelnau, x 1. A more compact type which has assumed the polygonal shape of column due to crowding. The double nature of the intercolumnar walls is not apparent in the picture. Specimen from Iowa Mississippian; negative furnished by Geology Department, State University.
4. Portion of colony of *Acervularia inequalis* H. & W., x 1. A still more compact type, with single intercolumnar walls. Specimen from Iowa Devonian; negative furnished by Geology Department, State University.
5. *Balanophyllia socialis*. An example of solitary Hexacorallum. From Bourne (1905).
6. *Caryophyllia*, with undetached bud, x 1. Specimen from about sixty fathoms, off Barbados, British West Indies.
7. An unidentified specimen from Barbados, showing parent corallite and three generations of buds in place.
8. *Dendrophyllia profunda* Pourt., x ½, showing formation of a dendroid colony by successive lateral buds partly embedded in coenenchyma. Specimen from Florida, 230 to 400 fathoms.

PLATE IV

1. *Amphihelia*, x ¾. A more complex dendroid colony formed by alternate marginal budding, with dichotomous branching caused by twin-budding. The newly-formed calices have the original trumpet shape of solitary cup-corals but later become embedded in coenenchyma. Specimen from Barbados, 50 to 100 fathoms.
2. *Oculina robusta* Pourt., x ½. A further development of the coenenchyma idea. Deposition of coenenchyma keeps pace with the outward growth of the calices, and this, together with the greatly increased diameter and much more numerous calices per unit area, makes this one of the most compact of dendroid colonies. Specimen from Florida reefs.
3. *Dendrophyllia diaphana* Dana, x 1. The large size, trumpet shape, and comparative fewness of the calices, as well as the small amount of coenenchyma, mark this as a primitive type of colony. From Vaughan (1918, Plate 60, Fig. 3a).
4. *Dendrophyllia willeyi* (Gardiner), x ½. A slightly more advanced type than 3. From Vaughan (1918, Plate 60, Fig. 4).
5. *Galaxea fascicularis* (Linn.), x ½. A still more advanced type of spreading colony. The calices are reduced in size and increased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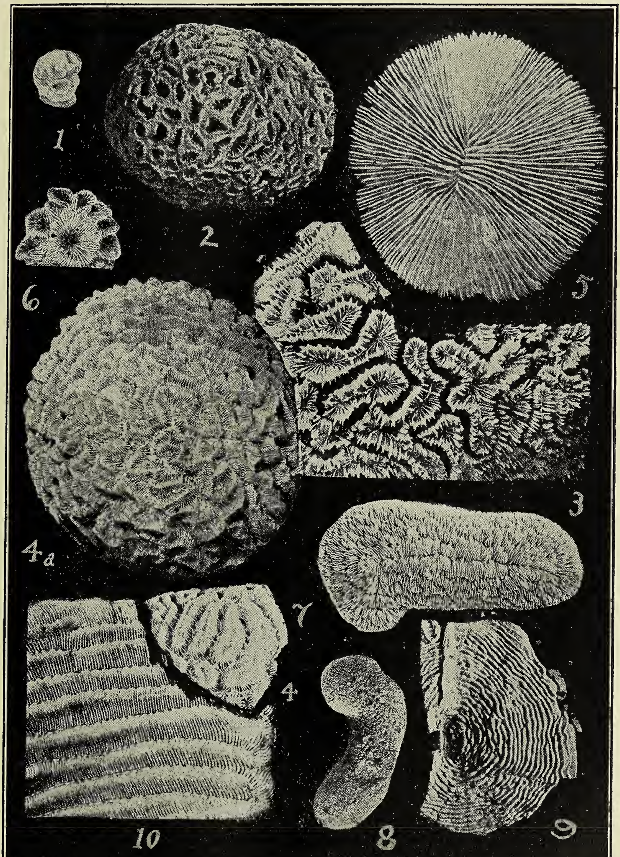
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in number but the amount of coenenchyma is still small. From Vaughan (1918, Plate 34, Fig. 1).

6. Small portion of a head of *Orbicella annularis* Dana, x 1. A good example of a compact massive colony with small, numerous calices completely embedded in coenenchyma. Specimen from Florida reefs.
7. *Lophohelia prolifera* E. & H., x ½. A simple type of dendroid colony formed by unequal fission, with incomplete deposition of coenenchyma. Specimen from Florida, 230 to 400 fathoms.
8. *Eusmilia fasciculata* (Pallas), x ½. A cespitose colony formed by fission, without coenenchyma. Specimen from Barbados, about eight fathoms.

PLATE V

1. *Heteropsammia multilobata* Moseley, x ½. A primitive type of spreading colony arising by fission. The calices are few, relatively large, and exserted. From Moseley (1881, Plate XII).
2. *Dichocoenia*, x ½. A massive colony arising by fission. The fission-groups of calices are distinct but the spaces between them are completely filled with coenenchyma. Specimen taken from West Indian reef.
3. *Mussa sinuosa* (Lam.), x ½. An advance toward the meandrine type. The fission-groups are long and sinuous but the walls are distinct and separated by unbridged spaces. From Vaughan (1918, Plate 49, Fig. 3).
4. Small portion of colony of *Diploria*, x ½. The typical meandrine type. The walls between the fission-rows are still distinct at the summits but filled in at the base with coenenchyma and connected by costæ. Specimen from West Indian reefs.

4a. A colony of *Meandrina*, x ½. A very high type of meandrine coral. The separation between fission-rows is reduced to a single narrow column wall, Specimen from West Indian reefs.

5. *Fungia danae* E. & W., x ½. A typical solitary fungid. Specimen from Pacific ocean.
6. *Cyathoseris subregularis* Reuss, x ½, from the Oligocene of Italy. A primitive fungid colony formed by costal budding. From Zittel-Eastman's Textbook of Palaeontology, 1913, reproduced by permission of the publishers, Macmillan & Company.
7. *Herpetolitha crassa* Dana, x ¼. A comparatively low type of fungid colony. From Vaughan (1918, Plate 54, Fig. 1).
8. *Polyphyllia talpina* (Lam.), x ¼. The calices are crowded and less regularly arranged than in *Herpetolitha*. From Vaughan (1918, Plate 54, Fig. 2).
9. *Pachyseris speciosa* (Dana), x ½. A high type of agaricid colony, calices completely confluent in long parallel rows. From Vaughan (1918, Plate 54, Fig. 3).
10. *Pachyseris torresiana* Vaughan, x 2. Showing the continuous rows of calices. From Vaughan (1918, Plate 55, Fig. 1a).

SOME EXPERIENCES WITH LABORATORY CONTROL OF FIELD WATER SUPPLIES

JACK J. HINMAN, JR.

PUBLISHED WITH THE PERMISSION OF THE SURGEON GENERAL, U. S. ARMY

The Water Analysis Laboratories of the American Expeditionary Forces began their work in January and February, 1918. The personnel consisted of Engineer and Medical Department officers and men. The Medical Department representatives were almost entirely from the Sanitary Corps and were furnished to the Engineer Department under provisions of G. O. 108, War Department, Washington, 1917. The organization formed a part of the Water Supply Service which was built around the 26th Engineers, the Water Supply Regiment, as a nucleus.

The responsibility for the purity of the water supplied to troops, as well as the provision of the water up to the water points in the zone of fighting, was first delegated to the Engineers by G. O. 34, G. H. Q., A. E. F., February 25, 1918. The responsibility was extended to the Service of Supplies by G. O. 131, G. H. Q., A. E. F. August 7, 1918, and the whole service more fully explained and specified by Bulletin 55, G. H. Q., A. E. F., August 8, 1918. The responsibility for the quality of water beyond the water points remained with the Medical Department.

Officers and men of the Water Analysis Laboratories were assigned to the District of Paris, the various Base Sections, the Intermediate Section, the Advance Section, S. O. S., to the Armies and to the companies of the 26th Engineers. The Sanitary Inspectors of Water of the Divisions were not members of the staff of the Water Analysis Laboratories. The Division Sanitary Inspector of Water found his duties accurately defined by Memoranda 5 and 7 (Revised), Office of the Chief Surgeon, Division of Laboratories and Infectious Diseases, A. P. O. 721, August 14, 1918. He worked under the direction of the Division Sanitary Inspector and confined himself chiefly to sanitary surveys of sources of supply and supervision of the treatment of water in Lyster bags. He was directed to refer any extensive chemical and bacteriological laboratory work to the Medical Department

Fig. 48

representative on the staff of the Water Supply Officer for the Army. The laboratories employed for the work of the Water Supply Service were usually operated more or less independently as sections of Medical Department laboratories to which the Water Supply personnel was attached for purpose of administration and supply. Of course, additional water analysis was carried out by the regular Medical Department laboratories, sometimes in coöperation with the Water Supply Laboratories, sometimes independently.

For special work in the advance zones the laboratory work was conducted in mobile laboratories, in the laboratory space of the "sterilab" water purification trucks and with transportable laboratories supplied in chests.

The methods of water analysis were based chiefly upon the Standard Methods of Water Analysis of the American Public Health Association, 1917, and Medical War Manual No. 6, Laboratory Methods of the U. S. Army, 1918. The standard of purity adopted was the 1914 standard of the United States Treasury Department for drinking water supplied by common carriers in interstate traffic. This standard requires that the number of bacteria growing at 37° C. on agar shall be less than 100 per c.c. of water and that not more than one out of five 10 c.c. portions shall show the colon bacillus when tested for gas formation in lactose broth and confirmed by litmus lactose or Endo agar plates. Eosin methylene blue lactose agar plates also were used in the confirmatory tests. A bulletin on Water Analysis giving the methods was published for the A. E. F. by the Bureau of Medical Publications of the American Red Cross Society.

Bacteriological water work was not the only laboratory work undertaken. At least one of the laboratories undertook work on boiler waters for locomotives and cranes, another did work on laundry waters, another on cooling water for airplane motors and so on. Operation of filter plants and chlorinators, supervision of Lyster bag chlorination, sanitary surveys and other investigations fell to the lot of practically all officers of the service.

The writer's first A. E. F. assignment was to the Water Analysis Laboratory, Paris. This assignment, however, was merely temporary and orders came to proceed to the headquarters of Base Section 3, at London, where further orders were received designating him as Water Supply Officer with station at Winchester and laboratory in the Base Laboratory located there. The Water Laboratory was in a small room adjacent to the Base Laboratory which had at one time been occupied as a tea room. The equipment was adequate and work was undertaken promptly. All of the inspections, collections, analytical work and typing was done by the writer. The typing was quite a big part of the work as nine copies of every report had to be made in order to have enough for the various officers to whom reports were to be sent. A specially qualified sergeant and private were about to leave Paris for England to assist in the work when the armistice was signed and they were retained in France. At the time of the armistice there were nearly one hundred hospitals and camps in Base Section 3 in which American detachments were stationed. Many of these were Air Service troops who were rapidly assembled in larger camps. On the termination of hostilities the writer's instructions had been to finish first the work in the Southern district and then proceed to the work in the north in Scotland and Ireland. The armistice found the work in the southern district unfinished, so that aside from a thorough survey of the water supply of Liverpool, the work done was confined to the counties of Hampshire, Wiltshire, Devonshire and Sussex.

About the middle of January, 1919, the laboratory was closed and the writer ordered back to Paris. Here he was engaged in office work for a time, then sent into the Department of the Marne to work on evaluation of war damages to water plants and sewage systems for the Peace Commission. On the abrupt termination of this work, he attended the University of Rennes for a month and was then ordered to duty as officer in charge of the Water Analysis Laboratory, American Embarkation Center at Le Mans.

At this time the troops were going home and Le Mans with its eight outlying divisional areas was a busy place. The Water Laboratory was housed in an old French garage. It had two rooms, one of which was used as an office. The personnel consisted of the writer, three second lieutenants, two first class sergeants, a wagoner and five privates. There were two motorcycles with side-cars assigned to the laboratory and two Fords from the transportation pool were used in addition. The laboratory opened a "sterilab" purification truck, controlled the operation of the United States Filter Plant at Pontlieu and supervised the chlorination of water by six chlorinating machines at other places. Close watch was kept on the quality of the water produced by the Le Mans City Water Plant at L'Epau. Much effort was expended in the attempt to check up the chlorination of water in Lyster bags by the various transient organizations. This checking consisted largely of tests for free chlorine by means of potassium iodide and starch or orthotolidine. Samples showing no free chlorine were bacteriologically examined. Experience showed the utility of the rule to consider all water contaminated and therefore unsafe for use without chlorination. There was one small typhoid outbreak believed to be due to the drinking of spring water contaminated by use as a lavoir.

The Water Analysis Section at Le Mans had in addition to the laboratory facilities in the French garage, both a mobile laboratory truck and a sterilab. The equipment of both of these mobile units was quite complete for the work they were designed to do. They had incubators, hot air sterilizers, Arnold sterilizers and autoclaves in addition to an ample stock of glassware and chemicals well packed in partitioned drawers lined with canton flannel. The mobile laboratory was mounted on a White-truck chassis, while the sterilab was mounted on a Pierce-Arrow truck chassis.

In addition to the laboratory equipment the sterilab carried a Gould pump, a pressure filter with alum pot and a solution-feed chlorinator with siphon- or bubble-meter. It successfully purified an impure river water and was an excellent piece of equipment. The laboratory space of the sterilab was not used as such but used as sleeping quarters for the men in charge owing to the ease of taking samples to the stationary laboratory in Le Mans.

LABORATORIES FOR THE STATE BOARD OF HEALTH,
STATE UNIVERSITY OF IOWA.

SWIMMING POOL SANITATION

JACK J. HINMAN, JR.

The swimming pool, being really a sort of common bath, rapidly departs from a sanitary condition, unless prompt and adequate measures are taken to maintain a reasonable degree of purity in the water. Moreover, since various types of intestinal infections, infections of the respiratory system, eye and ear infections, gonorrheal infections and skin infections have been traced to the waters of swimming pools, the protection of the bathers by means of proper treatment of the water and rigid inspection of all entrants into the pool is essential to safety.

The supervision of preliminary soap shower baths is a factor capable of greatly reducing the burden on the water purification apparatus and also capable of reducing the amount of chemical treatment necessary. If the pool is carelessly supervised it is possible for the bathers to make it an unpleasant and perhaps an unsafe place.

The construction of the pool room and the tank are features of importance, of course, since they make cleaning easy or difficult and to a certain extent determine the habits of the patrons. Convenient toilet facilities, convenient showers in good repair and furnished with an ample supply of warm water and a clean pathway will aid the bathers in entering the pool in reasonably clean condition. Provision of a visitor's gallery which allows the exclusion of persons wearing street shoes is highly desirable.

The manner in which suits and towels are handled is of considerable importance. Washing is not always sufficient to kill the organisms causing skin diseases, a fact which may require steam sterilization to be practiced. To be sure, careless handling of the cleaned suits and towels may undo the work of sterilization and leave them in as bad a state as ever.

However, the matters which are of greatest interest have to do with the pool water itself. Proper construction makes it easier to maintain the pool in a clean condition and proper supervision tends to reduce the contamination of the water, especially the more dangerous contamination from bathers carrying pathogenic organisms.

The State University of Iowa has two pools; one of 61,200 gallons capacity at the Women's Gymnasium, the other of 89,100 gallons capacity at the Armory. Both are lined with white tile and located in light rooms. The women's pool has a scum gutter entirely around the pool, while at the men's pool the gutter is on the two sides and not on the ends. The water of both pools is continuously purified by passage through a filter. At the women's pool the filter is a single-unit, open, gravity installation with a capacity of 138,240 gallons per 24 hours; at the men's the apparatus is a two-unit, enclosed pressure filter of a capacity of 116,000 gallons per day. Both plants employ aluminum sulphate as a coagulant. Filtered water is treated with 0.34 to 1.0 parts per million copper sulphate and 0.3 to 2.0 parts per million calcium hypochlorite. The dosage is varied according to the condition of the water in the pools. When the plants were installed it was intended to use liquid chlorine for disinfection, but the apparatus secured did not give good results and finally had to be discarded on account of the difficulty of keeping it in repair. The men's pool is kept at a temperature of 76° F., while the women's pool runs up to 84° F.

From the foregoing brief statement some idea of the operation of the pools may be obtained. More complete descriptions of the chemical equipment have been given elsewhere.[1]

Since the commencement of operations in January, 1916, samples have been taken every day that the pools have been in use. Sundays and holidays have been omitted as the pools have been closed at such times.

Table No. 1, which summarizes the results from January 27, 1916, to March 31, 1920, is the longest series of consecutive swimming pool results with which the writer is familiar. Table No. 2 gives the periods varying from 12 to 136 days elapsing between the times of filling and emptying. While some of these periods have been terminated by the failure of the water to respond to treatment, most of them have been determined by external factors, such as vacations, shortage of coal, need for the pool room for an S. A. T. C. dormitory and so on.

Table No. 1 is a sort of frequency chart showing the number of days on which the bacterial counts fell within certain limits, and also showing the number of times gas-forming organisms were found in lactose broth and acid colonies on lactose agar.

1 Hinman, Engineering and Contracting **46**, 135 (Aug. 9, 1916).
Hinman, Journal of the American Water Works Association, **4**, 86 (March 1917).
Hinman, American City (City Edition) **16**, No. 4, 305 (April, 1918).
Hinman, American Physical Education Review, December, 1920.

TABLE NO. 1. THE STATE UNIVERSITY OF IOWA—SWIMMING POOLS

January 27, 1916—March 31, 1920

		Litmus Lactose Agar at 37°C. 24 hrs.								Plain Agar at 20°C. 48 hrs.								Gas Formers Lactose Broth				Acid Colony L. L. Agar	
		Days None In 1 c.c.	1-10	11-50	51-100	101-500	501-1000	>1000	No. Platings	1-100	101-500	501-1000	1001-10,000	10.001—20.000	20.001—30.000	>30.000	No. Platings	Gas in 1 c.c.	No. Plantings	Gas in 10 c.c.	No. Plantings	Acid Colonies 1 c.c.	No. Platings
Women	Filters alone	1	17	5	0	1	0	0	24	3	7	5	7	3	1	0	26	3	26	....	....	1	24
Women	" & Chlorine	7	20	9	1	5	0	0	42	0	3	1	24	10	7	0	45	0	45	....	....	0	42
Women	" & $CuSO_4$	0	2	11	5	61	0	0	79	1	0	0	34	27	20	0	82	0	82	....	....	0	79
Women	" & $CuSO_4$+Cl	5	48	36	22	49	0	0	160	12	23	13	74	25	11	1	159	1	46	5	70	1	160
Women	" $CuSO_4$+hypo	107	227	77	38	83	24	39	595	84	93	67	258	44	14	31	591	4	591	39	591	6	591
Women	Totals	120	314	138	66	199	24	39	900	100	126	86	397	109	53	32	903	8	790	44	659	8	896
Men	Filters alone	1	23	2	0	0	0	0	26	0	4	4	13	6	2	0	29	7	29	....	....	2	26
Men	" & Chlorine	16	19	5	4	1	0	0	45	0	0	4	30	11	10	0	45	0	45	....	....	0	45
Men	" & $CuSO_4$	2	11	8	10	47	0	0	78	0	0	1	49	23	11	0	84	0	84	....	....	0	78
Men	" $CuSO_4$+hypo	130	299	150	54	83	15	18	749	86	115	80	373	68	17	13	752	18	634	114	632	19	750
Men	Totals	149	352	165	68	131	15	18	898	86	119	89	455	108	40	13	910	25	792	114	632	21	899
Totals of all Exam.		269	666	303	134	330	39	57	1798	186	245	175	852	217	93	45	1813	33	1582	158	1291	29	1795

Grand Total: 8279 Examinations.

TABLE NO. 2. S. U. I. — SWIMMING POOLS

January 27, 1916 — March 31, 1920

Women			Men		
Filled	Emptied	Days	Filled	Emptied	Days
1-21-16	5-19-16	119	1-21-16	5-27-16	127
5-21-16	8-24-16	95	5-28-16	8-24-16	88
9-21-16	12-21-16	91	9-25-16	12-21-16	87
1-6-17	4-4-17	88	1-5-17	4-4-17	89
4-9-17	6-12-17	64	4-9-17	6-9-17	61
6-19-17	8-25-17	67	6-21-17	8-26-17	66
9-28-17	12-22-17	85	9-25-17	12-22-17	88
1-6-18	1-19-18	13	1-7-18	1-19-18	12
2-22-18	6-5-18	103	2-22-18	3-28-18	36
6-17-18	8-31-18	75	4-3-18	6-7-18	65
1-28-19	6-13-19	136	6-21-18	8-30-18	70
6-18-19	8-30-19	73	1-22-19	3-21-19	58
10-9-19	11-28-19	51	3-25-19	6-13-19	80
1-11-20	3-25-20	74	6-18-19	7-25-19	37
			7-30-19	8-30-19	31
			10-6-19	11-28-19	53
			1-7-20	2-12-20	36
			2-17-20	3-26-20	38
			3-31-20		

Since the condition of the pool water is dependent upon the contamination introduced by the bathers and the natural multiplication of bacteria as well as upon the amount of purified water returned to the tank and the degree of purification, it has been thought best to take all samples after the pool has been used for the day so as to have samples representing the worst condition of the pool. It is obviously undesirable to take the effluent from the filters as a representative sample because that represents the purified water rather than the pool water itself. A small quantity of practically sterile water is naturally not able to improve the quality of the pool water to the same extent as a large volume of water not quite so thoroughly treated.

There is no agreement upon the degree of purity necessary in the water of swimming tanks, although it would be generally accepted that the more nearly the water approached the purity of drinking water, the better. But there is no very general agreement as to the degree of purity which a water must have to pass into the classification of drinking water. Perhaps the United States Treasury Department Standard of 1914, for water supplied to passengers by common carriers in interstate traffic, is the most generally recognized standard. It requires that the water shall show less than one hundred bacteria per c.c. on agar at 37° C. after 24 hours incubation and also that it shall show not more than one positive confirmed test for *B. coli* out of five 10 c.c. plantings of the water. It would seem that 500 bacteria at 37° C. is a more reasonable requirement for pool water and that the colon bacilli should be absent in one cubic centemeter.

The environmental conditions in the pool are such that the growth of the ordinary water bacteria is much stimulated. Temperature and food conditions enable the few organisms remaining after disinfections to multiply rapidly and give aftergrowth represented by large numbers. There is no special reason to regard these bacteria as pathogenic, and unless the bacterial count at 37° C. is high and colon type organisms are present, there is probably no reason to think that a high 20° C. count has any particular significance. Some workers have entirely omitted the enumeration at 20° and neglected the information which the 20° C. count may give at times.

We have found the 20° count subject to sharp fluctuations, although likely to show up in the worst manner within the first few days after the pool is filled. From the operation standpoint we have not paid great attention to this first aftergrowth. When the pool shows a high 20° C. count after having been in use some time and we find it difficult to reduce it promptly we take it as evidence that the food conditions are too advantageous. We may then advise that the pool be emptied.

We watch the 37° C. count more zealously than we do the 20° C. ones. While about 20 per cent of the latter have passed the limits which we have arbitrarily set as desirable, only about 5 per cent of the former have passed the limits.

The presence of gas-formers and acid colonies is regarded as most significant of all. If these are persistent, even in 10 c.c. quantities of water, the advice is given to empty the pool. The gas-forming organisms have not all received the confirmatory test for *B. coli.* Of those that have been specially tested about one-fourth have proven to be *B. coli.* It should always be kept in mind that these figures give the results on samples taken after use, not on the pool as it is after having received purified water all night. Fresh contaminations are considered to be more dangerous than older ones.

In the table given the figures for purification by filters alone may be misleading. They appear to show superior results. As a matter of fact only the instructors were using the pools at that time and the bathing load was only about 1 per cent of the normal load. Attention is called to the high percentage of positive tests for gas- and acid-forming bacteria found. Our experience has been that, while the filters are running, the use of copper sulphate has apparently given the least satisfactory results. Personally I am inclined to think that copper sulphate plus chlorine is most satisfactory. We have obtained good results with copper sulphate plus calcium hypochlorite, however.

As has been noted by others in other localities we find that the numbers of bacteria in the women's pool tend to be higher than in men's pool. This is probably due in part at least to the suits worn. The fact that the women's pool is kept at a temperature about six degrees higher than the men's pool may also be a factor in favoring the tendency to higher 37° C. bacterial counts. Here, however, the bathing load at the men's pool is greater than at the women's pool and the occurence of gas-forming organisms is more frequent.

In conclusion, the writer wishes to acknowledge the work of Mr. Deloss H. Barber, Mr. Frank Kennan, Mr. Cecil E. Ewen, and Mr. Roy M. Mayne, who have operated the filter plants and made most of the examinations of the pool waters. He also wishes to acknowledge the work of Miss Zelma Zentmire, who supervised the operation of the pools during the period he spent in the Army.

Laboratories for the State Board of Health,
State University of Iowa.

CLADOCERA OF THE OKOBOJI REGION

FRANK A. STROMSTEN

The following list of Cladocera is a continuation of the list published in the Proceedings of the Iowa Academy of Science for 1917. It represents the species collected during the summer of 1919, from June 24 to September 1.*

PHYLUM: ARTHROPODA

Class: Crustacea

SUB-CLASS: ENTOMOSTRACA

Order: CLADOCERA

FAMILY: SIDIDAE

Genus *Sida* Straus 1820

Sida crystallina (O. F. Mueller) 1785. Abundant throughout the season. Widely distributed in kettle holes and lake. A tow taken off the end of the laboratory dock at night above a sunken electric light was especially rich in Sida.

Genus *Diaphanosoma* Fisher 1850

Diaphanosoma leuchtenbergianum Fisher 1850. Not abundant. Found late in the season from surface tows taken on West Okoboji lake after a heavy rain and strong wind.

Genus *Pseudosida* Herrick 1884

Pseudosida bidentata Herrick 1884. Rare. Few specimens found in lake tow on August 23.

Genus *Latonopsis* Sars 1888

Latonopsis occidentalis Birge 1891. Not abundant. West Okoboji lake, August 2.

Family *DAPHNIDAE* Straus 1820

Genus *Daphnia* O. F. Mueller 1785

Daphnia pulex var. *pulicaria* Forbes. Abundant in kettle holes and lake during July.

Daphnia retrocurva Forbes 1882. Most abundant species of Daphnia found in lake tows during July and August.

Daphnia longispina proper (O. F. Mueller) 1785. Abundant in lake tows.

* For descriptions and figures of species see Ward and Whipple, Fresh-Water Biology, pp. 676-739, 1918. Herrick, C. L., Synopsis of the Entomostraca of Minnesota: Second Report of State Zoologist, pp. 145-276, 1895.

Daphnia longispina var. *hyalina* Leydig 1860. Great variations in form of crest. Deep and surface tows, West Okoboji lake.

Daphnia longispina var. *longiremis* Sars 1861. Not abundant. Deeper tows on West Okoboji lake.

Genus *Simocephalus* Schoedler 1858

Simocephalus vetulus (O. F. Mueller) 1776. Abundant. Widely distributed, present in practically all collections.

Simocephalus serrulatus (Koch) 1841. Very abundant. Widely distributed.

Genus *Scapholeberis* Schoedler 1858

Scapholeberis mucronata (O. F. Mueller) 1785. Abundant. Drainage canal and West Okoboji lake.

Genus *Ceriodaphnia* Dana 1853

Ceriodaphnia reticulata (Jurine) 1820. Abundant. Kettle holes and drainage canal.

Ceriodaphnia megalops Sars 1861. Rare. Kettle hole north of Milford.

Ceriodaphnia quadrangula (O. F. Mueller) 1785. Found with C. megalops.

Ceriodaphnia laticaudata P. E. Mueller 1867. Not abundant. Grassy kettle holes.

Genus *Moina* Baird 1850

Moina brachiata (Jurine) 1820. Very abundant. Kettle holes, lakes and drainage canal.

Moina affinis Birge 1893. Abundant. A kettle hole species.

Moina rectirostris (Leydig) 1860. Muddy kettle holes.

Family *BOSMINIDAE* Sars

Genus *Bosmina* Baird 1845

Bosmina longirostris (O. F. Mueller) 1785. Very abundant everywhere.

Family *MACROTHRICIDAE* Norman and Brady

Genus *Bunops* Birge 1893

Bunops serricaudata (Daday) 1888. Rare. Outlet of Center lake near Hayward's bay.

Genus *Ilyocryptus* Sars 1861

Ilyocryptus sordidus (Liével) 1848.

Ilyocryptus spinifer Herrick 1884. Both species abundant. Kettle holes.

Genus *Macrothrix* Baird 1843

Macrothrix laticornis (Jurine) 1820.

Macrothrix rosea (Jurine) 1820.

Macrothrix rosea var. *tenuicornis* Kurz. Abundant in kettle holes and canal. *M. rosea* most abundant and widely distributed.

Family *CHYDORIDAE* Stebbing

Genus *Eurycercus* Baird 1843

Eurycercus lamellatus (O. F. Mueller) 1785. Common. Drainage canal and kettle holes.

Genus *Camptocercus* Baird 1843

Camptocercus rectirostris Schoedler 1862. Abundant. Kettle holes.

Camptocercus macrurus (O. F. Mueller) 1785. Rare. Drainage canal.

Genus *Kurzia* Dybowski and Grochowski 1894

Kurzia latissima (Kurz) 1874. Rare. Deep tows.

Genus *Acroperus* Baird 1843

Acroperus harpae (Baird) 1835.

Acroperus angustatus Sars 1863. Abundant in kettle holes and surface tows of lake. Many intermediate forms are found.

Genus *Oxyurella* Dybowski and Grochowski 1894

Oxyurella tenuicaudia (Sors) 1862. Rare. Grassy kettle holes.

Genus *Leydigia* Kurz 1874

Leydigia quadrangularis (Leydig) 1860. Abundant in small lakes, kettle holes and canal.

Leydigia acanthocercoides (Fisher) 1854. Only a few specimens found in one kettle hole.

Genus *Alona* Baird 1850

Alona guttata Sars 1862. Common. Kettle holes and drainage canal.

Alona guttata var. *tuberculata* Kurz. Found in one kettle hole.

Alona affinis (Leydig) 1860. Not common. Kettle holes.

Alona quadrangularis (O. F. Mueller) 1785. Deep lake tow.

Alona costata Sars 1862. Not common. Kettle holes.

Alona rectangula Sars 1861. Common. Kettle holes.

Alona intermedia Sars 1862. Not common. Smaller lakes.

Genus *Graptoleberis* Sars 1863

Graptoleberis testudinaria (Fisher) 1848. Not common. Surface tows of West Okoboji lake.

Genus *Dunhevedia* King 1853

Dunhevedia setigera (Birge) 1877. Rare. Kettle holes.

Genus *Pleuroxus* Baird 1843

Pleuroxus procurvatus Birge 1878. Abundant. Kettle holes and surface tows of lake.

Pleuroxus hastatus Sars 1862. Rare. Kettle holes.

Pleuroxus striatus Schoedler 1863. Not common. Kettle holes.

Pleuroxus denticulatus Birge 1877. Very abundant. Everywhere.

Genus *Chydorus* Leach 1843

Chydorus globosus Baird 1850.

Chydorus sphaericus (O. F. Mueller) 1785. Abundant. Everywhere.

Genus *Alonella* Sars 1862

Alonella excisa (Fisher) 1854. Not common. Kettle holes.

Family *LEPTODORIDAE* Lilljeborg

Genus *Leptodora* Lilljeborg

Leptodora kindtii (Focke) 1844. Abundant in deep tows, ten meters or more in West Okoboji lake and in surface tows late in the season after a heavy wind from the open lake.

Laboratories of Animal Biology,
State University of Iowa.

COPEPODA OF THE OKOBOJI REGION

FRANK A. STROMSTEN

BRANCH: ARTHROPODA

Class: Crustacea

SUBCLASS: ENTOMOSTRACA

Order: COPEPODA

Suborder: Eucopepoda

Group: GNATHOSTOMA

FAMILY:CENTROPAGIDAE

Genus *Diaptomus*

Diaptomus oregonensis Lilljeborg 1889. Okoboji. Kettle holes and Gar lakes. Abundant in June and July.

Diaptomus pallidus Herrick 1879. Abundant in Middle Gar lake and in some kettle holes.

Diaptomus leptopus Forbes 1882.

Diaptomus clavipes Schacht 1897. Common in East Okoboji and a few kettle holes.

Diaptomus sicilis Forbes 1882. Abundant in lakes and kettle holes.

Diaptomus sanguineus Forbes 1876. Not common in summer in drainage canal. Also found in one surface tow of West Okoboji lake (Miller's Bay).

Diaptomus signacauda Lilljeborg 1889. Surface tow, West Okoboji lake.

Diaptomus siciloides Lilljeborg 1889. Very abundant in kettle holes and West Okoboji lake in late summer.

FAMILY: CYCLOPIDAE

Genus *Cyclops*

Cyclops ater Herrick 1882. Very abundant in kettle holes and lake.

Cyclops viridis Jurine 1820. Found in one kettle hole

Cyclops veridis americanus Marsh. Common in kettle holes.

Cyclops modestus Herrick 1883. Kettle holes.

Cyclops serrulatus Fischer 1851. Common and most widely distributed.

Cyclops prasinus Fischer 1860. Not common.

Cyclops phaleratus Koch 1838. Very abundant in kettle holes and lakes.

Cyclops bicolor Sars 1863. Abundant in kettle holes.

Cyclops fimbriatus Fisher 1853. Very abundant in drainage canal and lakes.

Cyclops fluviatilis Herrick. Abundant everywhere.

Cyclops signatus var. *cornatus* Herrick. Kettle holes. Not common.

Cyclops signatus var. *tenuicornis* Herrick. Kettle holes. Not common.

Cyclops insignia Claus 1857. Drainage canal and West Okoboji lake.

Cyclops macrurus Sars 1863. Marble lake. Not common.

FAMILY: HARPACTICIDAE

Genus *Canthocamptus*

Canthocamptus minutus Claus 1863. Weedy kettle holes. Rather common.

Laboratories of Animal Biology,
State University of Iowa.

THE ROTATORIA OF THE LAKE OKOBOJI REGION*

DWIGHT C. ENSIGN

INTRODUCTION

This report is based upon a series of collections and studies made during the months of July and August, 1919, at the Iowa Lakeside Laboratory. It is incomplete, since numerous species which will doubtless be found in this locality have been missed by reason of the short time during which collections were made.

The region of the Iowa Lakeside Laboratory seems to be an especially good place for the study of the Rotatoria. A wide variety of habitats is within available distance of the laboratory grounds; the open lake, the quieter waters of the sand-bar pond and the canal, the numerous kettle holes, and the marshy swamps near the lake shore afford many different kinds of collecting. It is probable that succeeding years of study will as much as double the list of species found in this locality this year, one hundred and eight in all, of which five have not yet been satisfactorily identified and are not included in this report.

Little work has been done upon the Rotatoria of the state of Iowa, so that it is difficult to know how many forms to expect. The only other list of Iowa rotifers which was available for comparison was one prepared by Mr. Wright Stacy [1] of the State University of Iowa; twenty-eight species were listed, all except five of which were found at Okoboji also. The species recorded from Iowa City by Mr. Stacy which did not appear in this summer's collections are: *Brachionus urceus* (Linnaeus), *Monostyla arcuata* (Bryce), *Lepadella oblongata* (Ehrenberg), *Diurella weberi* (Jennings), and *Philodina erythopthalma* (Ehrenberg). It might be mentioned in passing that Mr. Stacy's *Brachionus urceus* [2] would seem from his figure to be the *Brachionus urceolaris* of Hudson and Gosse,[3] which by Harring, in his *Synopsis of the Rotatoria* [4] is assigned to *Brachionus capsuliflorus,* a species which occurred in great abundance at Okoboji.

* Based upon collections and studies made during the summer of 1919 at The Iowa Lakeside Laboratory.

1 Stacy, Wright, Studies of the Rotifera of Iowa — A Thesis.
2 *Idem.*, p. 42, plate V, figure 2.
3 Hudson and Gosse, The Rotifera, volume II, p. 118, plate XXVII, figure 6.
4 Harring, H. K., Synopsis of the Rotatoria: U. S. Natl. Museum Bull. 81, p. 20.

Collections were made at Okoboji from the several localities studied, bolting-silk tow-nets with 29,929 meshes to the square inch being used. A Birge bucket was also used to some extent; the bolting-silk in this was the same gauge as that of the tow-nets. Most of the material was studied in a fresh condition. No really satisfactory method of preserving the il-loricate forms was found; the best that could be done was to narcotize them with a solution of nicotine and then to gradually add alcohol until a strength of from fifty to sixty per cent was reached. This method had the disadvantage of shrinking many of the il-loricates, even though the alcohol was added very slowly. By far the most satisfactory studies were those made from living specimens.

This report consists of an itemized statement as to the occurrence and abundance of the several species. The revised terminology as brought out by Harring [5] is used throughout. A thumbnail sketch of each species recorded is to be found in the two plates (Plates VI and VII). These drawings were made, for the most part, from life; in many of the loricates, the sketch is merely the outline of the lorica. The sketches are included to give to those unfamiliar with the terminology a definite idea as to the wide variety of forms found in this rather limited region.

The numbered localities on the map (Fig. 49) indicate the principal collecting grounds. Following is a brief description of each of these; the numbers correspond with those on the map.

1. Lake Okoboji. Collections made in Lake Okoboji were confined to surface tows and tows at a depth of about five feet, usually not more than a few rods from the shore. *Ceratophyllum, Myriophyllum, Potamogeton, Vallisneria,* and numerous species of algae are found near the shore, and rotifers occur in considerable numbers among these plants.

2. Drainage canal. The drainage canal is the collecting ground *par excellence* for rotifers. It is almost a mile long, from ten to fifteen feet wide, and about ten feet deep, filled almost to the surface of the water with aquatic plants. The entrances from the lake are choked with sand; there is no current except such sluggish water movements as may be set up by the wind.

3. Sand-bar pond. This is a shallow pond with two openings from the main lake, situated on a sand-bar at the mouth of Miller's bay. Its shores are bordered by marsh grasses, sedges, and reeds; duckweed also is found here in great abundance. The depth of the pond is nowhere more than two or three feet.

5 *Idem.*

4. Kettle hole. Kettle hole 4 is small, rather shallow, bordered on one side by a section road and on the others by sedges and marsh grasses.

5. Kettle hole. Kettle hole 5 is across the road from kettle hole 4. It is much larger and deeper. Aquatic plants are found growing in it quite abundantly. While it is connected with 4 by a small culvert, there are some noticeable differences in the rotatorian faunæ of the two.

6. Kettle hole. Kettle hole 6 is a small muddy kettle hole in the middle of a pasture; very few species of rotifers were found here.

7. Kettle hole. Kettle hole 7 is rather shallow and muddy, and is located in the middle of a stock pasture. Three distinct varieties of *Brachionus havanaensis* were taken from this kettle hole, the only place in the district where this form occurred.

8. Kettle hole. Kettle hole 8 is a small marshy pool near Emerson's bay. Few rotifers were found here.

9. Creek near Egralharve. This is a small intermittent creek, not extensive in its rotatorian fauna.

10. Marshes near West Okoboji. Under this are grouped several marshy kettle holes and sloughs near the railroad station of West Okoboji, at the north end of Lake Okoboji.

11. Gull Point kettle hole. This is a rather large kettle hole on Gull Point, connected with the lake by a small channel. No very extensive study of it was made.

12. Green slough. This is a large body of water, connected in the early part of the season with Lake Okoboji by a channel about four feet wide and one foot deep; this channel becomes closed as the water level falls in the later part of the season. The slough is filled with aquatic plants and is bordered by sedges and reeds.

13. Swamps near Center Lake. Here are included several marshy bodies of water in the general vicinity of Center lake.

14. Marsh near Manhattan. This is really a large kettle hole with a very marshy, boggy shore. It is almost impossible to get near the edge of the kettle-hole proper. Such collections as could be made were from shallow puddles of water in the grass near the edge. Two species of *Mikrocodides* were found here.

15. Gar lakes. The Gar lakes are connected with East Lake Okoboji. Very little collecting was done here.

16. Fish ponds. The ponds of the State Fish Hatchery at Orleans, at the head of East Lake Okoboji, furnished many

species of rotifers, principally the loricate forms. These fish ponds are shallow artificial ponds; most of them have *Ceratophyllum* and other aquatic plants in them.

17. Sunken lake. This is a small, very deep lake, not far from the west shore of Spirit lake, having practically no aquatic vegetation near the shore, where the collecting was done.

18. Hottes Lake. Hottes lake is of good size, but is rather shallow. Its shores slope off very gradually, and many species of rotifers were taken from among the water plants near the bank.

19. Little Spirit Lake. A tow was taken from among *Ceratophyllum* and algæ near the bank of Little Spirit lake, bringing several species of rotifers.

20. Marble Lake. Marble lake is quite similar to Hottes lake, but is somewhat larger. Its banks are edged with reeds.

21. Little Sioux river. Five species of rotifers were found in water from Little Sioux river, a small rather sluggish stream about two and a half miles from the laboratory grounds.

LIST OF ROTATORIA

With notes on distribution, and other features

ORDER PLOIMA

Notommata aurita (Müller) (Plate VI, Fig. 1). Several individuals of this species were found in water from the swamps about Center lake (13).

Notommata brachyota Ehrenberg (Plate VI, Fig. 2). This species was found in abundance on *Rivularia echinulata,* floating in Miller's bay (1). The animal is a voracious feeder; several groups of *Rivularia* were found in which the trichomes were almost wholly eaten away, each with four or five rotifers on it. The animal is salmon pink in color. On the *Rivularia* were also found a few *Vorticellae;* one specimen of *Taphrocampa annulosa* was found here also. *Rivularia* from several other localities was examined, but rotifers were found only on that from Lake Okoboji.

Notommata copeus Ehrenberg (Plate VI, Fig. 3). Only one individual of this species was found, in water from the vicinity of Center lake (13).

Notommata najas Ehrenberg (Plate VI, Fig. 4). This large species was found in water from ponds and kettle holes near the north end of Lake Okoboji (10), several individuals being taken here. It was met with again in water from Little Spirit lake (19).

Notommata pachyura (Gosse) (Plate VI, Fig. 5). Found near the entrance of the drainage canal (2), eight individuals being recognized.

Notommata saccigera Ehrenberg (Plate VI, Fig. 6). This species was found in considerable numbers in a jar of algæ, chiefly *Mougeotia,* which had been brought into the laboratory; records failed to show from what locality the algæ had come. This is the smallest species of the genus found here.

Taphrocampa annulosa Gosse (Plate VI, Fig. 7). This species was found first on *Ceratophyllum* from the mouth of the canal (2). It was later recognized on a globe of *Rivularia echinulata* along with *Notommata brachyota*, q.v.

Pleurotrocha sordida (Gosse) (Plate VI, Fig. 8). Found in tows made in the marsh near the north end of Lake Okoboji (10). Three individuals were taken.

Cephalodella catellina (Müller) (Plate VI, Fig. 9). Two individuals of this species were found among weeds in a pond opening from the drainage canal (2).

Cephalodella forficula (Ehrenberg) (Plate VI, Fig. 10). This species was found in Lake Okiboji (1), where it was rare; common in the drainage canal (2); a few individuals in kettle hole (7); and a few in kettle holes near West Okoboji (10).

Diaschiza gibba (Ehrenberg) (Plate VI, Fig. 11). Fairly abundant in the canal (2); a few individuals from kettle hole (8); two from Hottes lake (18).

Diaschiza gracilis (Ehrenberg) (Plate VI, Fig. 12). This very small form was found in considerable abundance both in the canal (2), and in the sand-bar pond (3).

Diaschiza tenuior Gosse (Plate VI, Fig. 13). Somewhat similar in appearance to *D. gracilis,* but larger; three specimens were found in water from a weedy pond along the canal (2).

Monommata orbis (Müller) (Plate VI, Fig. 14). This includes *Furcularia longiseta* and *Furcularia aequalis* of Hudson and Gosse;[6] both varieties were found near the mouth of the canal (2).

Dicranophorus forcipatus (Müller) (Plate VI, Fig. 15). Found only near the mouth of the canal (2); one specimen.

Epiphanes brachionus (Ehrenberg) (Plate VI, Fig. 16). Found in a stagnant pool near the north end of Lake Okoboji (10); one specimen.

Epiphanes clavulata (Ehrenberg) (Plate VI, Fig. 17). Collected from the same stagnant pool with *E. brachionus;* two specimens of this were found.

Epiphanes senta (Müller) (Plate VI, Fig. 18). Nine specimens were found in the canal (2), and five in the sand-bar pond (3). The species was found once among red *Euglenae,* the large stomach of the rotifer being colored red by them; when a specimen is found among green *Euglenae,* the stomach is green.

Microcodon clavus Ehrenberg (Plate VI, Fig. 19). Two specimens were found at different times in water from the canal (2); this is the only place it was found. It can be recognized by the brilliant purple pigment spot in the head, the eye.

Mikrocodides chlaena (Gosse) (Plate VI, Fig. 20). Two specimens were found among weeds in a marshy pool near Manhattan (14).

Mikrocodides robustus (Glasscott) (Plate VI, Fig. 21). Three specimens were found with *M. chlaena,* in a weedy, marshy pool (14).

Brachionus angularis Gosse (Plate VI, Fig. 22). Abundant in kettle

[6] Hudson and Gosse, The Rotifera, volume II, p. 46, plate XVIII, figures 15 and 16.

holes (4) and (5); rare in Green slough (12); a few individuals in water from Little Sioux river (21).

Brachionus budapestinensis Daday (Plate VI, Fig. 23). This species was found in a tow from a small roadside pond near kettle hole (6); twelve individuals were found, this being the only rotifer in the tow.

Brachionus calyciflorus Pallas (Plate VI, Fig. 24). This is a very common species, being found in abundance in the canal (2), the sand-bar pond (3), kettle holes (4) and (5), a creek near Egralharve (9), and the fish ponds (16); it was met with more rarely in water from the marshes near West Okoboji (10), Gull Point kettle hole (11), Green slough (12), Gar lakes (15), Hottes lake (18), and Little Sioux river (21).

Brachionus capsuliflorus Pallas (Plate VI, Fig. 25). This species was found abundantly in the canal (2), the sand-bar pond (3), marshes near West Okoboji (10), and Green slough (12); and less frequently in kettle holes (4) and (5), Gull Point kettle hole (11), Gar lakes (15), and Marble lake (20).

Brachionus havanaensis Rousselet (Plate VI, Fig. 26). Three varieties of this species were found in great numbers in kettle hole (7); there is great variation as to length of posterior spines.

Brachionus patulus Müller (Plate VI, Fig. 27). This species was found most abundantly in August; it occurred in Lake Okoboji (1), the canal (2), creek near Egralharve (9), Gar lakes (15), the fish ponds (16), Sunken lake (17), Hottes lake (18), Little Spirit lake (19), and Marble lake (20).

Platyias quadricornis (Ehrenberg) (Plate VI, Fig. 28). Found abundantly in Lake Okoboji (1), and kettle hole (5); more rarely in marshes near West Okoboji (10) and in Little Spirit lake (19).

Keratella cochlearis (Gosse) (Plate VI, Fig. 29). Collected in great numbers from Lake Okoboji (1), the canal (2), the sand-bar pond (3), kettle holes (4) and (5), marshes near West Okoboji (10), Gull Point kettle hole (11), Gar lakes (15), fish ponds (16), Sunken lake (17), Hottes lake (18), Marble lake (20), and Little Sioux river (21). The variety *tecta* also was found, in which the posterior spine is lacking; this occurred in the canal (2).

Keratella quadrata (Müller) (Plate VI, Fig. 30). Three specimens were found in the canal (2).

Keratella serrulata (Ehrenberg) (Plate VI, Fig. 31). Found in water from a loop in the canal (2).

Notholca striata (Müller) (Plate VI, Fig. 32). Found in the canal (2), along with *Keretella cochlearis* and *K. quadrata*.

Anuraeopsis fissa (Gosse) (Plate VI, Fig. 33). Collected among weeds near the mouth of the canal (2), three specimens; kettle hole (5), one specimen; Hottes lake (18), one specimen.

Mytilina mucronata (Müller) (Plate VI, Fig. 34). Two specimens were found with *M. ventralis brevispina* in water from a weedy canal pond (2).

Mytilina trigona (Gosse) (Plate VI, Fig. 35). Four specimens were found with other *Mytilinidae* in a weedy canal pond (2).

Mytilina ventralis (Ehrenberg) (Plate VI, Fig. 36). Collected in marshes near West Okoboji (10), where it was found quite plentifully;

fairly abundant in kettle hole (7), and in Hottes lake (18); a few individuals found in water from Gar lakes (15) and from Little Spirit lake (19).

Mytilina ventralis brevispina (Ehrenberg) (Plate VI, Fig. 37). Four specimens were found among weeds in a small pond along the canal (2).

Euchlanis dilatata Ehrenberg (Plate VI, Fig. 38). Found abundantly in the canal (2), fish ponds (16), and Hottes lake (18).

Euchlanis pyriformis Gosse (Plate VI, Fig. 39). Several individuals of this species were found in water from the entrance of the canal (2); a few were found in Little Spirit lake (19).

Euchlanis triquetra (Ehrenberg) (Plate VI, Fig. 40). By far the commonest of the three representatives of the genus in the region, being found abundantly in Lake Okoboji (1), in kettle hole (7), in Green slough (12), and in the fish ponds (16); a few individuals were found in Gar lakes (15) and in Sunken lake (17); one was found in water from Hottes lake (18), and one in water from Little Spirit lake (19).

Dipleuchlanis propatula (Gosse) (Plate VI, Fig. 41). Two individuals were found in water from a marshy kettle hole near West Okoboji (10).

Lecane gissensis (Eckstein) (Plate VI, Fig. 42). One individual was found in a tow near the mouth of the canal (2).

Lecane luna (Müller) (Plate VI, Fig. 43). Quite common. Found in the canal (2), kettle hole (8), a pond near West Okoboji (10), fish ponds (16), Hottes lake (18), Little Spirit lake (19), Marble lake (20), and Little Sioux river (21). A few specimens were taken from Lake Okoboji (1), but the species is not common there.

Monostyla acus Harring (Plate VI, Fig. 44). Several individuals were found in water from the fish ponds (16).

Monostyla bulla Gosse (Plate VI, Fig. 45). Very common. Collected from the canal (2), the sand-bar pond (3), kettle hole (7), kettle hole at West Okoboji (10), Gull Point kettle hole (11), Green slough (12), Gar lakes (15), fish ponds (16), Sunken lake (17), and Marble lake (20). The species was found several times attached in considerable numbers to the outside of the aquatic worm, *Stylaria lacustris*; in such cases, it attaches itself to the body of the worm by means of its toe.

Monostyla cornuta (Müller) (Plate VI, Fig. 46). This is a small *Monostyla*, not very common here. It was found in a kettle hole at West Okoboji (10), and again in Hottes lake (18).

Monostyla crenata Harring (Plate VI, Fig. 47). Two specimens were found in a tow from Lake Okoboji (1), near the laboratory dock.

Monostyla lunaris Ehrenberg (Plate VI, Fig. 48). This species was found in the canal (2), kettle hole (5), a swamp near West Okoboji (10), and Hottes lake (18). The body in some specimens appeared clear and hyaline, and in others had a brick-red coloration.

Monostyla quadridentata Ehrenberg (Plate VI, Fig. 49). Rather common in this region, being found in Lake Okoboji (1), the canal (2), the sand-bar pond (3), and kettle hole (7).

Lepadella acuminata (Ehrenberg) (Plate VI, Fig. 50). This species was found in a jar of algæ which had been brought into the laboratory from the canal (2). It was collected also from a swamp near West Okoboji (10).

Lepadella ovalis (Müller) (Plate VI, Fig. 51). This was the most common species of the genus. It was found in great numbers in the canal (2), near West Okoboji (10), and in Green slough (12); less abundantly in the fish ponds (16), Sunken lake (17), and Little Spirit lake (19).

Lepadella patella (Müller) (Plate VI, Fig. 52). A few individuals were found in the canal (2), the fish ponds (16), and Hottes lake (18).

Lepadella triptera Ehrenberg (Plate VI, Fig. 53). This small *Lepadella* was found in water from a swamp near the head of Lake Okoboji (10), and in the fish ponds (16).

Lophocharis oxysternon (Gosse) (Plate VI, Fig. 54). This species was found first in kettle hole (4); later two individuals were collected in a kettle hole near West Okoboji (10), and one in Little Spirit lake (19).

Lophocharis salpina (Ehrenberg) (Plate VI, Fig. 55). This *Lophocharis* was found in a weedy marsh (14), in the fish ponds (16), and in Little Spirit lake (19); it is not abundant anywhere.

Colurella adriatica Ehrenberg (Plate VI, Fig. 56). This species was found only near the mouth of drainage canal (2). Two specimens were found at different times.

Colurella bicuspidata Ehrenberg (Plate VI, Fig. 57). This species, with *C. obtusa*, was found in a stagnant pool near West Okoboji (10). It seems to be very rare, as only one individual was found.

Colurella deflexa (Ehrenberg) (Plate VI, Fig. 58). This *Colurella* was collected among weeds in the sand-bar pond (3); it was also found in a marsh near West Okoboji (10). Fairly common.

Colurella obtusa (Gosse) (Plate VI, Fig. 59). This species was collected from a jar of *Spirogyra* which had been brought into the laboratory from the canal (2). It was later found in a stagnant pool near West Okoboji (10). Not common.

Trichotria pocillum (Müller) (Plate VI, Fig. 60). This form was found on some algæ brought from the canal (2). Three individuals were recognized. It was not found elsewhere.

Trichotria tetractis (Ehrenberg) (Plate VI, Fig. 61). Found in a weedy marsh near Manhattan (14); two specimens.

Macrochaetus collinsii (Gosse) (Plate VI, Fig. 62). This species was found in great abundance in the canal (2), but not until after the middle of August.

Scaridium longicaudum (Müller) (Plate VI, Fig. 63). Seven or eight specimens were found in water from the mouth of the canal (2).

Trichocerca elongata (Gosse) (Plate VI, Fig. 64). Found in a tow from a small roadside pond near kettle hole (5); two specimens from the canal (2), and one from Little Spirit lake (19).

Trichocerca lophoessa (Gosse) (Plate VI, Fig. 65). Only two individuals of this species were found, both from a small pool near Center lake (13).

Trichocerca rattus (Müller) (Plate VI, Fig. 66). This species is rather common. It was found first in a deep tow in Lake Okoboji (1); later, many specimens were found in the canal (2), in kettle hole (5), in Sunken lake (17), and in Hottes lake (18).

Trichocerca stylata (Gosse) (Plate VI, Fig. 67). Found in some abundance in Lake Okoboji (1), the canal (2), and the sand-bar pond (3).

Diurella brachyura (Gosse) (Plate VII, Fig. 1). This species was found in a small pond opening from the drainage canal (2), together with several other species of *Diurella*.

Diurella porcellus (Gosse) (Plate VII, Fig. 2). Four specimens of this were found in a small pond opening from the drainage canal (2). This is the species that is compared by Gosse to "a fat young pig" [7] in appearance.

Diurella tenuior (Gosse) (Plate VII, Fig. 3). This species was found with others of the genus in a weedy canal pond (2). Four individuals.

Diurella tigris (Müller) (Plate VII, Fig. 4). This is a common species, especially in the earlier part of the summer. Found in canal (2), kettle hole (4), kettle hole (7), and the fish ponds (16).

Gastropus hyptopus (Ehrenberg) (Plate VII, Fig. 5). Two specimens were found in water from a swamp near West Okoboji (10).

Ascomorpha eucadis Perty (Plate VII, Fig. 6). Several specimens were found near the mouth of the canal (2).

Synchaeta pectinata Ehrenberg (Plate VII, Fig. 7). This species is common in Lake Okoboji (1), and in the sand-bar pond (3); a few individuals came from the marshes near West Okoboji (10). One of the most active and vigorous species found.

Polyarthra trigla Ehrenberg (Plate VII, Fig. 8). Common in Lake Okoboji (1) the canal (2), the sand-bar pond (3), and kettle hole (5); a few individuals were found in kettle hole (8) and in Hottes lake (18).

Asplanchna brightwellii Gosse (Plate VII, Fig. 9). A fairly common species in Lake Okoboji (1), the canal (2), and the sand-bar pond (3). One of the most fascinating species to study.

Asplanchna priodonta Gosse (Plate VII, Fig. 10). Found in kettle hole (4); one specimen.

Asplanchnopus multiceps (Schrank) (Plate VII, Fig. 11). From a marsh near Manhattan (14), and Marble lake (20); one specimen from each locality.

Testudinella mucronata (Gosse) (Plate VII, Fig. 12). Found with *T. patina* and *T. truncata* in water from the canal (2); rare.

Testudinella patina (Hermann) (Plate VII, Fig. 13). Quite common; found in Lake Okoboji (1), canal (2), sand-bar pond (3), kettle hole (5), kettle hole (7), marshes at West Okoboji (10), Gull Point kettle hole (11), Green slough (12), Gar lakes (15), fish ponds (16), and Little Spirit lake (19). This beautiful creature was described by Müller as "animalculum crystallinum, splendore nulli secundum;" [8] a description which it really merits.

Testudinella truncata (Gosse) (Plate VII, Fig. 14). Found with the other two representatives of the genus in the canal (2); rare.

Pompholyx sulcata Hudson (Plate VII, Fig. 15). Found in a marsh near the upper end of Lake Okoboji (10); two individuals.

Pedalia mira (Hudson) (Plate VII, Fig. 16). This remarkably interesting "skipping rotifer" was found near the entrance of the canal (2),

[7] Hudson and Gosse, The Rotifera, volume II, p. 67.
[8] Quoted in Hudson and Gosse, The Rotifera, volume II, p. 112.

in tows made on two consecutive days only, near the middle of August. Several specimens were found on each of the two days.

Filinia cornuta (Weisse) (Plate VII, Fig. 17). A few individuals were found near the entrance of the canal (2).

Filinia longiseta (Ehrenberg) (Plate VII, Fig. 18). This species was abundant in Lake Okoboji (1), the canal (2), the sand-bar pond (3), and Gull Point kettle hole (11); a few individuals were found in kettle hole (6), in a creek near Egralharve (9), in the fish ponds (16), and in Little Sioux river (21).

Filinia passa (Müller) (Plate VII, Fig. 19). Not quite so abundant as *F. longiseta;* found in Lake Okoboji (1), in kettle hole (5), and in a kettle hole near West Okoboji (10).

ORDER FLOSCULARIACEA

Floscularia ringens (Linnaeus) (Plate VII, Fig. 20). Found on *Ceratophyllum, Myriophyllum,* and others of the larger aquatic plants, but never on fresh, green, young plants. Collected from Miller's bay, Lake Okoboji (1), and from the sand-bar pond (3).

Limnias ceratophylli Schrank (Plate VII, Fig. 21). Found on *Ceratophyllum,* often with *Floscularia.* Collected from Miller's bay, Lake Okoboji (1), and from the sand-bar pond (3).

Ptygura longicornis (Davis) (Plate VII, Fig. 22). Found in great abundance among floccose material on old *Ceratophyllum;* not collected here on any other water plant. Sand-bar pond (3).

Sinantherina socialis (Linnaeus) (Plate VII, Fig. 23). Clusters are found on the tips of *Ceratophyllum* leaf-lobes, like globular balls of gray jelly. Fairly rare here. Sand-bar pond (3).

Lacinularia flosculosa (Müller) (Plate VII, Fig. 24). Collected from Lake Okoboji (1), the canal (2), and the sand-bar pond (3). This species was found in great abundance on the tips of the leaf-lobes of *Ceratophyllum,* being the most common of all attached rotifers in this region. It seems to be profusely distributed in the lake. Of sixty-eight colonies of social rotifers examined from one collection, sixty-seven were of this species, and one was *Sinantherina socialis.* The color of the colony is brownish yellow to salmon; the species is easily recognized by the color and by the four opaque warts or collar knobs. The collar knobs of the specimens from the sand-bar pond (3) and from the canal (2) are almost black; those of specimens found on *Ceratophyllum* in the open lake (1) are light brown. Colonies were found also on the roots of the common duckweed and of *Lemna trisulca.*

Conochilus hippocrepis (Schrank) (Plate VII, Fig. 25). Found in great numbers in kettle hole (6) on one day only, July 7, a sunny, cool day.

Conochiloides dossuaris (Hudson) Plate VII, Fig. 26). This species was first found in kettle hole (4); later it was found rarely in the canal (2), Marble lake (20) and one specimen from Lake Okoboji (1).

ORDER COLLOTHECACEA

Collotheca algicola (Hudson) (Plate VII, Fig. 27). Found in colonies of *Rivularia pisum,* the animal being embedded in the gelatine of the

Rivularia. This species is very uncommon in this region, as more than a hundred and fifty growths of *Rivularia* were examined, and only two were found with *C. algicola* inhabiting them. The two growths which did have rotifers in them were on *Ceratophyllum* from the canal (2); one growth had five rotifers in it, the other two.

Collotheca campanulata (Dobie) (Plate VII, Fig. 28). Found on duckweed roots, together with *Vorticella.* Two specimens were found, both from a stagnant pool near West Okoboji (10).

ORDER BDELLOIDA

Adineta vaga (Davis) (Plate VII, Fig. 29). This species was obtained by collecting a handful of dried leaves, twigs, etc., from the eaves of the cottage on the laboratory grounds and soaking the material in water for twenty-four hours. Along with *Adineta vaga* were found *Rotaria rotatoria* (see below), and numerous protozoa, notably *Paramecium.*

Philodina citrina Ehrenberg (Plate VII, Fig. 30). This species was found (rare) in water from Green slough (12), Hottes lake (18), and Little Spirit lake (19). Its yellowish color is perhaps its most outstanding characteristic.

Philodina megalotrocha Ehrenberg (Plate VII, Fig. 31). Found only in the sand-bar (3). The smallest representative of the genus found here.

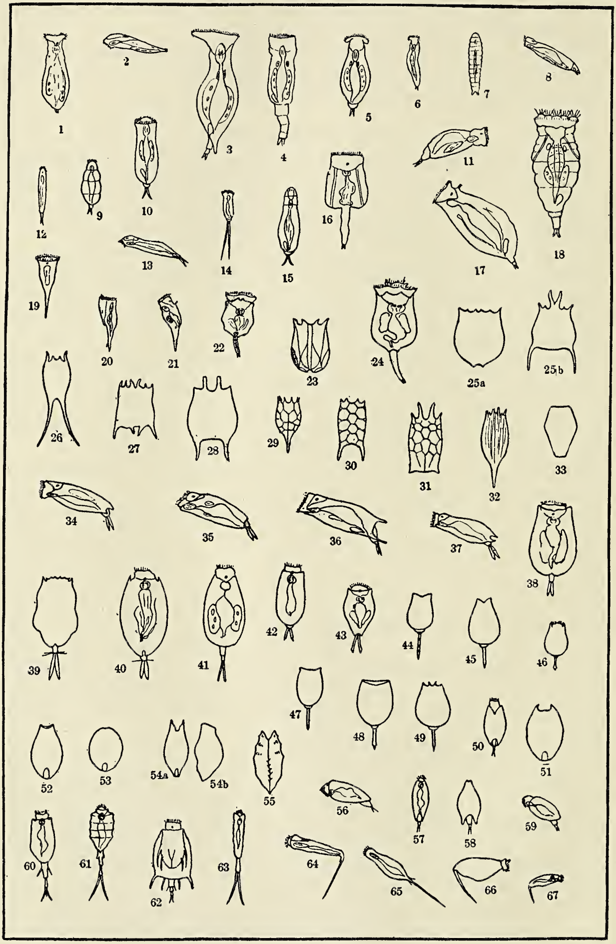
Philodina roseola Ehrenberg (Plate VII, Fig. 32). Found on weeds and in tows from the sand-bar pond (3), kettle hole (4), and Little Spirit lake (19). This species bears repeated drying and revivifying.

Rotaria macroceros (Gosse) (Plate VII, Fig. 33). Two specimens were found in a marshy, weedy pool near Manhattan (14).

Rotaria macrura (Ehrenberg) (Plate VII, Fig. 34). Found in the canal (2), the sand-bar pond (3), Gull Point kettle hole (11), Green slough (12), and Gar lakes (15). This species is viviparous. One individual which was under the microscope for observation had a fully developed young rotifer in her coelomic cavity. During the course of the study, the body wall of the mother ruptured (probably due to pressure from the cover glass caused by drying of the preparation) and the young rotifer swam out. It progressed for a short distance through the water, swimming by means of its ciliary wreath, and then anchored itself and commenced to take food. The mother continued to move her ciliary wreath for several minutes, but soon died.

Rotaria rotatoria (Pallas) (Plate VII, Fig. 35). This species is very common. Besides being found in the material from the eaves of the cottage (see above, under *Adineta vaga*), it was found in Lake Okoboji (1), the canal (2), the sand-bar pond (3), kettle hole (4), kettle hole (5), kettle hole (6), kettle hole (7), marshes at West Okoboji (10), Green slough (12), Gar lakes (15), fish ponds (16), Hottes lake (18), Little Spirit lake (19), and Marble lake (20).

Rotaria tardigrada (Ehrenberg) (Plate VII, Fig. 36). Found on water weeds and in sediment from the canal (2), kettle hole (4), kettle hole (7), swamp at West Okoboji (10). and Little Spirit lake (19).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EXPLANATION OF PLATES*

PLATE VI. ORDER PLOIMA

Fig.
1. Notommata aurita.
2. Notommata brachyota.
5. Notommata pachyura.
6. Notommata saccigera.
7. Taphrocampa annulosa
8. Pleurotrocha sordida.
9. Cephalodella catellina.
10. Cephalodella forficula.
11. Diaschiza gibba.
12. Diaschiza gracilis.
13. Diaschiza tenuior.
14. Monommata orbis.
15. Dicranophorus forcipatus.
16. Epiphanes brachionus.
17. Epiphanes clavulata.
18. Epiphanes senta.
19. Microcodon clavus.
20. Mikrocodides chlaena.
21. Mikrocodides robustus.
22. Brachionus angularis.
23. Brachionus budapestinensis.
24. Brachionus calyciflorus.
25. Brachionus capsuliflorus.
    a, b. Varieties.
26. Brachionus havanaensis.
27. Brachionus patulus.
28. Platyias quadricornus
29. Keratella cochlearis
30. Keratella quadrata.
31. Keratella serrulata
32. Notholca striata.
33. Anuraeopsis fissa.
34. Mytilina mucronata.
35. Mytilina trigona.
36. Mytilina ventralis.

Fig.
3. Notommata copeus.
4. Notommata najas.
37. Mytilina ventralis brevispina.
38. Euchlanis dilatata.
39. Euchlanis pyriformis.
40. Euchlanis triquetra.
41. Dipleuchlanis propatula.
42. Lecane gissensis.
43. Lecane luna.
44. Monostyla acus.
45. Monostyla bulla.
46. Monostyla cornuta.
47. Monostyla crenata.
48. Monostyla lunaris.
49. Monostyla quadridentata.
50. Lepadella acuminata.
51. Lepadella ovalis.
52. Lepadella patella.
53. Lepadella triptera.
54. Lophocharis oxysternon.
    a. Dorsal view.
    b. Lateral view.
55. Lophocharis salpina.
56. Colurella adriatica.
57. Colurella bicuspidata.
58. Colurella deflexa.
59. Colurella obtusa.
60. Trichotria pocillum.
61. Trichotria tetractis.
62. Macrochaetus collinsii.
63. Scaridium longicaudum.
64. Trichocerca elongata.
65. Trichocerca lophoessa.
66. Trichocerca rattus.
67. Trichocerca stylata.

* For convenience in figuring, a sliding scale is used in Plates VI and VII. An animal 100 micra in length is figured as 10 mm.; for each additional 100 micra, 2.5 mm. are added. This gives some idea as to comparative size, yet the figures are all of convenient proportions.

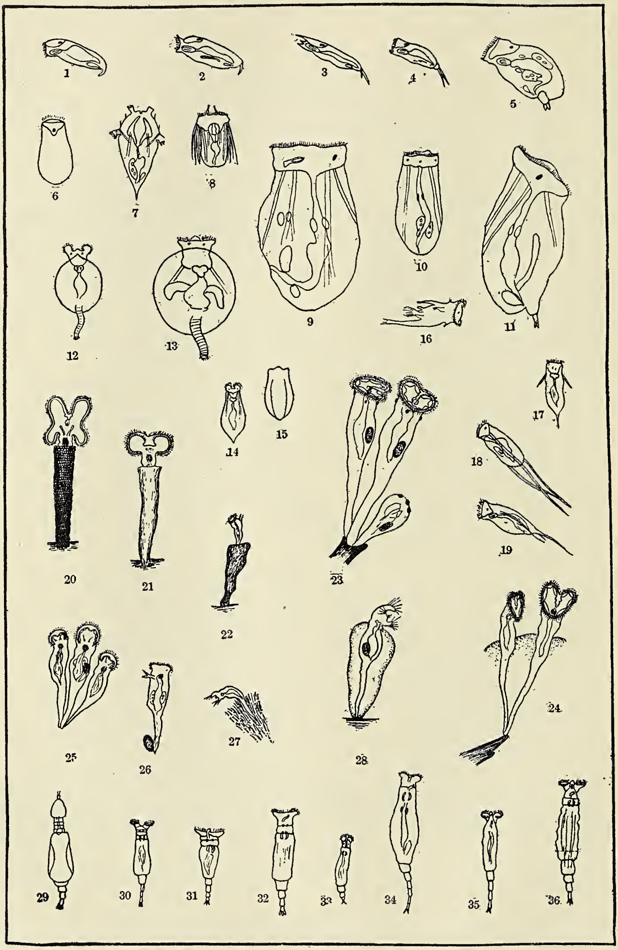
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PLATE VII. ORDERS PLOIMA, FLOSCULARIACEA, COLLOTHECACEA, AND BDELLOIDA

Fig.

1. Diurella brachyura.
2. Diurella porcellus.
3. Diurella tenuior.
4. Diurella tigris.
5. Gastropus hyptopus.
6. Ascomorpha eucadis.
7. Synchaeta pectinata.
8. Polyarthra trigla.
9. Asplanchna brightwellii.
10. Asplanchna priodonta.
11. Asplanchna multiceps.
12. Testudinella mucronata.
13. Testudinella patina.
14. Testudinella truncata.
15. Pompholyx sulcata.
16. Pedalia mira.
17. Filinia cornuta.
18. Filinia longiseta.

Fig.

19. Filinia passa.
20. Floscularia ringens.
21. Limnias ceratophylli.
22. Ptygura longicornis.
23. Sinantherina socialis.
24. Lacinularia flosculosa.
25. Conchilus hippocrepis.
26. Conchiloides dossuaris.
27. Collotheca algicola.
28. Collotheca campanulata.
29. Adineta vaga.
30. Philodina citrina.
31. Philodina megalotrocha.
32. Philodina roseola.
33. Rotaria macroceros.
34. Rotaria macrura.
35. Rotaria rotatoria.
36. Rotaria tardigrada.

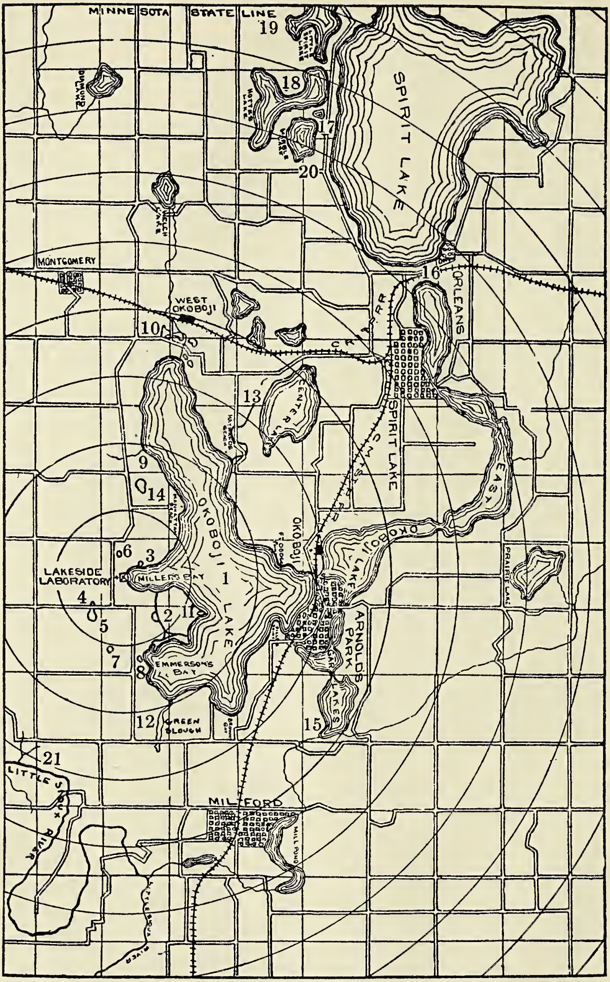

Fig. 49. MAP OF THE LAKE OKOBOJI REGION, SHOWING COLLECTING GROUNDS. 1. Lake Okoboji. 2. Drainage canal. 3. Sand-bar pond. 4. Kettle hole. 5. Kettle hole. 6. Kettle hole. 7. Kettle hole. 8. Kettle hole. 9. Creek. 10. Marshes and kettle holes. 11. Gull Point kettle hole. 12. Green slough. 13. Center Lake. 14. Marsh. 15. Gar lakes. 16. Fish ponds at Orleans. 17. Sunken Lake. 18. Hottes Lake. 19. Little Spirit Lake. 20. Marble Lake. 21. Little Sioux River.

SUSCEPTIBLE AND RESISTANT PHASES OF THE DIVIDING SEA-URCHIN EGG WHEN SUBJECTED TO VARIOUS CONCENTRATIONS OF LIPOID-SOLUBLE SUBSTANCES, ESPECIALLY THE HIGHER ALCOHOLS*

FRANCIS MARSH BALDWIN

INTRODUCTION

That dividing Arbacia eggs show periods of varying susceptibility and resistance when exposed to chemical substances and to various physical conditions has been proved by numerous investigations. When eggs from a single fertilized lot were placed at regular successive intervals after fertilization in cyanide containing sea-water (m/100 to m/200), Lyon [1] found that they were highly resistant to poisoning fifteen or twenty minutes after fertilization, while eggs exposed to the same solution at the time of cytoplasmic division were promptly killed. Later, after the first division had been completed, the resistance to poisoning again returned, followed by a second susceptible period at the second cleavage. Loeb [2] later noted that the unfertilized eggs show greater resistance to cyanide poisoning than the fertilized eggs, and Mathews [3] indicated that in dividing eggs, the period of maximum susceptibility is "immediately before and during segmentation," and that just after segmentation the egg becomes relatively highly resistant. Similar results were obtained by Spaulding [4] in experiments with weak solutions of ether (1/64 per cent in sea-water). The period of high resistance continued up to the beginning of the first cleavage, and then fell during cleavage to zero, with a sharp rise immediately afterwards. There was a short period of susceptibility immediately following fertilization. He found also in acid and salt solutions (pure isotonic KCL and NaCL) a similar but less clearly defined rhythm of susceptibility. Eggs subjected to heat, electrical stimulation and hypertonic sea-water behave in a similar manner. Thus, Lyon [5] observed that the eggs were most resistant to heat at a time previous to the first cleavage, and were most readily injured at the time of division.

* From the Marine Biological Laboratory, Woods Hole, Mass., and the Department of Zoology, Iowa State College, Ames, Iowa.

A. R. Moore [6] finds that the resistance to hypertonic sea-water is least "immediately before and during each cytoplasmic division, and that the maximal resistance is shown 35 to 45 minutes after fertilization and just after each division." More recently Lillie [7] (1916), has made an extensive study of the rhythmical changes in the resistance of the dividing sea-urchin egg to hypotonic sea-water, and has discussed the physiological significance of this rhythm. His experiments show clearly that at or about the time of formation of the cleavage furrow, a marked decline takes place in the resistance of the egg to hypotony, and cytolysis is then rapid and complete. After the cleavage furrow is fully formed the original resistance returns. A similar reversible decline of resistance takes place at the second and third cleavage, and is probably general for mitotic cell-division. The minimum of resistance is found during the formation of the furrow. Both the decline and the return of resistance are rapid, the greater part of each phase occupying four to five minutes. Some increase of susceptibility is apparent ten or twelve minutes before the first appearance of the furrow. Similar observations have been made by Herlant [8] in the egg *Paracentrotus lividus.*

From such experiments it appears that the resistance of the eggs to a variety of injurious agencies is least at the time when they are undergoing rapid change of form. To account for these rhythmical changes in the physiological state of the egg, Lillie [9] (1909) puts forward the hypothesis that they are essentially the result of variations in the physical condition, especially the permeability, of the surface-film or plasma-membrane, the latter undergoing a reversible increase in permeability at the time of cleavage. If a rythm of alternate increase and decrease of permeability accompanies the rhythm of the mitotic process, it seems logical to infer that the entrance of solutes into the cell would occur most readily when there is a loss of semi-permeability. Accompanying this change would be a decrease of the electrical surface-polarization, and this in turn probably would alter the metabolic processes, especially oxidations within the cell. Cell metabolism then is inseparably bound up with cell-permeability; and the plasma-membrane, or semi-permeable surface-layer is something more than a haptogen membrane (to which it has frequently been compared). In discussing this subject in a later paper, Lillie [10] makes it especially clear that this "general characteristic of semi-permeability (the all-essential insulating and diffusing-preventing property) is not merely the result of a special chemical composition and structural density, such as determine the semi-permeability of a precipitation-membrane, but is inseparable from the living condition, *i.e.,* is actively maintained by a continual process of metabolism. The proof of this is that death — the cessation of metabolism — however caused, is invariably followed by a loss of semi-permeability, *i.e.,* the normal state of the membrane then ceases to be maintained and the unhindered processes of diffusion lead to the disintegration of the cell. Hence destruction of the surface-layer by artificial means — cytolytic substances, heat, extensive mechanical injury — is quickly fatal to all cells.

In the experiments about to be described, I have studied the behavior of fertilized Arbacia eggs when subjected for definite brief lengths of time to various concentration of some of the higher alcohols — anyl, hexyl, heptyl, octyl and capryl — at different periods of the cell-division cycle. This work was undertaken at the Marine Biological Laboratory, at Woods Hole, Massachusetts, during the past summer (1919) at the suggestion of Professor Ralph Lillie, to whom the writer expresses his hearty thanks for many kind suggestions and directions during its prosecution.

EXPERIMENTATION

In order to procure a sufficient number of eggs for each series of experiments, between one and two dozen large females were opened, and their eggs collected into finger bowls. By successive washing and settling, a uniform mass of mature eggs was obtained, which could be inseminated and divided into two parts; one to be used for the control, and the other for the experiments. It was found early in the work that the success of the experiments depended upon having batches of eggs which were sufficiently mature and uniform, so that all eggs reached successive stages in their development at practically the same time. It was also found that great exactness in the time-relations of the operations was absolutely essential, and that any variation once entered upon was sufficient to make the results worthless from a comparative standpoint. Usually two series of experiments were started in a day; one in the morning to be carried over to the gastrula stage by the following morning, and one in the afternoon, to be examined the following afternoon. After extended preliminary experimentation, it was found convenient, in any one series, to keep the time of exposure constant and to vary the concentration of substance used, although in a considerable number of experiments the opposite procedure was adopted, that is, the time was varied and the concentration kept constant.

Practically the same procedure was observed throughout the entire experimentation. At each of the successive intervals after fertilization, usually ten minute intervals, about one-half of a medicine pipette containing a suspension of the inseminated eggs was placed in a small corked Erlemyer flask, contining 50 c.c. of the solution of the alcohol in sea-water, and allowed to remain for the time of exposure chosen (usually five minutes). After the given time had nearly elapsed, the excess liquid was poured off, and the eggs with a little of the liquid were placed in a watch glass and the immediate results of the treatment were observed under the low power of the microscope. At the termination of the time of exposure, the watch glass containing the eggs was carefully immersed in a large volume of sea-water in a finger bowl and the water was changed several times to rid it of the excess substance. Finally the eggs were very carefully washed with a stream of water from the medicine-dropper, and set aside to undergo development. The proportion proceeding with development to the free-swimming larval stage was subsequently determined. It was found that the estimate of the proportion surviving to the blastula stage was more readily and exactly made if the watch glass containing the eggs was removed from the bowl of sea-water just before the free-swimming larval stage was reached. Thus all survivors could be confined within a small volume, and the count or estimate easily made. As a rule, the experiments were carried up only to about the time of second cleavage, since the evidence indicates that the same variation of susceptibility occurs in each cell division cycle. Moreover divergencies between the different eggs in any lot become more pronounced as time elapses, and it is important that all eggs of a lot should be in the same physiological state at the time of treatment.

At first several preliminary experiments were necessary in order to determine the most suitable range of concentrations to be used, since the times of exposure determined upon were brief, the longest being ten minutes, while in some cases the exposure was only three minutes. In this connection, the tables given by Lillie [11] in his paper on the action of various anæsthetics in suppressing cell-division in sea-urchin eggs, were exceedingly helpful. For i-amyl [12] alcohol, he finds 0.45 to 0.4 volumes per cent a favorable anæsthetic concentration for eggs subjected for two and one-half hours, while 0.5 vol. per cent and above are somewhat rapidly toxic. For capryl[13] alcohol he finds the anæsthetizing concentrations to range between 0.012 and 0.02, and notes that even in sub-anæsthetic concentrations this alcohol exhibits a relatively high specific toxicity. With the help of these data, and also Fühner's[14] observations showing that in a series of monohydric aliphatic alcohols each member of the group is from three to four times as effective (for equimolecular concentrations) as its immediate predecessor, it became a comparatively easy matter to approximate the most suitable concentration of each alcohol after the first had been determined.[15]

AMYL ALCOHOL

Summarizing briefly the results of preliminary observations: it was found that the most satisfactory concentration of i-amyl alcohol when used with exposures of three to eight minutes, was between 0.7 and 0.9 vol. per cent. Solutions of this strength are sufficiently toxic to prevent many but not all the eggs thus treated from developing to a larval stage. Solutions weaker than 0.7 vol. per cent permit practically all eggs to proceed to the blastula stage with those exposures, with little appreciable difference. At 1.0 vol. per cent not more than 20 per cent of eggs form free-swimming blastulæ even when exposed at the period of highest resistance; (*e.g.*, 30 to 40 minutes after fertilization) and above this concentration the toxicity is such that the decline in survivals is very rapid. In 1.25 vol. per cent solutions, all eggs are killed in all stages with exposures of nine minutes.

Table I summarizes the results of a typical series of experiments with i-amyl alcohol. This particular series of experiments was started in the afternoon of July 16, and the observations noted in the third column were carried over into the morning of the following day. A similar series of experiments performed at about the same time with the same alcohol in somewhat lower concentration (0.8 vol. per cent), but with slightly longer (10 minute) exposures yielded substantially the same results. On the following day experiments were carried out on eggs subjected to 1.1 vol. per cent solutions with only brief (3, 4 and 5 minute) exposures with results noted above.

In the controls about one-half of the eggs were in the two-celled stage at fifty-three minutes after fertilization, and at sixty-five minutes between 85 and 90 per cent were divided. There is a definite period of well marked susceptibility immediately following fertilization; the susceptibility then gradually and progres-

TABLE I. 1-AMYL ALCOHOL

July 16, 1:45 P.M. The fertilized eggs were placed in 50 c.c. of 0.9 vol. per cent i-amyl alcohol, at the intervals after fertilization noted in column 1. All exposures except the first (1) (6 minutes) were of eight minutes duration

Intervals after Fertilization	Observed Condition of the Eggs at the Time of Removal from Solution	Proportion Forming Blastulæ and Conditions of Remaining Eggs Next Day
(1) 3-9m	Fertilization-membranes well formed. No marked cytolytic change noted.	About 5 per cent form free-swimming blastulæ. Considerable numbers cytolyzed.
(2) 10-18m	No marked change in appearance. Uniform.	About 10 per cent form blastulæ. Not so badly cytolyzed; most cells intact.
(3) 20-28m	Membranes markedly swollen in some cases. Slight fading of pigment.	Nearly 30 per cent free-swimming blastulæ. Most eggs intact.
(4) 30-38m	A few cells plasmolyzed, other membranes markedly swollen.	Between 30 and 40 per cent free-swimming blastulæ. Most others intact but swollen.
(5) 40-48m	No marked change. Faint indication of cleavage furrow in a few scattered cells.	Large majority (75 to 80 per cent) form swimming blastulæ.
(6) 50-58m	About 65 per cent in two-celled stage. Others intact.	Relatively few (less than 10 per cent) form surviving blastulæ.
(7) 60-68m	About 90 per cent in two-celled stage. Others intact.	Between 30 and 35 per cent form blastulæ.
(8) 70-78m	Practically all in two-celled stage.	Few (15 to 20 per cent) form blastulæ. Others intact.
(9) 80-88m	A few are starting second cleavage furrow.	3 to 5 per cent form blastulæ. Others intact.

sively declines up to the end of forty-eight minutes (just before the first cleavage). There then follows a very susceptible period just at the time of cleavage. Later the resistance phase reappears until about the time of the second cleavage. If the time intervals are plotted as abscissæ, and the percentage of surviving blastulæ as ordinates, the relationships may be represented in the curve shown below (Fig. 50).

HEXYL ALCOHOL

In exploring the range of suitable concentrations for hexyl alcohol, the next higher member of the series, assuming that it should be approximately three times as effective as i-amyl alcohol, three preliminary experiments were performed. For these, solu-

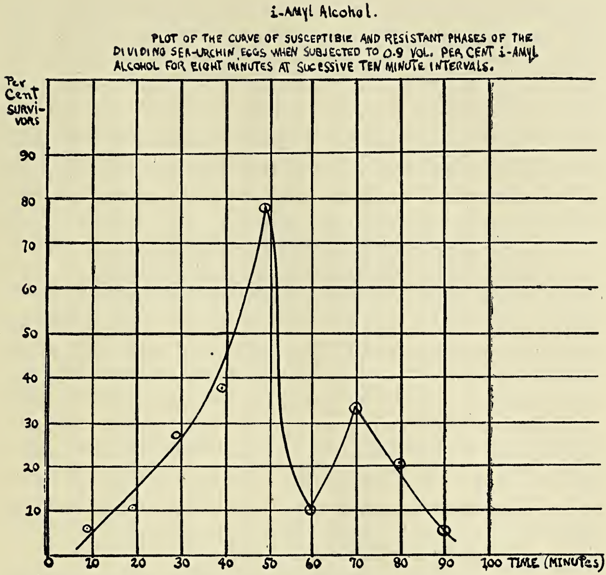

Fig. 50

tions of 0.1, 0.25 and 0.30 vol. per cent respectively were used. The time of exposure was shortened to five minutes, for the reason that it was thought the concentrations were, if anything, a little above the optimum. The results clearly showed that the solution of 0.1 vol. per cent was not sufficiently toxic to demonstrate any variation of susceptibility in the eggs, since at whatever period they were exposed practically all eggs survived to the free-swimming blastula stage. On the other hand, the two higher concentrations proved too toxic, so that practically none of the eggs continued their development after subjection to these solutions at any period. The 0.25 vol. per cent solution, although it suppressed further development, was not quite intense enough in its action to cause cytolysis in the eggs, with few exceptions. The 0.30 vol. per cent concentration caused very slight cytolysis, and rupture was almost universal. Accordingly, series of experiments were carried out to test the various concentrations between 0.1 vol. per cent and 0.25 vol. per cent.

These results show a much less definite evidence of a rhythm of susceptibility than those just described for i-amyl alcohol. The eggs apparently maintain throughout the cycle a relatively high resistance to the concentrations of hexyl alcohol here used, with only a slight increase of susceptibility at the time of first cleavage; in the one case (0.17 vol. per cent) there is evidence of a slight return of resistance just afterwards, and in the other (0.13 vol. per cent) there is not. Why there should be this difference in the behavior of the two alcohols is difficult to explain. The exposures to hexyl alcohol were perhaps insufficiently prolonged to bring out a well marked differential effect at the different stages of the cycle. Again, it is well known that certain anæsthetics are less effective than others in suppressing the cell-division process; also many neuromuscular responses react differently to a given anæesthetic in different animals, and in the same animal at different ages. Thus Lillie [16] found chloretone much less effective than chloral hydrate in suppressing cleavage in Arbacia eggs. As regards the alcohols that he tried, he lists propyl, butyl, amyl in the order of increasing favorability, while ethyl and capryl show a higher toxicity than others.[17] It may be that differences, both qualitative and quantitative, in the lipoid elements of the tissues, and hence in the plasma-membrane, form the basis of the observed physiological difference.

In the controls which were running parallel to these experiments just described, a majority of the eggs entered the two-celled stage at about fifty-eight minutes after fertilization. At sixty-five minutes after fertilization, between 85 and 90 per cent had cleaved. Practically all eggs in the controls had reached the blastula stage the following day.

HEPTYL ALCOHOL

A series of six experiments was performed with this alcohol to determine the limits of suitable concentration. Reasoning from the data in the preceding, it was thought that the optimum concentration would be between 0.04 and 0.07 vol. per cent, but to make sure, concentrations as low as 0.02 and as high as 0.08 vol. per cent were used. As a matter of fact, solutions of 0.06 and 0.07 vol. per cent were found to be the best suited to the experiments, although it is interesting to note that even weaker solutions showed marked toxic action on eggs at the time of formation of the first cleavage furrow, while during the stages preceding and succeeding division, they had relatively little influence. Briefly summarizing, the results show that 0.07 vol. per cent approximates the favorable concentration for this alcohol, while the solutions on either side are slightly hypo- and hyper-toxic respectively; that is, in the one case practically all eggs survive to the blastula stage, and in the other nearly all die. Recovery of resistance after the first division appears to be relatively slow. When the percentage of surviving blastulæ is plotted against the time intervals, regarding as typical the data of the 0.07 vol. per cent solution, an interesting curve (see figure 51 below) is obtained

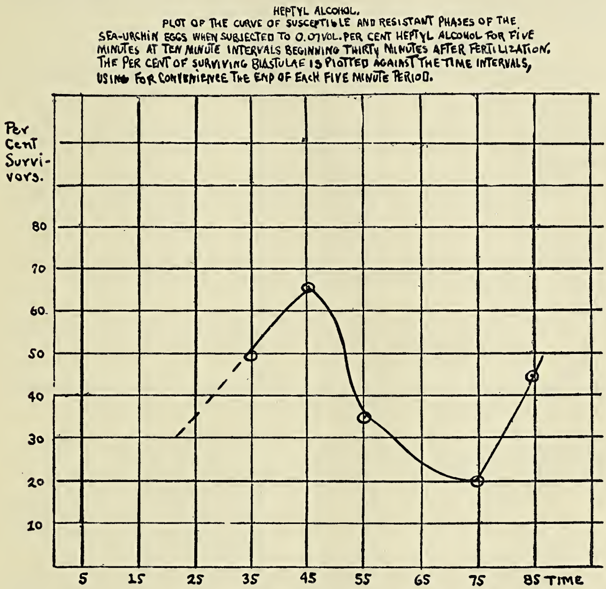

Fig 51

which is fairly comparable with the one shown for i-Amyl alcohol. There is a gradual rise in resistance up to the period of first cleavage, with a sharp drop during cell-division followed by a slow recovery.

OCTYL ALCOHOL

Normal octyl alcohol apparently is considerably more toxic than its isomere capryl alcohol. In a series of five experiments with octyl alcohol in concentrations ranging from 0.010 to 0.030 vol. per cent, the best concentration for exposures of five minutes was found to be in the neighborhood of 0.015 vol. per cent. On the other hand the outcome of fourteen experiments with capryl alcohol showed the optimum concentration for the same time of exposure to be between 0.035 and 0.045 vol. per cent, which is between two and three times the favorable concentration of normal octyl alcohol. Table II summarizes a typical experiment using normal octyl alcohol of 0.013 vol. per cent concentration. For exposures of five minutes duration, this concentration gave the best results, and showed very clearly the resistant and susceptible phases.

TABLE II. NORMAL OCTYL ALCOHOL

Fertilized eggs were subjected for five minutes to 0.013 vol. per cent of normal octyl alcohol at intervals of ten minutes.

Intervals after Fertilization.	Observed Condition on Removal from Fluid	Observed Condition the Following Day
(1) 15-20m	Fertilization membrane well formed. Slight loss pigment.	Nearly 50 per cent active blastulæ. Others badly cytolyzed, few ruptured.
(2) 25-30m	No noticeable cytolysis although very marked loss of pigment.	About 65 per cent active blastulæ. Others cytolyzed.
(3) 35-40m	Decided loss of pigment. No marked change in membrane or cytoplasm.	Nearly 80 per cent active. Others intact.
(4) 45-50m	About 2 per cent show first furrow. Slight loss pigment; no cytolysis.	Practically all active blastulæ.
(5) 55-60m	Over half in first cleavage.	About 85 per cent active.
(6) 65-70m	About 90 per cent in two-celled stage.	Almost 60 per cent active blastulae, numbers of two-celled eggs present and mostly intact. Some badly cytolyzed and ruptured.
(7) 75-80m	Aside from loss of pigment no noticeable change.	Between 65 and 70 per cent active blastulæ. Others cytolyzed but intact.
(8) 85-90m	A few (1 per cent) just begin to show second cleavage furrow. No marked change in appearance.	Between 85 and 90 per cent active blastulæ. Others cytolyzed but intact.

CAPRYL ALCOHOL

As mentioned before, experiments with various concentrations of capryl alcohol showed that for brief exposures, the most favorable concentration was clearly three times that of normal octyl alcohol. This may perhaps be accounted for in some measure

TABLE III.

Fertilized eggs were subjected for five minutes at ten minute intervals to 0.035 and 0.045 vol. per cent capryl alcohol.

Intervals	0.035 Vol. Per Cent		0.045 Vol. Per Cent	
	Observed Condition	Condition Following Day	Observed Condition	Condition Following Day
(1) 10-15m........	Membranes well formed. No great difference from normal eggs.	75 to 80 per cent active. Others cytolyzed but mostly intact.	No marked difference from normal eggs.	About 65 per cent active. Others badly cytolyzed.
(2) 20-25m........	Membrane slightly swollen. No marked cytolysis.	About 83 per cent active. Others badly cytolyzed.	No marked change.	Nearly 85 per cent active. Others intact.
(3) 30-35m........	Few show loss of pigment, cytoplasm shrunken in some cases.	About 92 per cent active. Others intact.	Marked fading of pigment. No marked cytolysis.	Between 85 and 90 per cent active. Some ruptured eggs motile.
(4) 40-45m........	No marked change. None show cleavage furrow.	About 95 per cent active blastulæ. Others intact.	No marked change, slight loss of pigment.	About 70 per cent active. Others mostly intact.
(5) 50-55m........	Nearly half show first cleavage furrow. No marked change.	80 per cent active blastulæ. Few ruptured.	No marked change.	About 50 per cent active blastulæ. Most others badly cytolyzed, many ruptured.
(6) 60-65m........	Nearly all show first cleavage furrow. No marked cytolysis.	About 50 per cent active blastulæ. Most others ruptured.	Practically all in two cell stage. Some loss pigment.	About 40 per cent active. All others badly ruptured. Some still in two cells.
(7) 70-75m........	No marked change. Few scattered cells show second furrow.	About 30 per cent active blastulæ. Others badly cytolyzed.	No marked change except loss of pigment.	Nearly 30 per cent active. Others badly cytolyzed. Few persist in two cells.
(8) 80-85m........	No marked cytolysis.	Nearly 80 per cent active blastulæ. Others mostly intact.	No marked change.	Nearly 50 per cent active blastulæ. Others cytolyzed but mostly intact.

by the fact that not all samples of capryl alcohol are uniform in chemical composition and purity; a slight difference in this respect is known to make a decided difference in its chemical and physiological activity. In suitable concentrations, this alcohol is without doubt one of the most satisfactory for showing susceptible and resistant phases in dividing eggs. Several experiments were tried with this alcohol in which the concentration was kept constant and the time of exposure was varied; and from the data thus gathered, it seems probable that of the two factors, concentration is the more important. In other words, if the concentration is such that it gives the best results with a five minute exposure, when the exposure is prolonged to eight minutes, very little or no difference is detected. This generalization, however, probably could be applied only within narrow limits.

The data from two experiments using capryl alcohol in 0.035 and 0.045 vol. per cent concentrations respectively are given in Table III. These records are fairly typical of results of other experiments.

When plotted the data give interesting curves as shown below,

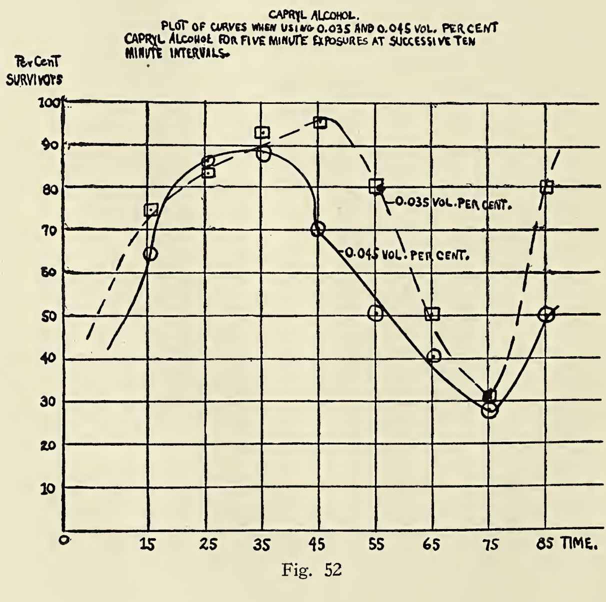

Fig. 52

which are fairly comparable to those shown before; that is, they are typically reversible (see figure 52).

SUMMARY

1. The developing sea-urchin egg when subjected to suitable concentrations of various lipoid-soluble substances — i-amyl, hexyl, heptyl, octyl and capryl alcohols — shows unmistakable rhythms of susceptible and resistant phases, which when taken in connection with the earlier observations of Lyon, Herlant, Mathews, Spaulding, Lillie and others, constitute additional evidence that a very intimate relation exists between the general physiological condition of the egg, and the physical state of its plasma-membrane.

2. During the first ten or fifteen minutes after fertilization the eggs are more susceptible than at any other time until the period just preceding division. A comparatively resistant phase gradually becomes more and more marked up to just before the first cell-division (about 45 or 48 minutes after fertilization). This is followed by a period of decidedly increased susceptibility which lasts for about 15 or 20 minutes, during which time marked cytological effects are noted. Subsequently the resistant phase is largely recovered, and maintained up to the time of the second cleavage.

3. The most favorable concentrations of the various alcohols for demonstrating the rhythm of susceptibility range as follows: i-amyl, between 0.7 and 0.9 vol. per cent; hexyl, between 0.13 and 0.17 vol. per cent; heptyl, between 0.06 and 0.07 vol. per cent; normal octyl, about 0.015; while capryl was considerably above its isomere (normal octyl) between 0.035 and 0.045 vol. per cent. The best records were obtained in experiments using i-amyl and capryl alcohols, possibly indicating a higher specific toxicity of these when compared to the others.

4. When suitable concentrations were used, no marked difference could be detected by varying slightly the durations of exposure. Eggs exposed for five, eight or even ten minutes to the same concentration gave similar results. This, however, probably would apply only within narrow limits.

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11. **R. S. Lillie,** Jour. Biolog. Chem., vol. 17, no. 4, pp. 129-30, 1914.
12. Cf. reference just cited; table VIII., p. 135.
13. Cf. reference just cited; table IX., p. 137.
14. **H. Fühner,** Arch. f. exp. Path. u. Pharm., lii, p. 69, 1904.
15. Capryl alcohol used in exposure of five minutes seemed not to obey this general rule, since in practically all experiments it was used in concentrations nearly three times its computed strength. (See p. 296.)
16. **R. S. Lillie,** Jour. Biol. Chem., vol. 17, no. 2, p. 130, 1914.
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Department of Zoology,
Iowa State College.

NOTES ON THE BRANCHES OF THE AORTA (ARCUS AORTAE) AND THE SUBCLAVIAN ARTERY OF THE RABBIT

FRANCIS MARSH BALDWIN

One plate (VIII) of eleven figures.

Bensley[1] in his Practical Anatomy of the Rabbit (p. 365), in discussing the blood vessels of the thorax describes the arch of the aorta as "beginning at the base of the heart, — — — — passes forward, and then describing a curve, in the course of which it lies slightly to the left of the median plane, turns backward along the ventral surfaces of the bodies of the thoracic vertebrae. With the exception of the coronary arteries the first branches are the large paired vessels arising from the anterior wall. They comprise the *common carotid* and *subclavian arteries*. On the right side the carotid and subclavian arise from a short common trunk, the *innominate* artery. The left common carotid arises immediately to the left of this vessel or from its base. The subclavian artery (a. subclavia) is the first portion of the artery of the anterior limb. It passes from its point of origin laterad to the anterior margin of the first rib, where it is replaced by the axillary artery. Near its point of origin, it gives off several branches, the relations of which are subject to considerable variation."

"The large paired vessels" referred to above is not exact and leads to confusion, since even in the usual condition it applies to neither the right and left common carotid arteries, nor the paired subclavian arteries, but to an innominate artery on the right side, and the left subclavian artery on the other. That the left common carotid artery usually arises immediately to the left of the base of the innominate is perhaps correct, although in by far the greater number of rabbits dissected by the writer the origin of this vessel is well up on the mesial side of the innominate. In cases where the left common carotid artery arises to the left of the innominate, there would be three vessels arising from the cephalic curve of the aorta and not two (a pair) as above described, a condition normally found in the human. With reference to the subclavian arteries, the statement as to their branches being subject to "considerable variation" is correct, but it seems important that the point should also be made, that great differences occur in these vessels on the right and left sides in the same animal.

Again, Parker and Haswell [2] describe correctly the relation of these vessels as they occur in the majority of cases, but the figure shown (p. 465) represents the condition in an abnormal individual, where the left common carotid artery originates as a branch from the arch of the aorta, and thus constitutes the third vessel from the arch, the innominate and the left subclavian being the other two. Since these discrepancies exist in the descriptions of the blood vessels of the region in the various texts, and in view of the variability of both the arteries given off by the arch of the aorta, and their subsequent subdivisions, especially those of the subclavian, it seems of sufficient interest to record their frequency and extent. Accordingly the following description is based upon the study of over one hundred specimens. Such records, of course, have no immediate practical value from the surgical or pathological sides, but from the educational considerations, especially from the standpoint of comparative anatomy, they are rather important. No doubt the variations which are described below are to be explained in part by the persistence of the fœtal conditions, or in some cases by abnormalities of the vessels themselves, or to the development of extrinsic parts in their immediate region. Many of the changes brought about probably are due to different modes of transformation of the primary vessels of the branchial arches, especially the fourth, since both the aorta and the pulmonary artery are derivatives of this arch. Again, it is well known that the heart itself originally develops high up in the neck region of mammals, and is gradually shifted downwards, so that this gradual shifting might account for some of the variations noted.

Of one hundred and six rabbits dissected,* nineteen individuals showed marked variations from the usual condition, either in the branches from the aorta, or in respect to the subclavian and its branches on either side. There were others (fifteen) which showed minor variations but which could easily be placed in some of those showing marked variations, so that their condition is represented, partly at least, in some one or in a composite of the subjoined figures.

In what may be termed the usual condition the aorta (Fig. 1,A)

* My thanks are here given to Mr. Ralph L. Parker, for collaboration in the dissections.

after giving off the coronary arteries close to its junction with the left ventricle passes cephalad a short distance and then describes a curve or a half circle and passes down the back, a little to the left of the ventral vertebræ. From the cephalic curve (arch) a comparatively large innominate or brachio-cephalic artery extends upward and a little to the right and soon bifurcates forming the left common carotid artery which passes immediately across the trachea to the left side of the neck, and a common trunk which gives rise to the right subclavian and the right common carotid arteries. A second branch from the curve of the aorta is the left subclavian artery which passes laterad and forward to branch in various ways. Usually on this side the superior intercostal (costo-cervical) (Fig. 1, I) is the first branch to be given off, and this passes caudo-mediad. Just distal and in close juncture with the superior intercostal artery is the internal mammary artery, while just opposite arises the vertebral artery. Distally the subclavian artery soon divides into the transverse scapular (T) and axillary (X) arteries. On the right side the superior intercostal and mammary arteries arise from a common trunk, as also do the vertebral and transverse scapular arteries just opposite them. The axillary artery passes to the region of the forearm. In some cases the superficial cervical artery branches from the subclavian, but usually it is a branch of the transverse artery of either side.

Variations of the subclavian artery of the left side. A number of interesting variations are noted in the order and sequential relationships of the various vessels arising from the left subclavian. Frequently the arteries originating from the subclavian artery are in close proximity to each other so that a veritable corona of the vessels is formed. In some cases as shown in figures 6 and 11 this takes place at quite a distance from the arch of the aorta, and can be called the long corona type, while in others typified in figures 9 and 10 and perhaps less conspicuously in figure 8, the corona formation is closely approximated to the aortic arch. Where the corona is formed, the usual order of the vessels may be described as normal, *i.e.,* beginning with the vertebral artery originating on the cephalo-mesal surface of the subclavian, the transverse scapular, axillary, mammary, and intercostal arteries followed in the cycle clockwise. In one specimen an interesting departure is noted, in that the intercostal artery (Fig. 6, I) takes its origin from the vertebral so that there is formed in this case a very short innominate with the vertebral artery. A number of cases are observed where the intercostal and mammary arteries formed a short innominate in common as is shown in figures 4 and 7. In one rabbit (Fig. 3, V) the vertebral artery of this side branches from the cephalic surface of the arch of the aorta at about its junction with the subclavian artery and in this case it is comparatively a much larger vessel than normal. In this specimen also the transverse scapular and mammary arteries have their origin some distance cephalad, and the interval between the intercostal and mammary arteries is very noticeable. In no case is there found an innominate formed by the left subclavian and the left common carotid arteries, which of course is the typical avian condition, and which has been described as occurring in most apes, and somewhat more rarely has been noted in the human. In three cases, however, varying in degrees, as shown in figures 6, 8 and 10, the left common carotid artery is a separate branch from the arch of the aorta, and in these the condition closely simulates the normal condition found in the human. In one instance the points of origin of the vertebral and the transverse scapular arteries are interchanged as shown in figure 2, and in another, figure 5, the vertebral artery arises from the latero-caudal surface of the subclavian in the same manner but distal to the intercostal and mammary cervical vertebræ. In the last specimen also a number of excessory blood vessels are noted, some of which parallel the mammary, others the intercostal arteries.

The subclavian artery of the right side. The blood vessels of this side which take their origin from the subclavian artery seem less variable in their relationships than those just described. There is the formation of what may be termed a corona in several instances, but this is with but one exception formed relatively close to the innominate, or to that portion close to the bifurcation of the innominate which forms the subclavian and right carotid arteries. Such a condition is typically shown in figure 5, where the vessels spread out in fan-shape formation about the subclavian. In one instance, the vertebral artery (Fig. 2, V) originates well cephalad and on the lateral surface of the right common carotid artery, so that its displacement from its usual position is rather striking. As regards the interrelation of the intercostal and internal mammary arteries all sorts of gradations of intervals exist from the formation of a conspicuous elongated innominate as is indicated in figure 3, or a much reduced innominate as shown in figure 11, to the more or less widely separated intervals as represented in figures 8 and 9. The intercostal artery in the last case is really a branch of the innominate, and has no connection with the subclavian. Usually the superficial cervical artery of this side as in the normal condition is a branch of the transverse scapular artery, but in two cases is was greatly displaced; one originating from the subclavian (Fig. 3), and another curiously entering the common junction of the intercostal-mammary vessels as shown in figure 10. In one case the transverse scapular artery originates as a branch of the vertebral well cephalad of the latter's junction with the subclavian, as in figure 8, although in two other specimens this condition is barely suggested in the close proximity of the origins of the two vessels, as in figure 9.

The manner of branching of the two carotid arteries from the innominate is of interest although not more variable than might be expected. In the majority of specimens showing differences in other respects the two carotid arteries branch well up on the innominate. In several cases the point of origin of the left common carotid artery is close to the curve of the aorta and in three cases (Figs. 6, 8 and 10) the junction is really on the arch, thus giving rise to an additional vessel in these cases as indicated above, which simulates very closely that found normally in the human. Three individuals (Figs. 7, 9 and 10) show the formation of a thyreoid ima so-called, a small vessel arising on the innominate between the right and left common carotid arteries, which passes forward to the thyreoid gland and gives off small vessels to the neck muscles of the region and to the trachea. . Its point of origin varies somewhat in the three animals but morphologically it bears the same position as has been described for a similar vessel in the human (McMurrich,[3] p. 511), that is, it passes forward from the innominate between the common carotid arteries of either side. It should be said, however, that since the common carotids of either side in man differ slightly in their points of origin from those in the rabbit, the formation of this vessel in the rabbit does not contribute to the formation of a fourth vessel arising from the arch of the aorta, as is the case in man, but does form a fourth vessel from the innominate. In a single case, as shown in figure 11, the arch of the aorta gives rise to but one vessel, an innominate, which passes cephalad for some distance before it breaks to form, first, the left subclavian, and a little farther forward the left common carotid artery, and the brachio-cephalic artery. This peculiar variation is interesting since it closely simulates the normal condition found in the horse. It may be explained by the fusion of the two aortic stems and the shortening of the fourth arch so that the left subclavian artery joins with the common stem during the transformation of the primary vessels. In one instance the left vertebral (Fig. 3, V) takes its origin well down on the left subclavian vessel so that it is almost in a position to be considered a separate branch from the arch of the aorta and could be interpreted as an additional vessel from the latter as has been recorded as a variation in the human (McMurrich, p. 511). It is easy to see how a slight displacement caudad of the left common carotid artery in this case would produce four distinct vessels originating from the arch of the aorta instead of the usual two.

SUMMARY

Although the usual number of blood vessels arising from the arch of the aorta in the rabbit is two — a so-called innominate or brachio-cephalic artery and a left subclavian artery — the variations from this condition herein described indicate the possibility of a considerable departure. In one individual (Fig. 11) a single vessel leaves the aortic arch and after passing a short distance forward subdivides successively to form the left subclavian, the left common carotid and the right subclavian arteries.

In a number of cases as shown in figures 6, 8 and 10 three vessels have their origin on the arch and in these the order is the brachio-cephalic, the left common carotid and the left subclavian arteries. In one individual (Fig. 3) the left vertebral replaces the left common carotid artery in the series, the carotid in this case having its origin on the innominate as normally. This case suggests the possibility of four vessels forming the series.

Conspicuous differences in the order and sequence of the vessels from the subclavian arteries of the two sides are noted. On the left side the vessels in a number of cases show a tendency to group themselves either proximally or distally in the form of a sort of corona as indicated in figures 6, 9 and 10. The formation of various innominate stalks common to certain arteries are found in some cases, while in others the intervals between certain arteries are rather noticeable. Less marked variations are noted in the vessels of the right side. The vertebral artery in one instance (Fig. 2) is displaced from its usual place to the lateral side of the right common carotid artery. The transverse scapular

artery in two cases is a branch of the vertebral, while the superficial cervical which is normally a branch of the transverse scapular, in one case (Fig. 10) leaves the subclavian as a common stalk with the intercostal and mammary arteries.

In three cases a small so-called thyreoid ima is present and in these this passes forward from its origin between the two common carotids, thus having the same morphological position in the rabbits as a similarly described vessel occupies in the human.

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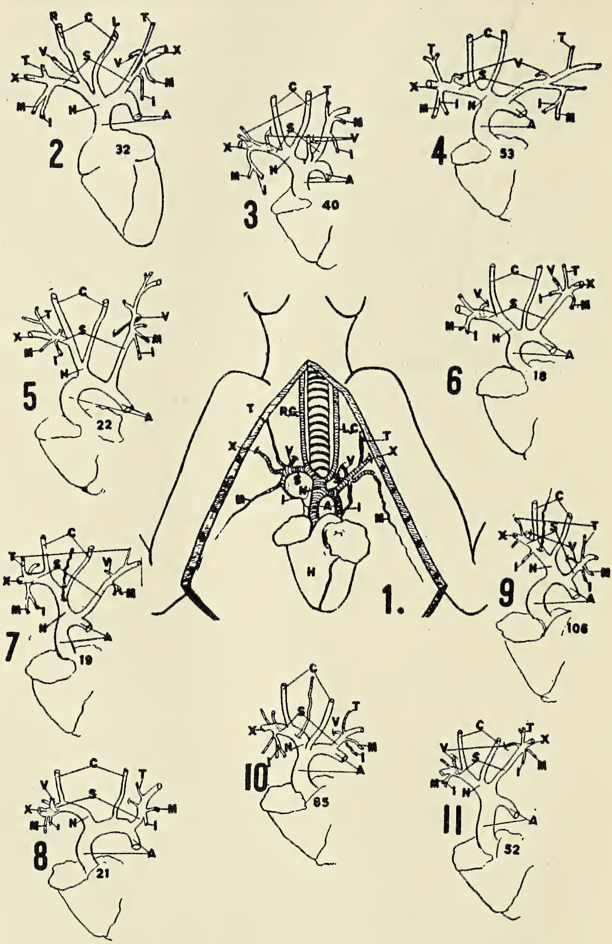
DEPARTMENT OF ZOOLOGY AND ENTOMOLOGY,
IOWA STATE COLLEGE.



EXPLANATION OF PLATE VIII

ABBREVIATIONS

A., Aorta, with its ascending transverse arch and descending (dorsal) portions.
C., common carotid arteries, (R) right and (L) left.
i., superior intercostal artery.
H., heart.
N., innominate artery.
M., internal mammary artery.
S., subclavian artery, right and left.
T., transverse scapular artery, including the superficial cervical artery.
V., vertebral artery, right and left.
X., axillary artery, right and left.

1. Diagrammatic ventral view of the arteries of the thoracic regions of the rabbit, showing the various branches as they occur in the majority of specimens. The innominate (brachio-cephalic) (N) and the left subclavian (S) are the two usual branches of the arch of the aorta. The left subclavian gives origin to a number of arteries as here shown, while the innominate bifurcates to form the two common carotids and the right subclavian arteries.
2. Schematic ventral view of the arteries of rabbit 32 which conspicuously indicates the vertebral artery of the right side as a branch of the right carotid artery. Notice on the left side the transverse scapular and the vertebral arteries are morphologically interposed and the intercostal and mammary arteries are separated by quite an interval. The left common carotid is well down at the base of the innominate almost constituting a separate branch of the arch of the aorta.
3. Ventral view of the arteries in rabbit 40. The vertebral artery of the left side is here formed close to the junction of the subclavian with the aortic arch, and thus forms what may be considered a third branch of the arch. The intercostal and mammary arteries of the left side are separated by a wide interval.
4. Rabbit 53 shows the formation of common stalks (innominates) for the intercostal and mammary arteries of both sides as well as the transverse and superficial cervical of the right. The brachiocephalic gives rise immediately to the left common carotid.
5. The arteries of rabbit 22 show differences in branches of the right and left subclavian vessels especially. The intercostal and mammary arteries originate separately on the right, the vertebral on the left is well cephalad of the other vessels, and makes a bend caudomesad as here shown. Accessory vessels are found on the left side also.
6. In rabbit 28 the formation of what may be termed a long corona of the left subclavian with a migration of the intercostal from the lateral surface of the subclavian to form a common stalk with the vertebral artery. The left common carotid artery is here a branch of the aortic arch so that three distinct branches are formed. The innominate is conspicuously long.
7. Specimen 19 shows among other variations the formation of the thyreoid ima, a small vessel originating on the innominate just caudad to the point of origin of the left common carotid artery and passing forward to the thyreoid gland of the neck.
8. Rabbit 21 shows interesting relationships of the innominate, left common carotid and left subclavian arteries, and shows the comparatively immediate subdivisions of the subclavian of either side. Such a condition may be designated as the short corona type.
9. Specimen 106 shows the so-called thyreoid ima and other minor variations especially in the interval between the intercostal and mammary arteries of the right side, and the formation of the short corona type of the left subclavian artery.

10. In rabbit 85 beside the thyreoid ima being present, the left subclavian takes its origin on the arch, and the superficial cervical of the right side passes out from the common stalk of the intercosto-mammary artery. The subclavian of the left side forms a short corona.
11. In rabbit 52 the innominate (brachio-cephalic) artery is the only vessel originating on the arch of the aorta, and subsequently subdivides as shown giving rise to a long corona typed left subclavian, left and right carotid arteries, and right subclavian artery. This condition thus typifies that found normally in the horse.

THE RELATIVE POSITION OF THE MAXIMA CONTRACTIONS OF THE AMPHIBIAN MUSCLE WHEN SUBJECTED TO VARIOUS RANGES IN TEMPERATURE

RALPH. L. PARKER

In the regular laboratory work in muscle-nerve physiology, it was noted that records obtained by subjecting frog muscles to various ranges of temperature did not exactly agree as to positions of maxima contractions with statements found in the texts, especially that of Howell.[1] At the suggestion of Dr. F. M. Baldwin a fairly large series of experiments has been carried out to determine the relative positions of maxima contractions of the gastrocnemius muscle of the frog under varying temperature conditions, and to compare the results thus obtained with those of other investigators. Two of the muscles died from being subjected to low temperatures so there were only twenty complete records. Many investigators have worked with this particular muscle and observed the effect of heat in other ways; duration of contraction at different ranges of temperature [1], [16]; the cause of heat rigor;[3] periods of irritability;[5] fatal maximum temperature at which a frog or exsected muscle will survive [6], [8], [10]. Howell, however, is the only one so far as I can find in the literature to make any statement concerning the position of the maxima contractions.

Fall or winter frogs of the species *Rana pipiens* were used and were obtained from a supply house in Chicago. Apparatus used was a muscle-lever, muscle-warmer with thermometer, bunsen burner, container for water bath, induction coil and key, and a rotary kymograph. All except the water container were of the Harvard type of instruments. The water container was of convenient size and made of galvanized iron. The exsected muscles were suspended within the muscle-warmer by means of a short wire terminating in hooks at each end. The opposite end from the muscle was attached to a wire hook on the short arm of the muscle-lever. The thermometer was placed in the muscle-warmer next to the muscle. The muscle-warmer was immersed in the solution within the container and then heated or cooled as was desired. A single stimulus was used of sub-maximal strength.

When the desired temperature was registered a stimulus was given, the record for that temperature labeled, and the drum turned a short space for the next stimulation.

A range of temperature from +10°C. down through 0°C. to —7°C. and then up through 0°C. to rigor caloris was used. It was found, however, that in order to reach the turning point below 0°C. it was necessary to change the temperature rapidly to prevent the muscle from being killed or to produce a period of no irritability. A cooling mixture of ice and salt was used as the means to produce the desired temperatures below 0°C. and when the turning point had been reached a bunsen burner was applied to increase the temperature. Records were taken at intervals of five degrees during the descent to 0°C.; below 0°C. they were obtained at each degree and on recovery the interval was usually taken each two degrees until rigor caloris was reached when the muscle became non-irritable.

There were no two muscles that responded alike throughout as would be expected but some were more or less similar or at certain points paralleled one another closely. As a whole the records of the muscles fell into one of the two classes; they showed either two maxima or three maxima points. For convenience the range of temperature was arbitrarily divided into four periods. The first period covered from +10°C. to —7°C.; the second one extended from —7°C. to +20°C.; the third period ranged from 22°C. to 42°C. and finally the rigor period from 44°C. to 50°C., where the majority of muscles went into rigor caloris, with complete loss of irritability.* The first maxima were found to fall into the first period, in the second came the second maxima, the third maxima appeared in the third period and the maxima of heat rigor in the fourth period. When only two maxima occurred they appeared in the first and third periods with the usual heat rigor maximum.

In the three-maxima class, when different individual records were studied, there seems to be two different points for the second maxima, one in the range from —5°C. to —2°C. and the other falling somewhere between +8°C. and +16°C. This might be accounted for in the latter case in some measure by exposure to the cold, since this might render the muscle non-irritable and a lag in response on recovery might result.

The first maxima of this group appeared between 10°C. and

* In the following discussion the rigor maximum was not included as a maximum, for other influences enter in and thus it would not compare favorably with those which were stimulated by electricity. Rigor caloris is discussed in a later paragraph.

—3°C. and the third between 34°C. and 42°C. The two-maxima class produced the first maxima between 10°C. and —3°C. and the second, after going through the second period in a rather symmetrical curve, appears in the third period from 36°C. to 42°C. The range of minimum temperature with the three-maxima was —6°C. to —2°C. for the first one, 12°C. to 30°C. for the second and 40°C. to 48°C. for the third. With the two-maxima records the first minimum was from —5°C. to +14°C. and the second 42°C. to 46°C. (Table I).

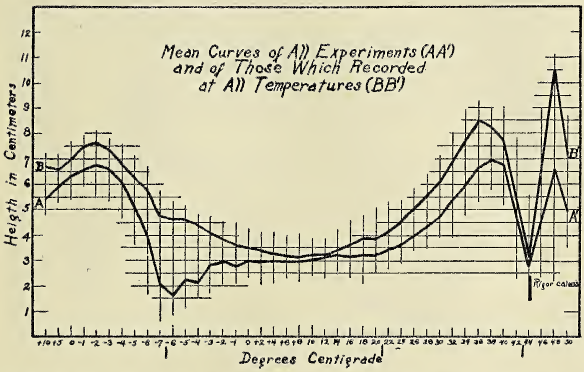


Fig. 53. Mean Curves of All Experiments and of Those Which Recorded at All Temperatures.
A-A′ represents a mean curve of all muscle records and each temperature is plotted.
B-B′ represents a mean curve of all muscle records which recorded at all ranges of temperature and each temperature is plotted.

To obtain a better conception of how the results of the twenty experiments compared, several curves were made and are subjoined below; one of all the records when averaged, (Fig. 53, A-A′); one showing the average of those recorded at all ranges of temperatures (seven) (Fig. 53, B-B′); average of all three-maxima contractions (Fig. 54, 11-11); average of all two-maxima contractions (Fig. 54, 9-9); a typical three-maxima curve (Fig. 55, 10-10); and a typical two-maxima curve (Fig. 55, 22-22). It will be seen from the curve of all the records from the muscles (A-A′) that three maxima appear, the first one at —2°C., the second at —2°C. and the third at 38°C. Rigor caloris began at 44°C. The curve of those registering at all temperatures (seven in number) is of the two-maxima type, the first at —2°C., the second at 36°C. Rigor caloris began at

44°C. (Fig. 53, A-A′ and B-B′). Those individuals which had three definite maxima were averaged, and numbered eleven (Fig. 54, 11-11). The first maximum was at —1°C., the second at —3°C. and the third at 36°C. Rigor caloris began at 42°C. Nine, the remainder of the twenty experiments, fell into the two-maxima class (Fig. 54, 9-9). The first maximum appeared at —2°C. and the other at 36°C. Rigor caloris began at 44°C. A typical two-maxima curve (22-22) and a typical three-maxima (10-10) curve are shown in Fig. 55. Here, as in the former,

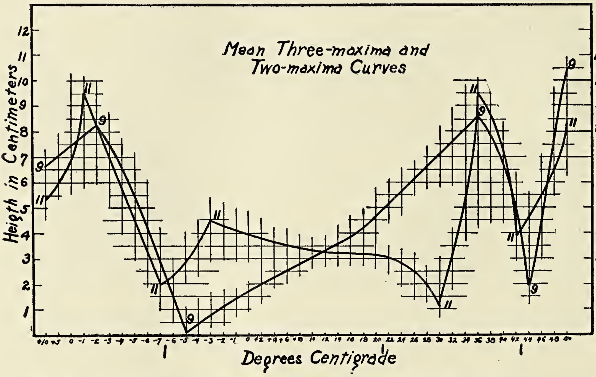


Fig. 54. Combined Mean Three-maxima and Two-maxima Curves.
11-11 represents a mean three-maxima curve which was plotted from the mean maxima and minima of the eleven which fell in this class.
9-9 represents a mean two-maxima curve which was plotted from the mean maxima and minima of the nine which fell in this class.

the first maximum appeared at —2°C. and the other at 38°C., while in the latter the first maximum is at —3°C., the second at —3°C. and the third at 40°C. Rigor caloris for (22-22) began at 41°C. and for (10-10) at 43°C.

The range of the first maxima for all curves was from —1° to —3°C. and fell in the first period. For the second maxima of all curves —3° to —2°C. was the limit and fell in the second period. The third maxima came from 36° to 40°C. and fell in the third period. Rigor caloris began from 41° to 44°C. and its maxima was from 48° to 50°C.

Rigor caloris maximum generally proximated the greatest maxima but when all were averaged it was slightly less than the greatest maximum. The greatest maximum measured 6.9 centimeters and that of rigor 6.6. In the individual cases, out of the

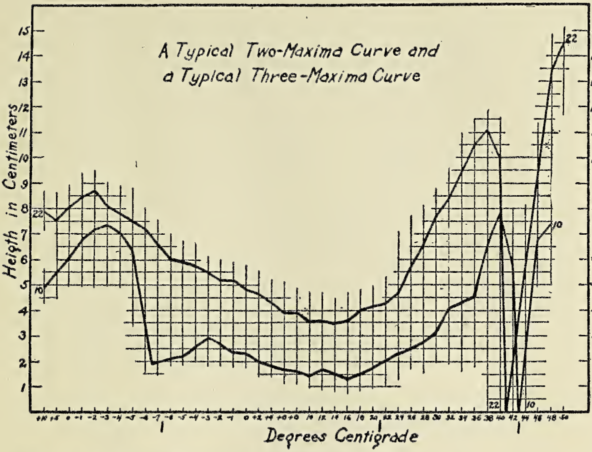


Fig. 55. A Typical Two-maxima and Three-maxima Curve.
10-10 illustrates a typical three-maxima curve which was plotted at every temperature. The numbers (10-10) denote the number of the experiment.
22-22 represents a typical two-maxima curve and each temperature is plotted. The numbers (22-22) as before denote the number of the experiment.

twenty there were twelve greater than the greatest maximum and eight less than it. For seven (B-B′) which recorded at all temperatures it was 2.0 centimeters greater than the greatest maximum. As in the case of the conglomerate average (A-A′), rigor of the three-maxima curve was less than the greatest maximum. The two-maxima rigor maximum was greater as was that of B-B′ and was 1.9 centimeters greater. It is, of course, rather difficult to evaluate results in terms of height of tracing, but comparative figures may have some value.

The only one to give any information on the subject is Howell [1] and he does not state where the information may be found or how it was obtained. I presume his statement of the position of the maxima applies to a series of experiments on individuals and is interpreted accordingly and is not based upon combined averages. Below is shown a table of results by several observers.

Table II shows the results when taken from all the curves as shown in figures 53, 54 and 55.

SUMMARY

When exsected gastrocnemius muscle of the frog is subjected to a relatively low temperature (—7°C.) two and three maxima

TABLE I. TEMPERATURES OF MAXIMA AND MINIMA CONTRACTIONS

		First Period		Second Period		Third Period		Fourth Period	
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Three-maxima	Parker	+ 10° to — 3°C.	—6° to — 2°C.	— 5° to — 2°C. + 8° to + 16°C.	12° to 30°C.	34° to 42°C.	40° to 48°C.	46° to 50°C.	
Two-maxima	Howell			5° to 9°C.	15° to 18°C.	26° to 30°C.	36° to 40°C.		
	Parker	10° to — 3°C.			— 5° to 14°C.	36° to 42°C.	42° to 46°C.	46° to 50°C.	
Other Observations	Marey					30° to 35°C.			
	Edwards					32.75° to 39.25°C.			
	Vincent and Lewis					38° to 40°C.			
	Carvallo and Weiss				25° to 30°C.	37° to 38°C.			

TABLE II. TEMPERATURES OF MAXIMA AND MINIMA CONTRACTIONS OF ALL CURVES.

Period	1st Max.	1st Min.	2nd Max.	2nd Min.	3rd Max.	3rd Min.	4th Max.	4th Min.
First	−1° to −3°C.	−6½°						
Second		to −5°C.	−2° to −3°C.	+6°				
Third				to 30°C.	36° to 40°C.	41°		
Fourth						to 44°C.	48° to 50°C.	

appear. But on the other hand when the muscle was not subjected to such low temperatures (—4°C. to —5°C.) in the first period and then was non-irritable for several changes in the range of temperature (about five) a third maximum appeared between the first and last.

The relative positions of the maxima contractions as I have found them in twenty experiments are as follows: The first maxima falls in the first period between —1° and —3°C.; the second maxima falls between —2° and —3°C. of the second period; the third maxima falls between 36° and 40°C. of the third period; while that of rigor caloris is usually between 48° and 50°C. of the fourth period.

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Department of Zoology,
Iowa State College.

EXPLANATION OF FIGURES

Short line between —7° and —6° is the limit of the first period, 20° and 22° is the limit of the second and 42° and 44° is the limit of the third period.

The ordinates represent the height of the tracing of the muscle lever in centimeters. The abscissa denote degrees of temperature Centigrade.

SOME IOWA RECORDS OF LEPIDOPTERA

A. W. LINDSEY

My first contribution to the study of the Lepidoptera of Iowa appeared in the Proceedings of the Academy for 1914 in the form of a list of butterflies, exclusive of skippers, taken in Woodbury county (Proc. Ia. Acad. Sci. xxi, 1914, 341-346). Later I was able to complete the identification of the skippers in my possession and to examine a number of collections in various parts of the state, thus increasing my list to such an extent that in 1917 I published a second list, embracing the entire state and including all of the Diurnals (Ent. News xxviii, 1917, 347-353). While the latter was in the hands of the printer during the summer of 1917 a number of additional records were made at Sioux City, and these, together with a few corrections, are mentioned below. It seems unnecessary to repeat the records already published.

With the exception of a few notes in "Lepidoptera" in 1918 I have not yet published any records of the moths taken in Iowa, though during my last few years of residence in the state I made the most of every opportunity to add to these and listed in manuscript several hundred species. Since taking up my residence in Decatur I have found it expedient to give up my private collection, but before doing so I am preparing this list, which shall include, with the exception of the more common species and a few others, only records of specimens now in my possession. All specimens which are rare or otherwise of interest are to be placed in the Barnes collection. The nomenclature and arrangement follows Barnes and McDunnough's "Check List" with a few changes made necessary by later studies.

PAPILIONOIDEA

Nymphalidae

NYMPHALINAE

Argynnis aphrodite Fab. One specimen at Sioux City, June 21, 1917.

Phyciodes tharos form vern. *marcia* Edw. The specimens recorded in my first list as *camillus* belong here.

Libytheidae

Libythea bachmani Kirt. Specimens formerly recorded as *carinenta* belong here. *Carinenta* is not known to occur north of Texas.

Riodinidae

Calephelis borealis G. & R. There is a specimen labelled Fairfax, Ia., in the collection at Ames.

Lycaenidae

THECLINAE

Strymon acadica Edw. Taken at Sioux City in 1917.

CHRYSOPHANINAE

Heodes dione Scud. Locally common at Iowa City.

Heodes helloides Bdv. I have taken this at Okoboji, Ames and Iowa City.

LYCAENINAE

Hemiargus isola Reak. Occurs as far east at Iowa City.

Plebeius melissa Edw. Taken at Sioux City in 1917.

HESPERIOIDEA

Hesperiidae

HESPERIINAE

Thanaos brizo Bdv. & Lec. Mid River and Homestead, May.

PAMPHILINAE

Oarisma poweshiek Parker. Sioux City, 1917.

Pamphila sassacus race *dacotae* Skin. A single female taken in 1909 at Sioux City proved a puzzle for years, but it has at last been identified by comparison with a paratype female in the Barnes collection.

Euphyes bimacula G. & R. One female was taken in 1917 at Sioux City.

SPHINGOIDEA

Sphingidae

Protoparce sexta Joh. Distribution general. Common.

Protoparce quinquemaculatus Haw. Common throughout the state.

Ceratomia amyntor Hbn. Sioux City.

Ceratomia undulosa Wlk. Sioux City and Iowa City.

Sphinx chersis Hbn. Sioux City, Macedonia.

Smerinthus jamaicensis Dru. Sioux City, Iowa City.

Paonias excaecatus A. & S. Throughout the state.

Paonias myops A. & S. Iowa City.

Cressonia juglandis A. & S. Sioux City, Macedonia.

Pachysphinx modesta Harr. Throughout the state.

Hemaris thysbe Fab. Sioux City. One specimen.

Hemaris diffinis Bdv. Sioux City and Dickinson county.

Hemaris diffinis f. aest. *axillaris* G. & R. Sioux City.

Pholus satellitia form *pandorus* Hbn. All parts of the state.

Pholus achemon Dru. Sutherland.

Ampeloeca myron Cram. Sioux City and Iowa City.

Sphecodina abbotti Swains. Iowa City, Macedonia.

Deidamia inscriptum Harr. I have seen three specimens of this interesting little sphinx in Professor Wickham's collection, all taken at Iowa City.

Amphion nessus Cram. Sioux City, Iowa City.

Xylophanes tersa Linn. Decorah (A. F. Porter) Muscatine.

Celerio gallii Rott. Decorah (A. F. Porter).

Celerio lineata Fab. Common everywhere.

SATURNIOIDEA

Saturniidae

Samia cecropia Linn. Common everywhere. This species feeds on a great many different trees, and I have counted as many as fifty cocoons on a single Box Elder.

Callosamia promethea Dru. Becoming rare in eastern Iowa, where it feeds on Wild Cherry.

Tropaea luna Linn. Fairly common throughout the state.

Telea polyphemus Cram. Also common everywhere.

Automeris io Fab. Found everywhere but not in large numbers. I have taken the larva on Bur Oak at Sioux City.

Ceratocampidae

Anisota rubicunda Fab. Ames, Iowa City.

Adelocephala bicolor Harr. Homestead.

Citheronia regalis Fab. Professor Wickham tells me that he has taken the larva of this species at Iowa City, and the record should be preserved.

Basilona imperialis Dru. I am indebted to Professor Wickham for records of the occurrence of this species at Iowa City.

BOMBYCOIDEA

Syntomidae

Scepsis fulvicollis Hbn. A common diurnal moth of the prairies.

Ctenucha venosa Wlk. Though this insect is much more common in Arizona and Central America, I have a single fresh specimen taken at Sioux City, July 21, 1915.

Arctiidae

NOLINAE

Roeselia minuscula Zell. Iowa City.

LITHOSIINAE

Clemensia albata Pack. Sioux City, August.

Hypoprepia miniata Kirby. Sioux City and Dickinson county.

Hypoprepia fucosa Hbn. Decorah (A. F. Porter), Muscatine (Hoopes collection).

ARCTIINAE

Ammalo tenera Hbn. Sioux City, May and June.

Ammalo inopinatus Hy. Edw. Sioux City, one specimen only.

Halisidota tesselaris A. & S. Throughout the state.

Eubaphe laeta Guer. Sioux City, July; Iowa City, June.

Eubaphe aurantiaca Hbn. Sioux City and Dickinson county.

Eubaphe immaculata Reak. Sioux City, July.

Eubaphe immaculata form *trimaculosa* Reak. Sioux City, July.

Phragmatobia fuliginosa race *franconica* Sloss. Sioux City, two specimens, April and July.

Diacrisia latipennis Stretch. Booneville, June (R. Whittle).

Diacrisia virginica Fab. One of our most common moths.

Isia isabella A. & S. Common everywhere.

Hyphantria cunea Dru. Throughout the state.

Estigmene acraea Dru. With the last. Common.

Estigmene congrua Wlk. Sioux City, May, June. Specimens of this were formerly identified as *M. vestalis amelaina* Dyar.

Ecpantheria deflorata Fab. Iowa City. Prof. B. Shimek once brought me a larva of this species taken on *Liparis liliifolia.*

Apantesis intermedia Stretch. Sioux City, late August.

Apantesis rectilinea French. Sioux City, one specimen, August 26.

Apantesis michabo Grote. Sioux City. Early September.

Apantesis arge Dru. Sioux City, Apr., July, August.

Apantesis virguncula Kirby. Sioux City, June 20, one specimen.

Apantesis vittata Wlk. Iowa City, August.

Apantesis vittata race *phalerata* Harris. Sioux City and Iowa City, May and August.

Euchaetias egle Dru. Sioux City.

Euchaetias oregonensis Stretch. Sioux City and Iowa City. Bred from *Asclepias* sp.

Utetheisa bella Linn. Iowa City, Ames, Sioux City.

Utetheisa ornatrix Linn. Lake Okoboji, July, 1916, L. L. Buchanan.

Haploa colona form *reversa* Stretch. Sioux City, June.

Haploa lecontei Bdv. Sioux City, June.

Haploa lecontei form *militaris* Harris. Sioux City, June, July. Very common in the woods.

Haploa lecontei form *vestalis* Pack. Sioux City, June, July. Less common than the preceding form.

Agaristidae

Alypia octomaculata Fab. Sioux City, June. The larva is fairly common at times on Woodbine, but I have never taken many adults.

Noctuidae

AGROTINAE

Heliothis paradoxa Grote. Professor Wickham has one male of this unmistakable species, taken at Iowa City, August 4, 1898.

Heliothis phloxiphaga G. & R. Sioux City, August 26, 1917, one male. A western species.

Heliothis obsoleta Fab. Common everywhere.

Dasypoudaea lucens ab. *luxuriosa* Grt. Sioux City, July, 1917, two specimens.

Lygranthoecia brevis Grt. Dickinson county, August; Sioux City, September. Two specimens only.

Lygranthoecia rufimedia Grt. A good series of this species was collected from the flowers of *Lactuca* sp. at Sioux City in June, 1917.

Lygranthoecia marginata Haw. Sioux City and Ames.

Lygranthoecia imperspicua Stkr. Two only, Ames, August 3 and 14, 1918, at light.

Schinia hulstia Tepp. Ames, August, 1918, one only.

Schinia chrysella Grt. Ames, Iowa City, August.

Schinia trifascia Hbn. Sioux City, August 26, September 2, 1917, two only.

Schinia oleagina Morr. Sioux City, August, September. Two specimens.

Schinia gracilenia Hbn. Sioux City, Ames, August, September.

Schinia tertia Grt. Iowa City, Ames, August, September. Fairly common.

Schinia lynx Gn. Iowa City (Wickham). In coll. Barnes from "Iowa."

Schinia gloriosa Stkr. I took a single perfect specimen of this beautiful species at Ames, August 23, 1918, at light. There is but one other in coll. Barnes, from Texas.

Euxoa niveilinea race *rabiata* Sm. Sioux City, September 7, 1915, two males.

Euxoa detersa race *personata* Morr. Iowa City, September.

Euxoa velleripennis Grote. Sioux City, September.

Euxoa messoria Harris. Sioux City, Iowa City; August, September.

Euxoa tessellata Harris. Sioux City, June, July.

Chorizagrotis auxilaris Grt. Sioux City, May and June, common.

Chorizagrotis auxilaris form *introferens* Grt. Sioux City, June.

Chorizagrotis agrestis Grt. Sioux City, May, June.

Chorizagrotis inconcinna Harv. One specimen from Sioux City, June 22, appears to be referrable to this species.

Chorizagrotis albicosta Sm. Sioux City, August 10, 1917, one specimen.

Feltia gladiaria Morr. Iowa City, September.

Feltia venerabilis Wlk. One specimen without a definite locality.

Feltia venerabilis race *arida* Ckll. Sioux City, September; Iowa City, September and October.

Feltia ducens Wlk. (*subgothica* Auct.) Sioux City, Iowa City; August, September.

Feltia subgothica Haw. Sioux City, August.

Agrotis badinodis Grt. Mid River, September 23, 1917, one specimen.

Agrotis ypsilon Rott. Sioux City, Iowa City; September.

Agrotis c-nigrum Linn. Sioux City, May, June and September; Iowa City, May, June, August, October.

Agrotis bicarnea Gn. Sioux City, Iowa City, August.

Agrotis baja Fab. Dickinson county, August, R. Whittle.

Agrotis unicolor Harris. Dickinson county, August 11, 1915, one female.

Lycophotia margaritosa Haw. Sioux City, July, September; Iowa City, August, November.

Lycophotia margaritosa form *saucia* Hbn. With the species.

Lycophotia scandens Riley. I have not seen Iowa specimens of this, but it is in coll. Barnes from Missouri, South Dakota, Illinois and Minnesota.

Ufeus satyricus Grt. Sioux City, one female, without date.

HADENINAE

Scotogramma trifolii Rott. Sioux City, late April and from July 13 to September 7; Iowa City, September. Probably our most common species of *Hadeninae.*

Polia distincta Hbn. Sioux City, April 22 to May 21, 1916.

Polia meditata Grt. Dickinson county, Sioux City, Iowa City; August, September.

Polia subjuncta G. & R. Sioux City, Iowa City, Ames; July, August.

Polia adjuncta Bdv. Sioux City, August; Iowa City, May.

Polia lilacina form *illabefacta* Morr. Sioux City, Iowa City; August.

Polia doira Stkr. Sioux City, two specimens, July 17 and 27.

Polia renigera Steph. Sioux City, Iowa City, Dickinson county; June to September.

Polia lorea Gn. Sioux City, June 16 to July 11.

Polia olivacea Morr. Sioux City, July 30, 1916, one male.

Chabuata signata Wlk. Dickinson county, Iowa City; August.

Chabuata notata Stkr. Dickinson county, August 27, 1915, one male; Sioux City, August 29, 1916, one female. *Syrissa* may later have to be separated from *notata,* in which case the first specimen will probably be referable to *syrissa.*

Eriopyga utahensis Smith. Sioux City, September 7, 1915, one male. This specimen is undoubtedly *utahensis;* I have carefully re-examined the genitalia and compared them with those of *incincta,* only to arrive again at this conclusion. A second specimen taken on the same date differs somewhat in habitus and may be *incincta,* but the abdomen is lacking so this cannot be proven.

Eriopyga oviduca Gn. Sioux City, one male, without date.

Eriopyga crenulata Butl. Iowa City, August.

Eriopyga intractata Morr. Homestead, May 19, 1917, three females.

Eriopyga vecors Gn. Iowa City, August.

Nephelodes emmedonia form *violans* Gn. Iowa City, September. Common on prairie flowers in the daytime.

Morrisonia evicta Grt. Iowa City, May 18, 1917, one male.

Orthosia garmani Grt. Iowa City, April, May.

Orthosia hibisci form norm. *insciens* Wlk. Iowa City, April.

Ceramica picta Harris. Des Moines, July, R. Whittle; Iowa City, April; Sioux City, August.

Cirphis pseudargyria form *callida* Grt. Iowa City, August.

Cirphis phragmatidicola Gn. Iowa City, August; Sioux City, September.

Cirphis unipuncta. Distribution general; May, June, August, September.

Neleucania albilinea Hbn. Iowa City, May, June, August; Sioux City, August.

CUCULLIINAE

Cucullia speyeri Lint. Sioux City, May.

Cucullia asteroides Gn. Iowa City, May; Sioux City, May, August.

Cucullia convexipennis G. & R. I have seen one specimen of this in Professor Wickham's collection.

Graptolitha bethunei G. & R. Iowa City, April, September.

Graptolitha antennata Wlk. Sioux City, April 2, 1916, one female.

Conistra sidus Gn. Iowa City, November. Sioux City.

Conistra morrisoni Grt. Mid River, October 11, 1917, one male.

Parastichtis bicolorago Gn. Iowa City, one specimen. The form *ferrugineoides* Gn. occurs from late September to early November at Sioux City and Iowa City, and fairly swarms at light during the warm evenings of October.

Parastichtis agressa Sm. Sioux City, September 3, 1917, one female.

Atethmia pampina Gn. Mid River, September 23, 1917, one female.

ACRONYCTINAE

Amphipyra pyramidoides Gn. Iowa City, Sioux City; August, September.

Amphipyra glabella Morr. Sioux City, August 19, 1917, one female.

Dipterygia scabriuscula Linn. Sioux City, June to August.

Septis lignicolora Gn. Sioux City, July; Iowa City, June.

Septis arctica Bdv. Dickinson county, July.

Trachea delicata Grt. Sioux City, Dickinson county, June and July.

Trachea miselioides Gn. Sioux City, August 17, 1918, one specimen.

Agroperina lutosa Andr. Sioux City, July 11, 1917, one female.

Agroperina helva Grt. Ames, August 15, 1918, two only.

Sidemia devastator Brace. A common species.

Phlogophora iris Gn. Dickinson county, July 25, 1917, one specimen, L. L. Buchanan.

Chytonix palliatricula form *iaspis* Gn. An "Iowa" specimen in coll. Barnes.

Leuconycta diphteroides Gn. Sioux City and Iowa City; July and August.

Leuconycta diphteroides form *obliterata* Grt. Iowa City, July.

Acronycta afflicta Grt. Iowa City, in coll. Wickham.

Acronycta retardata Wlk. Sioux City, August.

Acronycta caesarea Sm. Ames, August 12, 1918, one only.

Acronycta hamamelis Gn. Iowa City, May 9, 1917. The one specimen in my collection is rather puzzling, but seems to be this species.

Acronycta quadrata Grt. August 21, 1917, Sioux City, one female.

Acronycta lobeliae Gn. Dickinson county, August, 1916, one female, R. Whittle.

Acronycta radcliffei Harv. August 11, one male, Iowa City.

Acronycta morula Grt. Sioux City, June, August.

Acronycta interrupta Gn. Iowa City, Sioux City; May to September.

Acronycta lepusculina Gn. Iowa City, May; Sioux City, April, August.

Acronycta betulae Riley. Iowa City, May 26, 1917, one male, L. L. Buchanan.

Acronycta americana Harris. Iowa City, August; Sioux City, April, May, August.

Acronycta rubricoma Gn. Iowa City, June.

Acronycta lithospila Grt. Ames, August 5, 1918, one.

Acronycta oblinita A. & S. Sioux City, May and September; Iowa City, late April; Grinnell, June (W. W. Bennett).

Simyra henrici Grt. Iowa City, May 16, 1917, three specimens.

Hyppa xylinoides Gn. Sioux City, one male, without date.

Catabena lineolata Wlk. Sioux City, May 16 to August 28, Common.

Prodenia ornithogalli Gn. Sioux City, Iowa City; September.

Prodenia eudiopta Gn. Ames, August.

Laphygma frugiperda A. & S. Hamburg, reared by C. N. Ainslie.

Proxenus miranda Grt. Sioux City, May.

Galgula partita Gn. Sioux City, June; Iowa City, July; Dickinson county, August.

Galgula partita form *hepara* Gn. Sioux City, July.

Crambodes talidiformis Gn. Iowa City, June to August; Sioux City, May to August. Common.

Platysenta videns Gn. Sioux City, September 26, 1915, one.

Balsa malana Fitch. Sioux City, August; Iowa City, May.

Balsa labecula Grt. Sioux City, May 14 and June 29, 1916, two specimens.

Gortyna immanis Gn. Sioux City, September 6, 1917, one male.

Papaipema furcata Sm. Sioux City, August, September.

Papaipema arctivorens Hamps. Sioux City, August 11, 1917, one male.

Papaipema pterisii Bird. Ames, August, one.

Papaipema nebris Gn. Sioux City, Iowa City; September and October.

Papaipema nebris form *nitela* Gn. Sioux City, August 20, 1916, one female.

Ogdoconta cinereola Gn. Iowa City, June, July; Sioux City, May, July, August; Dickinson county, August.

Stibadium spumosum Grt. Iowa City, July; Sioux City, August, September.

Ipimorpha pleonectusa Grt. Sioux City, July.

Stiria rugifrons Grt. Ames, August 14, 1918, one.

Plagiomimicus pityochromus Grt. Sioux City, August 14, 1917, one.

Plagiomimicus expallidus Grt. Sioux City, August 4 to 15, common.

Archanara subflava Grt. Iowa City, July; Sioux City, July to September.

Euthisanotia grata Fab. Iowa City, late June; Sioux City, July 17 and 24, two specimens only.

Euthisanotia unio Hbn. Muscatine, one specimen in coll. Hoopes.

ERASTRIINAE

Chamyris cerintha Treitschke. Sioux City, June, July; Iowa City, May.

Lithacodia bellicula Hbn. Dickinson county, August.

Lithacodia carneola Gn. Sioux City, Iowa City; May to August.

Lithacodia apicosa Haw. Iowa City, May, July.

Lithacodia muscosula Gn. Sioux City, Iowa City; June to August.

Tarachidia tortricina Zell. Sioux City, September 4, 1917, two specimens. May be a form or race.

Tarachidia tortricina form *obsoleta* Grt. Sioux City, May 3, 1916, one.

Tarachidia erastrioides Gn. Sioux City, May, July to September.

Tarachidia candefacta Hbn. Sioux City, May, July; Dickinson county, August; Homestead, May.

Tarachidia binocula Grt. Sioux City, June 20, two specimens. These were incorrectly listed in the "Lepidopterist" as *virginialis* Grt.

SARROTHRIPINAE

Baileya ophthalmica Gn. Sioux City, April 2, 1910, one female; Iowa City, January 22, one female in coll. Wickham.

Baileya australis Grt. Sioux City, one specimen without date.

CATOCALINAE

Catocala innubens form *scintillans* G. & R. Iowa City, August 4, 1917, one male.

Catocala piatrix Grt. Iowa City, August, in coll. Wickham.

Catocala epione Dru. Iowa City, July.

Catocala habilis Grt. Nevada (Mrs. O. F. Hiser).

Catocala residua Grt. Iowa City, August, 1917 (L. L. Buchanan).

Catocala retecta Grt. Iowa City, August, in coll. Wickham.

Catocala palaeogama Gn. Clinton, a long series in coll. Barnes; Iowa City, July; Ames, July and August.

Catocala palaeogama form *annida* Fag. Iowa City, July, in coll. Wickham.

Catocala palaeogama form *phalanga* Grt. Iowa City, July 17, 1898.

Catocala insolabilis Gn. Iowa City, July 19, 1898, in coll. Wickham.

Catocala vidua A. & S. Dickinson county, September; Iowa City, October.

Catocala neogama A. & S. Sioux City, August.

Catocala neogama form *snoviana* Grt. Nevada, (Mrs. O. F. Hiser).

Catocala ilia Cram. Sioux City, July.

Catocala ilia form *uxor* Gn. Sioux City, July.

Catocala cerogama Gn. Sioux City, July 3, 1911, one female.

Catocala parta Gn. Sioux City, July and August; Iowa City, September.

Catocala luciana Hy. Edw. Sioux City, no date, one specimen.

Catocala luciana form *somnus* Dodge. Dickinson county, August 18, 1916, one male (R. Whittle).

Catocala meskei Grt. Sioux City, July to September; Moville, September.

Catocala cara Gn. Sioux City, no dates; Iowa City, September.

Catocala amatrix Hbn. Iowa City, September.

Catocala amatrix form *selecta* Wlk. Sioux City, August, September; Ames, August.

Catocala amatrix race *editha* Edw. Sioux City, one specimen, no date.

Catocala abbreviatella Grt. Sioux City, July.

Catocala whitneyi Dodge. Sioux City, Dickinson county, July, August.

Catocala coccinata Grt. Dickinson county, July (Arthur Abel), August (R. Whittle).

Catocala coccinata race *circe* Stkr. Nevada (Mrs. O. F. Hiser).

Catocala ultronia Hbn. Sioux City and Dickinson county, August; Nevada, July (Mrs. O. F. Hiser).

Catocala crataegi Saund. Iowa City, no date.

Catocala mira Grt. Sioux City, July.

Catocala grynea Cram. Nevada, July (Mrs. O. F. Hiser).

Catocala amica Hbn. Iowa City, common in July.

Catocala amica form *nerissa* Hy. Edw. Nevada, July (Mrs. O. F. Hiser).

Parallelia bistriaris Hbn. Sioux City, June.

Euclidia cuspidea Hbn. Sioux City, May; Homestead, common late in May.

Caenurgia erechtea Cram. Common throughout the state during all of the warm months.

Celiptera frustulum Gn. Iowa City, June 10, 1917, one only.

Argyrostrotis anilis Dru. Homestead, May 30, 1918, one specimen.

Zale lunata Dru. Sioux City and Dickinson county, July.

Zale galbanata Morr. Sioux City, Iowa City; April to August.

Zale lunifera Hbn. Sioux City, no dates.

PLUSIINAE

Autographa falcifera Kby. Sioux City, May; Iowa City, June.

Autographa falcifera form *simplex* Gn. Throughout the state, April to August.

Autographa brassicae Riley. The common "Cabbage Looper"; June, August.

Autographa precationis Gn. Distribution general, April, June, October.

Plusia aerea Hbn. Iowa City, in coll. Wickham.

EREBINAE

Raphia abrupta Grt. Sioux City, May 22, July 21, August 15; a small series. This was formerly incorrectly identified as *coloradensis*.

Raphia frater Grt. Iowa City, July.

Syneda howlandi Grt. Sioux City, May 9, 1910, one female at light. This specimen is badly rubbed, but it appears to belong here.

Phoberia atomaris Hbn. Sioux City, April, May.

Panopoda rufimargo form *rubricosta* Gn. Sioux City, one female, no date.

Strenoloma lunilinea Grt. Iowa City, August, 1917 (L. L. Buchanan).

Erebus odora Dickinson county, July (R. Whittle).

Thysania zenobia Cram. Iowa City, one specimen brought into the laboratory early in October.

Calpe canadensis Beth. Dickinson county, July 20, 1917, one female (Arthur Abel).

Scoliopteryx libatrix Linn. Throughout the state.

Plusiodonta compressipalpis Gn. Sioux City, Iowa City; July.

Alabama argillacea Iowa City, September.

HYPENINAE

Rivula propinqualis Gn. Dickinson county, August.

Phytometra rhodarialis race *coccinifascia* Grt. Sioux City, July 17. 1916, one specimen.

Oxycilla malaca Grt. Iowa City, June.

Phalaenostola larentioides Grt. Iowa City, July.

Spargaloma sexpunctata Grt. Iowa City, June 12, 1917, one.

Dyspyralis puncticosta Sm. Sioux City, July, August.

Metalestra quadrisignata Wlk. Sioux City, June 23, 1917, one.

Epizeuxis americalis Gn. Sioux City, Iowa City; July, September.

Epizeuxis aemula Hbn. Sioux City, July.

Epizeuxis lubricalis Geyer. Throughout the state, July and August.

Zanclognatha laevigata Grt. Sioux City, Iowa City; July.

Zanclognatha pedipilalis Gn. Sioux City, June, August.

Zanclognatha ochreipennis Grt. Sioux City, July.

Hormisa absorptalis Wlk. Sioux City, July 16, 1916, one female.

Philometra metonalis Wlk. Dickinson county, August; Iowa City, September.

Philometra eumelusalis Wlk. Sioux City, July.

Chytolita morbidalis Gn. Iowa City, June 12, 1917, one male, one female.

Renia salusalis Wlk. Iowa City, June.

Renia flavipunctalis Geyer. Throughout the state, July to September.

Bleptina caradrinalis Gn. Iowa City, June, July.

Phalaenophana pyramusalis Wlk. Iowa City, May and June; Sioux City, July and August; Dickinson county, August.

Palthis angulalis Hbn. Sioux City, June, July.

Bomolocha bijugalis Wlk. Iowa City, June, July; Sioux City, July, September.

Bomolocha palparia Wlk. Sioux City, June, August; Iowa City, July.

Bomolocha abalienalis Wlk. Sioux City, July, August.

Bomolocha deceptalis Wlk. Sioux City, June, July.

Bomolocha madefactalis Gn. Iowa City, July.

Bomolocha sordidula Grt. Sioux City, June.

Bomolocha toreuta Grt. Sioux City, August 29, 1916, one specimen.

Plathypena scabra Fab. Northwestern Iowa, August, September.

Hypena humuli Harris. Sioux City and Dickinson County.

Notodontidae

Ichthyura apicalis Wlk. Iowa City, June; Sioux City, August.

Ichthyura strigosa Grt. Iowa City, May 17, 1918, one male.

Ichthyura albosigma Fitch. Iowa City, August, in coll. Wickham.

Ichthyura albosigma race *specifica* Dyar. Sioux City, November 13, 1916, one male.

Datana ministra Wlk. Sioux City, Ames, July.

Datana perspicua G. & R. Sioux City, Iowa City, July.

Datana integerrima G. & R. Sioux City, August. I have seen large walnut trees almost completely defoliated by this species.

Datana contracta Wlk. Sioux City, Dickinson county, July.

Hyperaeschra stragula Grt. Sioux City, September 6, 1917, one female.

Hyperaeschra georgica H.-S. Sioux City, July 8, 1917, one.

Pheosia rimosa Pack. Sioux City, June; Ames.

Lophodonta angulosa A. & S. Ames, August 14, 1918, one.

Nadata gibbosa A. & S. Sioux City, May and July; Dickinson county July.

Nerice bidentata Wlk. Iowa City, May; Sioux City, August.

Heterocampa manteo Doub. Sioux City, July and August.

Heterocampa bilineata Pack. Ames, August 3, 1918, one female.

Misogada unicolor Pack. Ames, July 31, one.

Ianassa lignicolor Wlk. Ames, August.

Schizura ipomoeae Doub. Sioux City, August.

Schizura ipomoeae form *cinereofrons* Pack. Sioux City, June 24, 1917, one female.

Schizura unicornis A. & S. Sioux City, August 8, 1917.

Schizura apicalis G. & R. Sioux City, August, 1917.

Cerura cinerea Wlk. Iowa City, May; Sioux City, August.

Gluphisia septentrionalis Wlk. Sioux City, April, July, very common in August.

Thyatiridae

Pseudothyatira cymatophoroides Gn. Iowa City, July 27, 1898, in coll. Wickham.

Lymantriidae

Hemerocampa leucostigma A. & S. The common tussock moth. The larva, with its white tufted back, is a familiar sight, as also is the female cocoon with the frothlike egg mass, but the wingless female, and even the male, which appear in the northwestern part of the state in September, are less conspicuous.

Olene sp. I have three specimens of an *Olene* from Sioux City, but without some knowledge of the early stages they cannot be definitely identified.

Lasiocampidae

Tolype velleda Stoll. Dickinson county, September; Iowa City, September.

Malacosoma americana Fab. Sioux City, July 8, 1917, one male.

Heteropacha rileyana Harv. Iowa City, May; Ames, August.

Epicnaptera americana Harris. Sioux City, May 9, 1910, one male.

Drepanidae

Eudeilinia herminiata Gn. Sioux City, July; Iowa City, June.

Drepana arcuata Wlk. Iowa City, May 16, 1917, one, at light.

Geometridae

HEMITHEINAE

Nemoria mimosaria Gn. Iowa City, June 11, 1917, two.

Chlorochlamys chloroleucaria Gn. Sioux City, June; Iowa City and Dickinson county, August.

ACIDALIINAE

Euacidalia ossularia Hbn. Iowa City, June, July.

Xystrota hepaticaria Gn. Sioux City, May.

Acidalia enucleata Gn. Sioux City, July.

Acidalia enucleata form *relevata* Swett. Iowa City, June, July; Sioux City, July, September.

Acidalia enucleata form *adornata* Prout. Sioux City, September.

Ptychopoda demissaria Hbn. Sioux City, July 22, 1916, three specimens.

Ptychopoda inductata Gn. Iowa City, June; Sioux City, June to August; Dickinson county, August.

Haematopis grataria Fab. Common throughout the state; May to August.

Timandra amaturaria Wlk. Sioux City, July to September. Reared from *Convolvulus sepium.*

LARENTIINAE

Trichodesia albovittata Gn. Sioux City, June, August.

Heterophleps refusata Wlk. Sioux City, May; Iowa City, June.

Heterophleps triguttaria H.-S. Sioux City and Iowa City, June.

Dyspteris abortivaria H.-S. Sioux City, July 22, 1916, one specimen.

Rachela bruceata Hulst. Sioux City, October; Iowa City, November.

Lygris diversilineata Hbn. Iowa City, July; Sioux City, July to September; Dickinson county, July.

Dysstroma hersiliata Gn. Clinton, in coll. Barnes.

Xanthorhoe lacustrata Gn. Sioux City, May.

Orthonoma obstipata Fab. Sioux City, July; Iowa City, June, July, November.

Euphyia centrostrigaria Woll. Eastern Iowa, May, June; Sioux City, October; Dickinson county, August.

Euphyia multiferata Wlk. Iowa City, June 12, 1917, one.

Eulype hastata race *gothicata* Gn. Iowa City, June.

Venusia comptaria Wlk. Sioux City and Mid River, May.

Hydrelia albifera Wlk. Iowa City, June.

Eudule mendica Wlk. Iowa City, June; Dickinson county, July; Sioux City, July, August.

Eupithecia miserulata Grt. Iowa City, November; Sioux City, July.

GEOMETRINAE

Fernaldella fimetaria G. & R. Sioux City, June 22 and July 22, 1917, two specimens. Mrs. O. F. Hiser tells me that she has taken this species at Nevada also.

Bapta vestaliata Gn. Iowa City, June; Sioux City, June, July.

Bapta glomeraria Grt. Iowa City, Mid River; May.

Melilla xanthometata Wlk. Iowa City, May to July.

Physostegania pustularia Gn. Sioux City, June to August; Dickinson county, August.

Cabera quadrifasciaria Pack. Sioux City, June and July. In coll. Barnes from Clinton.

Cabera variolaria Gn. Dickinson county, August, one male.

Philobia aemulataria Wlk. Iowa City, June to August; Sioux City, May to August.

Macaria punctolineata Pack. Iowa City, August.

Macaria denticulata Grt. Dickinson county, August.

Phasiane sublacteolata Hulst. Sioux City, August 17, 1918, one male.

Phasiane mellistrigata Grt. Plymouth county, July 28, 1912, one. Iowa City, May 17, 1917, one (L. L. Buchanan).

Phasiane meadiaria Pack. Iowa City, May 19, 1917, one (L.L. Buchanan). This specimen was formerly identified as *snoviata,* but on more careful consideration it seems not to belong to that species.

Phasiane infimata Gn. Sioux City, Iowa City; July to September.

Phasiane eremiata Gn. Iowa City, May, June.

Phasiane maculifascia Hulst. Sioux City, May, July, August; Dickinson county, August.

Encomista dislocaria Pack. Sioux City, May 8, 1910, one.

Itame sulphurea Pack. Sioux City, July; Dickinson county, August.

Itame evagaria Hulst. Sioux City, June.

Itame subcessaria Wlk. Sioux City, July.

Itame exauspicata Wlk. Iowa City, June, July.

Itame pustularia Hbn. Iowa City, May to July.

Itame virginalis Hulst. Sioux City, August 1, 1916, one.

Catopyrrha coloraria Hbn. Sioux City, June.

Paraphia subatomaria Wood. Sioux City, May to August.

Lytrosis unitaria H.-S. Sioux City, July 7, 1917, one male.

Cleora pampinaria Gn. Sioux City, May, June, August.

Melanolophia signataria Wlk. Homestead, Iowa City, May.

Ectropis crepuscularia Schiff. Sioux City, April, July; Mid River, May; Iowa City, August.

Amphidasis cognataria Gn. Iowa City, August; Sioux City, May, July, August.

Phigalia titea Cram. Sioux City, Iowa City; April.

Palaeacrita vernata Peck. Sioux City, Iowa City; April.

Ellopia endropiaria G. & R. Homestead, June 14, 1918, one male.

Ellopia turbataria B. & McD. Iowa City, September.

Campaea perlata Gn. Iowa City, June.

Eugonobapta nivosaria Gn. Sioux City, Iowa City; June and July.

Ennomos subsignarius Hbn. Sioux City, July.

Ennomos magnarius Gn. Sioux City, August, September; Iowa City and Mid River, October.

Xanthotype vagaria Swett. Iowa City, June, August; Sioux City, May, August.

Plagodis keutzingaria Pack. Sioux City, three specimens, May 12, 20 and 22, 1916.

Plagodis fervidaria H.-S. Iowa City, May 17, 1917, one.

Plagodis phlogosaria Gn. Sioux City, August 11, 1917, one.

Plagodis arrogaria Hulst. Iowa City, July 17, 1917, one.

Hyperitis amicaria H.-S. Sioux City, July 17, 1917, one.

Hyperitis amicaria form *alienaria* H.-S. Iowa City, May, June; Sioux City, June.

Nematocampa limbata Haw. Sioux City, July, August, September. Reared from Box Elder.

Gonodontis hypochraria H.-S. Iowa City, June.

Gonodontis duaria Gn. Homestead, Iowa City, May.

Euchlaena irraria B. & McD. Iowa City, July.

Euchlaena serrata Dru. Sioux City, July 16, 1917, one male.

Euchlaena obtusaria Hbn. Sioux City, August, September. Reared from Sweet Clover.

Euchlaena astylusaria Dru. Sioux City, August 12, 1918, one female.

Euchlaena tigrinaria Gn. Iowa City, August; Sioux City, June.

Metanema inatomaria Gn. Sioux City, June 29, 1915, one.

Pero honestarius Hbn. Throughout the state. May, June, August.

Apicia confusaria Hbn. Sioux City, July.

Tetracis crocallata form vern. *aspilatata* Gn. Sioux City, June 28, 1917, one female.

Sabulodes lorata Grt. Sioux City, Iowa City, June.

Sabulodes transversata Dru. Sioux City, July; Iowa City, September, October.

Abbottana clemataria A. & S. Sioux City, April 8, 1910, one female.

TINEOIDEA

Zygaenidae

Harrisina americana Guer. Sioux City, no date.

Thyridae

Thyris lugubris Bdv. Sioux City, July.

Pyralidae

PYRAUSTINAE

Glaphyria glaphyralis Gn. Iowa City, July.

Glaphyria invisalis Gn. Sioux City, July.

Glaphyria psychialis Hulst. Iowa City, July.

Egesta eripalis Grt. Sioux City, July.

Lipocosma sicalis Wlk. Sioux City, July.

Desmia funeralis Hbn. Sioux City, June to August.

Blepharomastix magualis Gn. Iowa City, July.

Blepharomastix ranalis Gn. Iowa City, Sioux City; July.

Blepharomastix stenialis Gn. Iowa City, June and July.

Pantographa limata G. & R. Sioux City, August.

Sylepta obscuralis Led. Iowa City.

Evergestis straminalis Hbn. Sioux City and Dickinson county, August.

Crocidophora tuberculalis Led. Sioux City, July.

Loxostege dasconalis Wlk. Iowa City, June, one only.

Loxostege coloradensis G. & R. Sioux City, June.

Loxostege chortalis Grt. Sioux City, May; Iowa City, June.

Loxostege obliteralis Wlk. Iowa City, June; Sioux City, July, August.

Loxostege similalis Gn. Generally common.

Loxostege sticticalis Linn. Sioux City, May, June; Dickinson county, August; Iowa City.

Loxostege commixtalis Wlk. Sioux City, May.

Phlyctaenia ferrugalis Hbn. Dickinson county, August.

Phlyctaenia tertialis Gn. Iowa City, June.

Pyrausta fissalis Grt. Sioux City, June; Iowa City, July.

Pyrausta aeglealis Wlk. Iowa City, July.

Pyrausta flavidalis Gn. Sioux City, July.

Pyrausta penitalis Grt. Sioux City, August.

Pyrausta ainsliei Hein. Sioux City, August.

Pyrausta futilalis Led. Sioux City, August.

Pyrausta fumoferalis Hulst. Sioux City, August.

Pyrausta onythesalis Wlk. Sioux City, June.

Pyrausta generosa G. & R. Homestead, May; Sioux City, June.

Pyrausta signatalis Wlk. Iowa City, June; Sioux City, July.

Pyrausta funebris Strom. Homestead, June.

NYMPHULINAE

Nymphula badiusalis Wlk. Dickinson county, August.

Nymphula icciusalis Wlk. Dickinson county, August.

PYRALINAE

Pyralis farinalis Linn. General, June and July.

Hypsopygia costalis Fab. Sioux City, July, September.

Herculia olinalis Gn. Homestead, June; Sioux City, August.

CHRYSAUGINAE

Condylolomia participialis Grt. Iowa City, July.

SCHOENOBIINAE

Schoenobius mellinellus Clem. The species and both forms at Sioux City, July.

Schoenobius mellinellus form *dispersellus* Rob.

Schoenobius mellinellus form *albicostellus* Fern.

CRAMBINAE

Raphiptera minimella Rob. Ames, no date.

Crambus leachellus Zinck. Sioux City, August.

Crambus praefectellus Zinck. Dickinson county, August, determined by G. G. Ainslie.

Crambus alboclavellus Zell. Iowa City, July.

Crambus agitatellus Clem. Iowa City, June.

Crambus laqueatellus Clem. Iowa City, June; Sioux City, June, July.

Crambus hortuellus Hbn. Dickinson county, August, determined by G. G. Ainslie.

Crambus hortuellus form *topiarius* Zell. Iowa City, July.

Crambus albellus Clem. Iowa City, June, July.

Crambus turbatellus Wlk. Iowa City, July.

Crambus vulgivagellus Clem. Sioux City, common in August and September.

Crambus ruricolellus Zell. Dickinson county, August, determined by G. G. Ainslie.

Crambus mutabilis Clem. Ames, August, one only.

Crambus hemiochrellus Zell. Sioux City, July, one only.

Crambus trisectus Wlk. Sioux City, August, September, common.

Crambus caliginosellus Clem. Iowa City, July.

Crambus luteolellus Clem. Sioux City, June.

Thaumatopsis pexellus Zell. Sioux City, September.

Thaumatopsis repandus Grt. Sioux City, July.

Argyria nivalis Dru. Sioux City, July.

Argyria argentana Martyn. Sioux City, June.

One other species closely allied to *auratella,* has been taken at Sioux City in July. This is to be described by Dr. W. T. M. Forbes, and cotypes are in coll. Barnes. I have but one other Iowa specimen.

Platytes vobisne Dyar. One specimen without date from Sioux City.

Eoreuma densellus Zell. Ames, August.

Chilo comptulatalis Hulst. Ames, August.

Chilo forbesellus Fern. Sioux City.

EPIPASCHIINAE

Epipaschia zelleri Grt. Sioux City, July.

Tetralopha baptisiella Fern. Dickinson county, August.

PHYCITINAE

A number of Phycitinæ are on hand, but the group is in such a state that no attempt has been made to identify them.

Pterophoridae

Oxyptilus periscelidactylus Fitch. Sioux City, June.
Oxyptilus tenuidactylus Fitch. Sioux City, June.
Platyptilia carduidactyla Riley. Iowa City, July.
Oedematophorus paleaceus Zell. Sioux City, July.
Oedematophorus lacteodactylus Cham. Homestead, May.
Oedematophorus cretidactylus Fitch. Sioux City, July.
Oedematophorus eupatorii Fern. Sioux City, July.
Oedematophorus inquinatus Zell. Sioux City, August, common at light.
Oedematophorus monodactylus Linn. Sioux City, August, September.

Orneodidae

Orneodes hexadactyla Linn. Sioux City, April.

During the summer of 1918 I made an effort to obtain as many micro-lepidoptera as possible, with the result that I have on hand a considerable number of specimens. Some of these have been identified by Mr. Busck, of the National Museum, but so many remain to be worked over that I am omitting them entirely at present. The rearing of micros in the prairie areas, particularly of the western part of the state, should bring to light a great many interesting things.

The Barnes' Museum,
Decatur, Illinois.

A STUDY OF THE PHYLOGENY OF THE ANTEONINAE [1]

F. A. FENTON

A study of the biology of insect parasites and their relationships with that of their hosts offers a most attractive and productive field for research, and as yet, comparatively speaking, but little has been done in this field. This is particularly true with the *Hymenoptera,* and the writer has been interested in working out the biology of the Anteoninae, one of the parasitic groups of this order. These insects are parasitic on three families of the *Homoptera,* namely, the Cicadellidae, and Fulgoridae, commonly known as leafhoppers, and the Membracidae or treehoppers.

With the possible exception of members of the most primitive genus, the larvæ of the Anteoninae in their later stages are all attached externally to the host, protected and encased in the larval exuviæ, which instead of being cast off as is the case with other insect larvæ, are retained as a sort of sac for protection. Furthermore, with the exception of the genus *Aphelopus,* all the females have the front pair of legs greatly lengthened and otherwise adapted for grasping purposes. The coxa is excessively elongated, being often more than half as long as the femur; the trochanter is long and often somewhat curved; the femur is strongly club-shaped; and the tibia is thicker and shorter than the others. The greatest and most striking change has taken place in the fore tarsi, however, these being modified to form a chela or grasping organ fitted for holding the active prey, a character not found in any other insect group (Fig. 56. 7). The chela is composed of two arms or "pincers," one being the fifth tarsal joint which is proximally more or less lengthened, and the other one of the tarsal claws which has become greatly elongated. The remaining claw is much reduced or normal and is enveloped by the lobes of the empodium. These chelae show a great range of variation and complexity within the group, being variously provided with spines and lamellae (Fig. 56). In addition to this structure, which is peculiar only to the females, this sex has

[1] This group has been variously given the rank of family (Dryinidae) and subfamily (Anteoninae) by different writers. It is also included by some in the superfamily Proctoturpoidea, and by others in the Vespoidea.

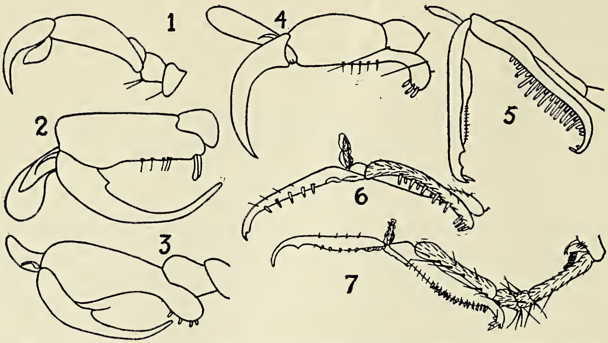

Fig. 56. Chelae of Anteoninae. 1. *Paranteon myrmecophilus*. 2. *Anteon vicinus*. 3. *Anteon arcuatus*. 4. *Anteon brevicollis*. 5. *Thaumatodryinus koebelei*. 6 *Haplogonatopus americanus*. 7. *Gonatopus erythrodes*. (Fig. 1 from Perkins, Figs. 2-5 from Kieffer.)

also lost the wings in a great many cases and the body has become ant-like. On the other hand, the males throughout the whole group are more primitive in structure and do not show the specialization that has taken place in the females.

Recent writers have placed the Anteoninae in Ashmead's superfamily Vespoidea because of the habit the females have of stinging and paralyzing the host before ovipositing. Since this is not true. at least in certain species of *Aphelopus* which is now considered the most generalized genus of the group, this fact should be reconsidered. If we assume that the paralyzing habit was developed later on in the phylogeny of the group, as the above fact seems to indicate, it appears that this subfamily and therefore the Bethylidae, should be removed from the Vespoidea. Probably the theory advanced by Perkins [2] that "they constitute a natural group, synthetic between the old Fossoreal series of the Aculeata and the true Serphoidea (Proctotrupoidea)" is more correct and that for the present they should be included in the latter superfamily.

Fortunately, owing to the rather large number of host records on hand and the smallness of the entire group, we are able to get a series of adults which illustrates nicely the evolution of the extreme specialized types from the most primitive species. Even here, however, there is some divergence of opinion as to the exact relationship of the different genera to each other.

2 Perkins, R. C. L., Report of work of the Experiment Station of the Hawaiian Sugar Planters' Association: Bull. 1, part 1, 1905, page 27.

Perkins [3] divided the Anteoninae which he considered a family (Dryinidae) into two subfamilies, namely the Aphelopinae, containing the one genus *Aphelopus* and the Dryininae in which he placed all the other genera. This latter subfamily he further divided into three tribes which were separated by the character of the stigma of the fore wing and by the number of joints in the labial palpi.

Kieffer,[4] in his monograph of the Bethylidae, divided the Anteoninae into four tribes; the Aphelopini, Anteonini, Lestodryinini and Gonatopodini. His first two tribes correspond with the Aphelopinae and Anteonini of Perkins. However, he placed the apterous forms in one tribe, the Gonatopodini and the more specialized winged chelate forms in the Lestodryinini.

There is no question about the first two tribes, *i.e.*, the Aphelopini and Anteonini; but the evidence seems to point out that both Perkins' and Kieffer's classification of the genera falling into the other two groups should be modified. There is little doubt, for instance, that the apterous forms have been derived from two different sources, both of which have been classified by Kieffer in his Lestodryinini. It has been noted many times that the males of certain genera of both the apterous *Gonatopus* group and the winged *Lestodryinus* group are very similar, and that at the same time in each of these tribes there is yet another division based on the character of the chela. In other words, in the higher, more specialized chelate genera there are two natural divisions based upon the character of the chelæ, whether the species are apterous or winged. Perkins [5] observed that in those dryinids parasitizing Cicadellidae the claw was not lamellate, while in those attacking Fulgoridae it was lamellate or serrate.

Further proof that the apterous forms are distinct was obtained also by Perkins when he split up the old genus *Gonatopus* into a number of genera, and this number has since been enlarged. The fact that other bethylid wingless forms superficially resemble the *Gonatopus* group emphasizes these conclusions, and indicates that the apterous ant-like form is the result of a certain condition of habitat.

Figure 57 illustrates what seems to the writer to be the real phylogeny of this subfamily. Group I contains the single genus *Aphelopus,* admittedly the most primitive and generalized

3 *Ibid.*, Bull. 11, 1912, page 10.
4 Kieffer, J. J., Das Tierreich, 41 Lieferung, 1914, page 11.
5 Perkins, *loc. cit.*

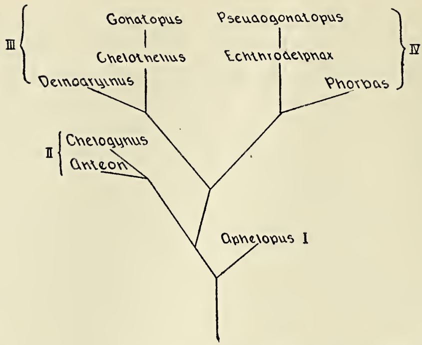

Fig. 57. Diagram illustrating phylogeny of the anteoninae.

of all the other genera. Both sexes are winged, the fore tarsi in the female are not modified to form chelæ, and there is thus no sex dimorphism. The wings show a reduced venation and have a broadly oval stigma. In our one record of oviposition [6] the host is not paralyzed and there is also more range in the kind of insect attacked, the Membracidae and Cicadellidae being subject to parasitism by species of this genus. There is great diversity in the larval habit, polymebrony having been found, the larvae in this case being internal and not being inclosed in sacs. When present the larval sac shows a more generalized structure.

Group II, comprising the genus *Anteon* and other related genera, shows a greater degree of specilization. While both sexes are winged there is some sex dimorphism, the females having the fore tarsi modified into chelæ. The latter are often either non-extensile or only partly so (Fig. 56, 1-4). The stigma is broadly oval as in the case with the first group but the wing venation is different, there being two basal cells present. Species in this group parasitize Cicadellidae only.

Group III comprises *Gonatopus* and related apterous genera as well as *Deinodryinus* and related winged genera. In the winged species the venation is similar to that found in group II, but the stigma is lanceolate. The type of chela is identical in both apterous and winged forms, the claw being non-lamellate (Fig. 56, 5 and 7). Species in this group parasitize Cicadellidac only.

6 Kornhauser, S. I., Journal of Morphology, vol. 32, no. 3, 1919, pages 547-554.

Group IV comprises *Pseudogonatopus* and related apterous genera as well as *Echthrodelphax* and related winged genera. This group is very similar to the preceding but is differentiated at once by the character of the chela, the claw of which is lamellate or serrate (Fig. 56, 6). Fulgoridae only are parasitized.

Department of Entomology,
Iowa State College.

RECENT ARMY WORM AND VARIEGATED CUTWORM OUTBREAKS IN IOWA

H. E. JAQUES

The 1919 and 1920 outbreaks of Army worms within our state were by no means new experiences for Iowa. Previous heavy losses from this pest, however, date back so many years that the younger generation of farmers knew them only by tradition. With older men, the memories of their experiences seem to have been somewhat confused so that many stories were related that were but in part in keeping with the history and habits of the Army worm. With all classes there seemed to be an unwarranted fear of the insect and exaggerated ideas of its ability to travel, reproduce and defy the efforts of man to control it.

THE 1919 OUTBREAK

Beginning early in June and continuing throughout the month reports of serious damage due to attacks of the Army worm and the Variegated cutworm were received from many of the counties in the southern part of the state. It was found that these attacks with the exception of a few scattering outbreaks, were confined to the four rows of counties comprising the southern part of the state, with a more or less serious infestation in practically every county within this range. Thruout the western half of this belt the Variegated cutworm was by far the most numerous while in the eastern part of this region the Army worm was easily the predominating species. This then represented the northern limits for this longitude of a general and destructive outbreak of the Army worm which occurred in the spring of 1919 and which had its southern boundary well down in Texas.

On the sixteenth of June in company with the county agent of Lee county a corn field west of Donnelson was visited. Army worms had hatched in a low lying woods pasture adjacent to the corn field and were at the time of our visit migrating well into the corn field. The corn which would average a foot in height was being seriously eaten, with many worms to the hill. Although it was mid-day with bright sunshine, the worms were actively at work. It was interesting to note that in a corner of the field, the entire heads were being eaten from a small patch of squirrel tail grass, *Hordeum jubatum,* which may be counted as one score for the Army worm.

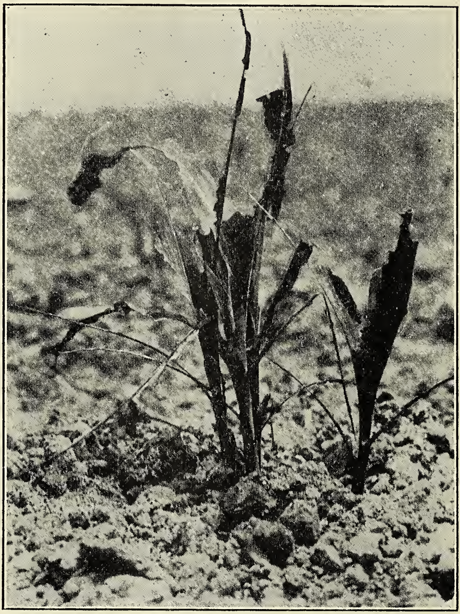

Fig. 58. Army worms beginning to destroy a hill of corn.

Later the same day in company with the county agent of Henry county a corn field near Salem was visited. There again the worms were coming from an adjacent pasture. In this case a large percentage of the hills of corn were eaten to the ground or the plants were reduced to short stumps.

A few weeks later representative fields thruout the infested areas were visited. The plan of work was to dig for pupæ, note adults and study the natural enemies with a view to determining the probable seriousness of future broods.

The Variegated cutworm (*Peridromia saucia*) while having a rather wide range of food plants seems to favor the leguminous crops and is so destructive to alfalfa as to be aptly termed the "alfalfa cutworm." The region of heaviest infestation in Iowa in 1919 of this pest was in the southwestern part of the state. Page county was one of the counties hardest hit. In it alfalfa, clover and wheat suffered severely. An active control cam-

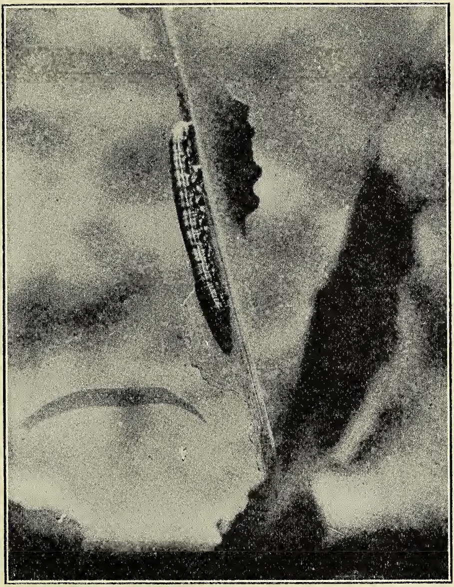

Fig. 59. Army worm feeding on corn (life size).

paign was conducted with good results as shown by a special report of County Agent Eichling. Montgomery and Pottawattamie counties seem to come next in order of severity. Further east in Marion, Mahaska, Jefferson, Van Buren and other counties it seems that the Army worm (*Leucania unipuncta* Haworth) did more damage than the Variegated cutworm while in the counties still further east the Army worm held the field unchallenged by its closely related competitor.

The Army worm seemed to confine itself in choice of food very largely to plants of the grass family, corn, small grains, timothy meadows and blue grass pasture suffering most heavily. In several places corn fields were invaded and the crop over areas up to five acres or more was seriously damaged or totally destroyed. Some wheat fields suffered a total loss while numerous Blue grass pastures were eaten to the ground with a serious temporary loss.

Our active field work was begun July 10, on which date several

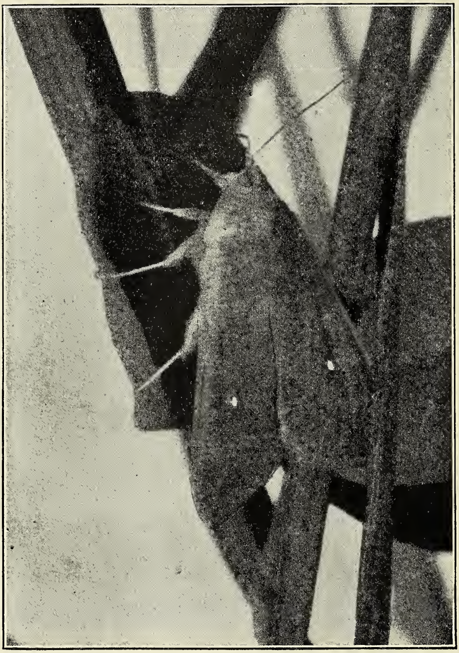

Fig. 60. Army worm moth (enlarged). The white spot on the wing is a distinguishing character.

infested regions in Marion county were visited. Adult moths were seen flying in the fields with a fair degree of abundance and pupæ were readily found by digging. Several species of parasitic Tachina flies and Braconids also were abundant. About one-third of the pupæ taken emerged that same day and the others which did not contain parasites within a very few days. Both species were found in this county, in some cases both in the same field. The trip then led to Mahaska and Wapello counties, thence to the southwestern part of the state. While an occasional living pupa was found for several weeks it came very shortly (by the fifteenth of July) to the time where practically all pupæ located showed either emergence or a parasitized state. It will be seen that the writer got into the field too late to get any very complete data on the emergence of the first brood, but it is quite plain that the end of that period for the year considered was about July 15.

In fields known to have been infested with either or both of these worms, as a rule little trouble was experienced in locating pupal remains and in reading their history. They were usually found buried from one-half inch to an inch and a half under ground tho sometimes they would be found on top of the earth, having pupated under some little rubbish lying there. The pupæ of the two species could be readily distinguished by color and size, those of the Variegated cutworm being somewhat larger than the Army worm pupa and a chocolate brown, while the pupa of the Army worm was more slender and a lighter reddish brown. Along the weed covered fence row of an alfalfa field north of Council Bluffs, the pupæ of the Variegated cutworm were found as abundant as forty to the square foot. Out in the field they were not nearly so numerous. Poison bran had been used. This was the highest record for abundance, though a number of counts made in other counties approached it. A few of these pupæ showed successful emergence but the greater percentage were parasitized.

It had been noted when the worms were doing their damage in the spring that many were carrying tachina fly eggs. Tachina flies were reared from pupæ of the worms taken by digging. The species by far the most abundant was *Archytas analis,* a large tachinid with bluish black abdomen, gray thorax, reddish brown eyes and white face. Many pupæ of the Variegated cutworm taken thruout the summer were filled with the open puparium of one of these flies. The abundance of the adult flies was further evidence that they had done their control work well. These flies could be found in abundance on the flowers of sweet clover, alfalfa, catnip and smartweed wherever the Army worm or Variegated cutworm had been numerous. In some fields there were so many as to suggest the presence of a swarm of bees.

In almost every field visited, numerous bunches of braconid pupæ could be found where they had emerged from their cutworm host. In some counties but few pupae could be found even where the larvæ had been numerous, showing that the parasites had done their work early.

Fig. 61. *Archytas analis*, adult, enlarged.

Mention should be made of the fungus diseases which destroyed larvæ and pupæ as well as of the several species of Ground beetles and Stink bugs found to be associated in the work of control.

Thruout the summer a lookout was kept for any indications of a second brood. No worms were seen or reported tho an occasional Army worm adult was taken, seeming to indicate a small second brood. The latter part of August and early September saw some individuals of *Archytas analis* again feeding at flowers. This seemed to indicate at least two broods, as earlier in August none of the species was to be found.

THE 1920 OUTBREAK

During the spring of 1920 occasional Army worm moths were observed flying to lights. The evening of April 21, an unusually abundant flight was reported at the farm of George Blasie near

Floris in Davis county. The moths were so numerous as they visited the flowers of a large apricot tree in the early evening as to practically cover the tree. They did not appear there again, however. The early summer of 1920 brought no reports of Army worm damage but during the last weeks of July it became apparent that northwestern Iowa was suffering heavily from Army worm attacks. This outbreak also touched the northeast corner of the state and extended on north into Minnesota. Prompt work on the part of the State Entomologist and the county agents brought the worms in many cases under control and greatly reduced the loss.

The oats crop suffered most heavily, the damage resulting from the worms climbing into the panicles and cutting off the spikelets until the ground was covered with loose oats. Reports of the loss of from five to ten bushels of grain to the acre were quite common and in some fields the loss was so nearly complete that the entire acreage was left uncut. Some farmers saved their grain by cutting it greener than they would otherwise have done. A farmer living in Pocahontas county told of seeing three binders working on Sunday in a very green piece of oats. He could not guess the reason until the wheels of his car began to skid from running on Army worms crossing the road. Low lying and rank growing oat fields suffered most. The early oats escaped by ripening ahead of the worms. Had the worms appeared a week or ten days earlier the loss of the oats crop would have been close to total in many areas.

From the oats the worms frequently went to the corn, which in most cases suffered but light damage due to its size and the fact that the worms were approaching maturity. In some fields, however, the leaves were stripped up to the ears and the silk cut off short from the younger ones. In such cases the worms could be found in the tips of the ears eating the growing silk, thus preventing its reaching a length to warrant pollination.

Some timothy meadows suffered. In mixed meadows the clover would be left standing even though the timothy and other grasses were cut tight to the ground. A patch of Soudan grass was seen where the side next to the damaged oat field was badly eaten, with many worms and pupæ to be found along the rows.

Some worms were observed to be dying of fungus troubles, while many white bunches of braconid cocoons, each telling of the wreck of an Army worm, could be found in the infested fields. Among the living worms in almost any field could be found shriveled specimens plainly "enjoying poor health." These needed only to be torn open to find from one to three or four maggots, young tachina flies. Adult tachina flies, with *Archytas analis* predominating, but one or more smaller species being common, were very abundant in the fields and many of the pupæ of the Army worms contained the larva or puparium of a tachinid, while a high percentage of the worms carried fly eggs on their "necks." Ground beetles of several common species were very numerous in the fields. *Harpalus compar* Lec. was the predominating species while *Calosoma calidum*, often mentioned as an enemy of Army worms, was not infrequently found. From the abundance of these many natural enemies it would seem unlikely that this same region would suffer from Army worms during the season of 1921.

It is difficult to estimate the amount of loss due to the 1920 outbreak of Army worms in our state, and not easy to say where the loss was greatest. It would seem that Sac and Pocahontas counties likely suffered most heavily altho certain regions in many of the counties were hard hit. It is interesting to note that Calhoun county, on the southern border of this year's outbreak, was the most northern county to have an Army worm outbreak in 1919, while Des Moines county was the only county of the twenty-two in the southern part of the state known to have Army worm troubles in 1919 that had the worm again this year. Early in April and thereafter for two months and more adult Army worms could be found at lights almost every warm night. It is an interesting question as to whether or not these moths in southern Iowa are in any way related to the appearance of worms in the northern half of the state.

The Variegated cutworm was not reported as a destructive agent to farm crops during the summer of 1920 tho from many parts of the state came reports of its damage to tomatoes. The worms after hiding in the soil by day would climb into the vines by night where they ate off the blossoms and young fruit or burrowed into the larger green ones and the ripe tomatoes.

From these two years' experience with Army worms and the closely related Variegated cutworm it is evident that poison bran bait will ordinarily offer an effective means of control; that where the worms are traveling they may be stopped by a well constructed ditch, but that it is a good plan to run a row of poison bran along the ditch to care for the few worms that will likely find some means of crossing the ditch; and that their natural enemies may be counted upon in most cases to get the matter well in hand and to prevent an outbreak the second year in a community. Where the crop will permit hogs will soon destroy immense numbers of worms if given access to the fields. The use of drags and rollers to crush the worms is sometimes suggested but had only a low percentage of efficiency when tried during these Iowa outbreaks.

While the Army worm is a notable traveller when in search

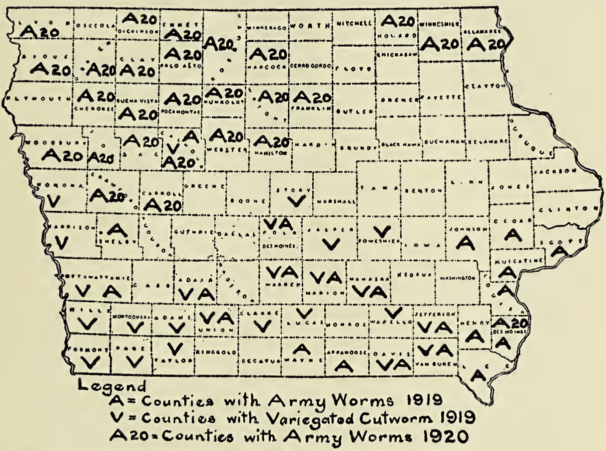

Fig. 62. Map of Iowa showing distribution of Army worms and Cutworms.

of food, his migrations are limited at the most to crossing a field or two. They never travel for miles or across counties. In our state it seems most likely that there are two broods per year. Whether they pass the winter as partly grown larvæ or in the pupa state or by both methods is not fully established.

The accompanying map shows the counties known to have suffered loss from these pests. The photographs are originals.

Department of Biology,
Iowa Wesleyan College.

A BIOLOGICAL RECONNAISSANCE OF THE OKEFINOKEE SWAMP IN GEORGIA: THE FISHES

E. L. PALMER AND A. H. WRIGHT

From the earliest days of North American ichthyology to the present the fishes of South Carolina and North Carolina have received particular attention and in more recent times according to one author [6] Florida fishes have attracted more general interest than those of any other state in the Union. Georgia forms by contrast have received scant attention and often have come into ichthyologic literature by inclusion in the range of northern species known from Florida or of southern species known from South Carolina and northward.

The only ichthyologist who is associated in literature with Okefinokee swamp is Charles H. Bollman.[10] In the latter part of June, 1889, he with Mr. Bert Fesler explored some of the lowland streams of Georgia and as the result of this trip lost his life. He spent most of his time at Savannah, at Waynesborough and at Millen on Ogeechee river, quite remote from the Okefinokee swamp. He spent a day or so at Waycross on Satilla river but it is doubtful if he entered the Okefinokee swamp proper. Some distance southeast of Waycross is the Little Okefinokee swamp, a tributary of Satilla river, but there is no evidence that he visited it. Jordan and Evermann [18] in speaking of *Chologaster cornutus* gives the following notation: "Gilbert. Bull. U. S. Fish Commission, VIII, 1888, 227, specimens from Okefinokee Swamp, Millen, Ga.; caudal fin more dusky, with little white at base." First of all only one specimen was taken and secondly this was secured at Millen, Georgia, one hundred or more miles north of the swamp.

The record that *Notropis roseus* [18] is "the commonest species in the Okefinokee swamps" is based on captures at Waycross and might possibly pass unchallenged yet it is hardly in Okefinokee swamp proper. But the hardest blow for a zealous lover of the Okefinokee is Dr. Jordan's statement that [16] "Charles Henry Bollman (1868-89) (was) stricken with fever in the Okefinokee Swamps in Georgia." The evidence from Dr. Gilbert's paper does not show it nor does he claim it but of course this does not preclude a trip of which no written record is made. Our party (1912) of thirteen was in the heart of the swamp for six weeks with no fever contracted thereafter and our record accords with the experiences of the Thompson brothers in Civil War times, with those of the surveying parties of 1879, and with those of the Harper brothers (1902-17).

In 1894 Dr. Einar Loennberg [20] compares the source of the marine and fluviatile elements in the ichthyfauna of Forida as follows: "From this it is thus evident that in the marine fishfauna of Florida the tropical components really are ruling. But this is not the case in regard to the 'ichthys' of the freshwater. If we completely omit all marine fishes, which not few in number, ascend streams and rivers and sometimes penetrate deep into the country, we can divide the real fresh-water fishes of Florida into two classes. 1) Fishes with wide distribution and which can be found far north from Florida. To this belong Lepidosteus, Amia, most of the catfishes, Erimyzon, Notemigonus, Dorosoma, the eel, Esox reticulatus, Labidesthes, Pomoxys, Chaenobryttus, Enneacanthus, Lepomis pallidus and Micropterus. Some other ones do not extend so far north, but go at least to South Carolina, as Zygonectes chrysotus, Gambusia, Girardinus and Lepomis holbrooki. All in all this class will embrace about a quarter of a hundred. The second class should include the typical Florida-fishes, but they are only half as many. To them belong Amiurus erebennus, Jordanella, Fundulus seminolis and F. ocellaris, Zygonectes henshalli and craticula, Lucania goodei, Elassoma evergladei, Lepomis punctatus and mystalis. A few are found in Florida and also in Georgia as Notropis roseus, Etheostoma quiescens. Molliensia latipinna extends westward to Mexico and Lepidosteus tristaechus southward to Cuba and Central America. As this second class however is not but about half as large as the first, the fresh water fauna of Florida with respect to the fishes can be said to have originated from the North and is thus not tropical. This is the more the case as most of even these freshwater fishes that are typical for Florida have relatives belonging to the same genera in other parts of North America."

At present there are few freshwater fishes which might be termed strictly Floridan, to wit:—*Jordanella floridae, Lucania goodei, Fundulus seminolis, Fundulus henshalli and Ameiurus erebennus* (the latter probably synonomous with *Ameiurus natalis* and not so important in this discussion).

In this connection it is interesting to note two casual collections of predominant fishes made by Francis Harper in January, 1917. On the prairies of the Okefinokee in one collection (Jan. 14, 1917) he secured *Lucania ommata, Fundulus chrysotus, Fundulus nottii* and *Gambusia affinis* in quantity and *Enneacanthus*. Later in a small random collection taken at Lake Tohopekaliga, Kissimmee, Florida, January 29, 1917, he took *Jordanella floridae, Lucania goodei, Fundulus seminolis* of the so called typical Florida fish, also *Molliensia latipinna, Heterandria formosa, Gambusia affinis* and *Enneacanthus gloriosus*. *Heterandria formosa* extends from North Carolina to Florida and *Molliensia latipinna* from South Carolina to Mexico. Both must be too brackish to enter the Okefinokee. One cannot resist the suggestion that the *Jordanella floridae, L. goodei, F. seminolis* and *F. henshalli,* associates of the above two brackish species, may be also somewhat brackish and too much so for the Okefinokee.

Many of these same characteristic forms of Florida appear to the north and east along the east coast under more brackish conditions, namely at Indian river and Lake Jessup. Among them are [14] *Jordanella floridae, Fundulus seminolis, Fundulus henshalli* and *Molliensia latipinna*. Woolman [23] found *L. goodei* along the west coast, *Jordanella floridae* in Alligator river, *Molliensia latipinna, J. floridae, L. goodei, F. seminolis* in Peace river, *Jordanella* in Hillsboro river and *M. latipinna, J. floridae, L. goodei,* and *F. ocellaris* in Withlacoochee river. None of these did he find in the Santa Fe river not far from the southern edge of the Okefinokee swamp. The Okefinokee swamp in its fish contents is decidedly fluviatile and hence the few species in our list. If, however, it be not rich in species it is teeming in individuals — small killifishes as a general food resource for the animals of the swamp and larger basses and catfishes as food for man.

Only two collections of fish have been made in Suwannee river previous to our trip of 1912, one by W. J. Taylor at Nashville, Georgia, Allapaha river, a tributary of the Suwannee river and west of the Okefinokee; the other, by Albert J. Woolman at Santa Fe river in Bradford county, Florida, to the south of the Okefinokee. The first collector took [19] "*Poecilichthys quiescens, Notropis metallicus, Elassoma evergladei,* and other interesting species." In this collection were two new forms, *Notropis metallicus* Jordan and Meek and *Zygonectes zonifer,* Jordan and Meek (this latter now considered a male *Fundulus nottii*). The minnow was not taken by us. Of the Woolman collection, he himself writes as follows: [23] "The Santa Fe River is an eastern, and one of the largest tributaries of the Suwanne River. Collections were made at three places on this river and its tributaries, in Bradford County.

"*The Santa Fe River* is the outlet of a lake of the same name, situated in the southeastern part of Bradford County. This lake is about 11 miles long, 5 miles wide, and very deep. Three miles southwest of Hampton, a station at the crossing of the Georgia and Southern Florida and the Florida Central and Peninsula railroads, the river is only about 20 feet wide, with an average depth of about 4 feet. Here the river follows through woodland, and is full of cypress trees, coarse grass, and algae. A red alga, Batrachospermum, was found in such abundance at this place as to hinder the use of seines. The examination was made January 3, 1891; water temperature, 49°F.

"*Sampson Creek* is a small northern tributary of the Santa Fe, and is very shallow. It afforded very few fishes. It was examined at Sampson, January 5, 1891; water temperature, 49°F.

"*New River* is a large northern tributary of the Santa Fe, and at the place where it was visited, New River Station, was of about the same size and character as the Santa Fe, but the water was more shallow. The bottom is sandy and black, the banks are low, and the vegetation extends down to and into the water. Fishes were not abundant. Examined January 5, 1891; water temperature, 50°F."

Woolman [23] secured sixteen species, three of which were not taken by us. These sixteen are:

Ameiurus natalis	Heterandria ommata
*Noturus gyrinus	Aphredoderus sayannus
*Noturus leptacanthus	Chaenobryttus gulosus
Erimyzon sucetta	Lepomis punctatus
*Notropis roseus	Lepomis pallidus
Gambusia patruelis	Lepomis megalotis
Zygonectes chrysotus	Etheostoma quiescens
Zygonectes nottii	Elassoma evergladei

Satilla river to which Little Okefinokee swamp is tributary is to the immediate east. At Waycross, Bollman [10] in June, 1889, collected the following, one species of which was missing from our collection:

*Notropis roseus	Elassoma evergladei
Gambusia patruelis	Lucius reticulatus
Aphredoderus sayannus	Labidesthes sicculus
Lepomis pallidus	Etheostoma fusiforme
Lepomis punctatus	

Thus we have added to our list, *Notropis mettalicus, Notropis roseus, Schilbeodes gyrinus* and *Schilbeodes leptacanthus,* or members of the *Cyprinidae* and *Siluridae*. These two families with Percidae (darters) furnish most of the hypothetical species which follow in a later list.

In the same publication Bollman's collections from Ogeechee river are reported. These are from a more remote locality yet might suggest some of the forms which might make a hypothetical list. The forms secured in this river and not recorded in our Okefinokee area by us or by others are:

Ameiurus platycephalus	Chologaster cornutus
Notropis chalybaeus	Lepomis auritus
Notemigonus c. bosci.	Etheostoma nigrum olmstedi
Opsopoedus emiliae	Etheostoma nigrofasciatum
Opsopoedus bollmanni	Etheostoma squamiceps

In the Altamaha river basin (Ockmulgee and Oconee rivers) far to the north of the swamp Jordan and Brayton [17] and Jordan [13] report the following species not found in the swamp:

Ameiurus brunniens (platycephalus)	Codoma callisema
Lepomis auritus	Ceratichthys rubrifrons
Hadropterus nigrofasciatus	Ceratichthys biguttatus
Boleosoma maculaticeps	Semotilus corporalis
Nothonotus inscriptus	Myxostoma cervinum
Alburnops amarus	Myxostoma papillosum
Hydrophlox lutipinnis	Ichthaelurus punctatus
Codoma xaenura	Ameiurus marmoratus

Strictly speaking we suppose the Florida group should be added to the hypothetical list, namely:

Jordanella floridae	Lucania goodei
Fundulus seminolis	Fundulus henshalli
Ameiurus erebennus	Ameiurus okeechobensis

Possibly a few of the coastal species might enter the swamp, to wit:

Fundulus ocellaris	Heterandria formosa
Molliensia latipinna	

The following freshwater species have also been recorded from Florida, namely: [18]

Ameiurus catus	Eupomotis holbrooki
Moxostoma aureolum	Lepisosteus tristœchus
Pomoxis sparoides	Lepisosteus osseus
Cliola vigilax	

Thus, we have a list of thirty-eight species of which several darters and minnows are least likely to occur in the swamp because they require different conditions, and are taken in rapid clear waters. Furthermore, if all these thirty-eight with our present twenty-eight species occurred in the swamp it would give sixty-six species or fifteen more freshwater forms than are recorded from Florida. Our Okefinokee list including the records of others includes the following twenty-eight species (starred forms are in our collections):

*Lepisosteus platostomus
*Amiatus calva
*Ameiurus natalis
*Schilbeodes gyrinus
Schilbeodes leptacanthus
*Erimyzon sucetta
Notropis roseus
Notropis metallicus
*Anguilla chrysypa
*Umbra limi
*Esox americanus
*Esox reticulatus
*Gambusia affinis
*Fundulus cingulatus
*Fundulus nottii
*Lucania ommata
*Aphredoderus sayannus
*Labidesthes sicculus
*Elassoma evergladei
*Centrarchus macropterus
*Enneacanthus obesus
*Chaenobryttus gulosus
*Lepomis megalotis
*Lepomis heros
*Lepomis punctatus
*Lepomis pallidus
*Micropterus salmoides
*Boleichthys fusiformis

Almost all of these include more or less widespread species. As pointed out above the distinctive so-called Florida forms are absent and no coastal species are recorded. The killifishes are represented by four species, the basses by eight species, the catfishes by three species and the darters by one species while in the hypothetical list the minnows are twelve in number, the killifishes seven, the basses three, the catfishes six and the darters four. Truly in number of species the swamp is a disappointing place and in no way comparable in this respect with the better known Everglades of Florida. Twenty-eight freshwater species compare not very favorably with the fifty-one freshwater forms of Florida. When a more systematic study of the fishes of the swamp is made and more varied localities within it and outside of it are worked then we may expect a more pretentious list. The new records ought to include more catfishes, minnows and killifishes.

Since this paper was submitted a visit to the swamp was made in the summer of 1921. Additional evidence in support of the conclusions reached was secured. Another visit will be made during the summer of 1922.

The more important observations of this paper are:

1. That Umbra limi (Kirtland) should include U. pygmaea De Kay. (pp. 362-364).
2. That the southern limit of the range of Umbra limi (Kirtland) is materially increased from North Carolina to southern Georgia. (p. 362).
3. That Esox americanus (Gmelin) should include E. vermiculatus Le Sueur. (pp. 364, 365).
4. That Lucania ommata (Jordan), a rare species redescribed, is abundant in the Suwannee River basin. (p.).
5. That Enneacanthus obesus Baird should include E. gloriosus (Holbrook). (pp. 368-370).

6. That our material strengthens the contentions of Smith,[22] McKay[21] and Bollman[4] that the genera Apomotis and Eupomotis should be included within the genus Lepomis. (pp. 371-373).
7. That the length of the pectoral fin is not of taxonomic importance in the separation of these supposed genera. (pp. 372, 373).
8. That Boleichthys fusiformis Girard should include Copelandellus quiescens (Jordan). (pp. 373-375).
9. That Fundulus cingulatus Cuvier and Valenciennes and Fundulus nottii (Agassiz) are of a group of nine (Zygonectes) forms which may some day be assembled into two or three forms. (pp. 365, 366).

Lepisosteus platostomus Rafinesque.

Short-nosed Gar, "Gar."

The occurrence of gars in the swamp is, according to the natives, not common. Inasmuch as these fishes favor freer water than is found in the swamp this was to be expected. The same natives report one at Mixon's Ferry over four feet in length and one at "Lop-a-Hawl river" (Allapaha river) about five feet in length. If these records are correct and we have no reason to question the veracity of these natives, this might be the Alligator Gar, *L. tristoechus,* because *L. platostomus* is supposed to have a maximum length of three feet. We have three specimens taken in 1912, 1914 and 1917.

Amiatus calva Linnaeus.

"Mud-fish" "Black-fish"

The very nature of the waters of Okefinokee swamp would lead one to expect to find this sluggish-water form in a list of its fish inhabitants. Strangely enough, it has not been given in lists of collections from definite localities near Okefinokee. General summaries of its range, however, note its presence from Florida to Virginia and from Minnesota to Texas; Smith[22] considers it abundant in North Carolina. We secured three specimens and in the stomach of one we found a warmouth.

Ameiurus natalis Le Sueur.

"Mud Cat," "Yellow Cat," Catfish, Cat.

The question of catfishes in Okefinokee is complicated by the reports of forms collected in neighboring regions as well as by the descriptions of natives and of authors. One might expect to find a number of species in the swamp in view of the large number reported as occurring nearby. Five species of Ameiurus are reported from North Carolina, namely: *A. catus, A. erebennus, A. natalis, A. nebulosus,* and *A. platycephalus.* Tennessee river is reported as having *A. melas* and *A. natalis.* Alabama river has the same species and Savannah river has *A. catus* and *A. platycephalus.* Florida has quite a diverse collection, *A. nebulosus* being reported from Peace river; *A. natalis* from Hillsboro, Withlacoochee and Santa Fe rivers and *A. erebennus* being described originally from St. John's river. It is evident from this that *A. natalis* would be the most probable inhabitant of the swamp and we identify the eighteen specimens which we have as belonging to that species.

The specimens which we have vary in length from nine to fourteen inches but the comparative measurements are remarkably uniform.

Parasites and enemies. The bodies of all of the fish were opened and examined for parasites. Eight of these had a nematode parasite inside of the body cavity. Besides these internal enemies, catfish have to contend with other inhabitants of the swamp. A large southern water snake, *Natrix s. fasciata* (Linne) was examined and found to contain an eleven inch catfish. Our notes show that catfishes and warmouths are caught more commonly than other species of fish by the natives and that these form a large proportion of the food of the people living in the swamp.

We examined the stomachs of each of the specimens with the view of obtaining data on the food habits. Many of the stomachs were empty. The others contained food ranging from decayed animal matter to freshly caught insects and fishes and crustaceans. One of the most interesting stomachs contained three catfish spines, the pectorals being about the same size as those of the fish which had eaten them.

The natives describe four species of catfishes in the swamp. One of these the "Mud Cat" gets to be almost two feet in length. We believe this to be *A. natalis.* They also describe a "Blue Cat" which they claim to be blue all over. It has a forked tail and is sometimes called "Forked-tailed Cat." Inasmuch as *A. catus* is reported from regions about Okefinokee and the description is not unlike that of this species, it seems highly probable that *A. catus* occurs in the swamp. The other two forms which they describe are not so easily disposed of. Neither their "Channel Cat" or "Toad Cat" has a forked tail. The former is described as having a round tail with specks along the body. Inasmuch as they call this form "Blue Cat" we infer that the main color is blue. The other, the "Toad Cat" squeals when it comes from the water, and is black with blue specks. It reaches a length of about a foot and a half. Inasmuch as color seems to be an inconstant character in catfishes it would seem to be a poor criterion for species separation. The habit of squealing has been ascribed to *A. nebulosus*. This species is also reported as being highly variable in color, in some cases being mottled, and we are inclined to believe that *A. nebulosus* may occur in the swamp. At any rate subsequent expeditions would do well to investigate the catfish problem.

Schilbeodes leptacanthus (Jordan).

Woolman [23] secured three small specimens in New river, a large northern tributary of Santa Fe river.

Schilbeodes gyrinus (Mitchill).

Tadpole Cat.

Woolman [23] reports it as rare in the Santa Fe proper and in Sampson creek of the Santa Fe. Several specimens were taken by us in 1921.

Erimyzon sucetta Lacèpéde.

Mullet, Creek Fish, Chub Sucker, "Sucker."

Two specimens were collected by Jackson Lee and F. Harper. Previous to the times we secured them, the natives had reported a "sucker" in Billy's Lake which they said was over a foot long and had large scales. Our specimens which were sent out later prove their contention. This species evidently is not at all abundant and does not rank high as a food fish.

Notropis roseus Jordan.

Woolman [23] found this form rare in Santa Fe river and remarked that in this place it was becoming less abundant than farther south. Gilbert [10] reported it as one of the most abundant minnows in the lowland streams of Georgia. It was obtained by Bollman in "Ogeechee River, and Satilla River, and was everywhere common." This may account for Jordan and Evermann's [18] note that it is "the commonest species in the Okefinokee swamps" which may or may not be true.

Notropis metallicus Jordan and Meek.[19]

This minnow was described from seven adult specimens taken "by W. J. Taylor in a tributary of the Altamaha (Suwannee) River, at Nashville, Ga." Jordan and Evermann [18] corrected the evident mistake and made it "the Allapaha — a tributary of the Suwannee River."

Anguilla chrysypa Rafinesque.

"Fish Eel," Eel.

We have no specimens of the eel but the natives describe it sufficiently well to warrant its inclusion in the list. They always termed it "fish eel" in contrast with the "snake eel" (*Amphiuma means*) and recognized its true fishlike characters. Occasionally they catch eels two feet long or more. It is considered uncommon in Billy's Lake and other deeper bodies of the swamp and a few have been reported from Suwannee river proper, according to the residents along it. (A specimen was collected by us in 1921.)

Umbra limi (Kirtland).

Mud Minnow, Dog-fish.

Smith [22] reports *Umbra* from a few localities in North Carolina and it is supposed that these localities mark the southern limit of the range of the family in America. Our specimen (8591) from the swamp therefore unquestionably increases the range of the genus.

In Jordan and Evermann's [18] account of the two American species *U. limi* (Kirtland) and *U. pygmaea* DeKay, it seems that the latter is "perhaps a variety" of the former though "no intermediate forms have been noticed." They distinguish between the two species primarily on the basis of coloration. *Umbra limi* is described as having a faint precaudal bar while that in *U. pygmaea* is distinct. The lower jaw in *U. limi* is pale in contradistinction to the black lower jaw of *U. pygmaea*. The color of *U. limi* is *dull* olive green while *U. pygmaea* is *dark* olive green and the former has pale cross bars while the latter has longitudinal streaks. *Umbra limi* is described as having pale longitudinal streaks as well as the cross bars but it is evident that the two species are quite close together. The question is complicated further by Gill [9] who in his monograph on the genus differs from Jordan and Evermann [18] in claiming that *U. pygmaea* is *light* olive green and *U. limi* is *dark* olive green. He mentions the longitudinal and vertical stripes as distinguishing characters but otherwise his descriptions of the two species are almost exactly identical. In summing up the situation then we have two authors who note very small differences between their species and who do not agree with each other in their comparison. Furthermore the distinguishing characters are based on coloration, a character which is admitted to be variable.

In view of the situation the material from Okefinokee, coming as it does from a hitherto unknown station, should prove of interest. We are unfortunate in that only one specimen of *Umbra* was collected. This was 2 inches long or 1¾ inches exclusive of the caudal. (Additional specimens were collected in 1921.) The jaws are not produced and are nearly equal. The lower one is if anything slightly longer than the upper. In these characters and in body measurements our specimen agrees most closely with the description of *U. limi,* the Western Mud Minnow, which is supposed to range from Quebec to Minnesota and south to Ohio river.

In regard to color, we find it difficult to place our specimen in the already established species. The color is, to be sure, olive green to brown, the color being deeper at the caudal extremity of each scale. The dorsal part of the body is, if anything, darker than the ventral but it would be difficult to describe the whole body as "dark" or "dull." If anything it is both. The gill covers are lighter in color than any other part of the body exposed in a lateral aspect. There is absolutely no indication of transverse stripes or vertical bars and it would seem to us that such characters are not sufficient to separate a species, particularly when both characters may appear in a given form. Gill [9] figures specimens of *Umbra* in which both streaks and bars are present. He does not himself name the species. There is a precaudal black bar with a fainter bar at the base of the fin, such as has been ascribed to both species. In our specimen this precaudal bar is very distinct, thus making the specimen agree more closely with the description of *U. pygmaea.* The lower jaw, on the other hand, agrees with that of *U. limi.* It is very pale beneath and dark but not *black* at the margin. The fins are slightly lighter in color than the body.

To sum up our findings, we would say that our specimen resembles *U. limi* in the body measurements and in the intensity of color of the precaudal bar. It has a lower jaw much like that of *U. pygmaea* and the range of *U. pygmaea* would lead us to expect it rather than *U. limi* in Okefinokee. Our specimen differs from the descriptions of both *U. limi* and *U. pygmaea* in regard to the lateral and vertical bars and stripes and inasmuch as Jordan and Evermann [18] and Gill [9] differ in regard to which species is the darker we cannot use this character effectively to any extent.

We are inclined to believe that Jordan and Evermann [18] are right in supposing that the *U. pygmaea* of De Kay is possibly a variation of *U. limi* (Kirtland) and in proposing that the two be grouped under the one species *U. limi* (Kirtland).

Esox americanus (Gmelin).

"Jack-fish," Banded Pickerel.

A study of the literature of *Esox americanus* (Gmelin) gives one a variety of concepts of the species. It is very similar to and we believe identical with *E. vermiculatus* Le Sueur. This opinion has been held by one of us for at least ten years. Apparently the main difference between the two supposed species is that *E. americanus* is always found east of the Alleghenies while *E. vermiculatus* is always found west of that range. To add to the confusion, we find that Gilbert [11] in writing of the Escambia river basin states that Hawkins creek, one of its tributaries, is the "easternmost record" for *E. americanus* while Jordan and Evermann [18] state that Escambia river is the "westernmost record" for the same species. Added to this, we find Bean [3] quoting Professor Cope as finding *E. vermiculatus* in Susquehanna river, although he adds that it is probably not native there.

Aside from the range, there is confusion in the descriptions of these species. Jordan and Evermann's [18] descriptions of the two differ primarily in that the head of *E. americanus* is 3 3/5 in length and the head of *E. vermiculatus* 3 1/4; the snout of *E. americanus* is 2 1/2 while that of *E. vermiculatus* is 2 1/5 in the head. They mention one supposedly clear cut difference, describing the eye of *E. vermiculatus* as "being exactly in the middle of the head; middle of eye nearer tip of chin than gill opening." This is manifestly a physical impossibility and can be of no value in comparison with *E. americanus* which has the "posterior margin" of the eye "scarcely behind the middle of the head, its middle nearer tip of chin than gill opening." The eye of *E. americanus* is described as being 2 2/3 in the head and that of *E. vermiculatus* as 2 1/2.

A composite of the measurements of these two species from five sources, (D. S. Jordan and B. W. Evermann,[18] T. H. Bean,[3] H. W. Fowler,[8] H. M. Smith,[22] and S. A. Forbes and R. E. Richardson [7]) shows the following:

	E. americanus	*E. vermiculatus*
Head measurements.......	3 + -3 3/5	3 1/5-3 1/2
Snout measurements.......	2 1/2-2 2/3	2 1/5-2 9/10
Eye measurements...	5 1/2-7	5 1/2-6 4/5

A glance at the above makes it evident that the head, snout or eye of *E. vermiculatus* may be larger or smaller than that of *E. americanus*. The characters are of little value. Our ten specimens show the following measurements: H. 2 5/6-3 1/5, Sn. 2 1/2-2 3/4, E. 5 1/2-7.

The fin formulae for the two species are identical or overlapping. Previous descriptions give the following: *E. americanus,* D. 11-14, A. 11-12; *E. vermiculatus,* D. 11-12, A. 11-12. Our specimens have D. 12-14, A. 11-13.

The color characters used to determine the species are almost invariably qualified as "usually", "sometimes", "about", "obscurely", "not distinctly" and the color is described as being "extremely variable." In view of this fact we can see no basis for recognizing two species on color characters alone, when color is so tricky in this genus, as many know who have worked with young of *E. lucius* and *E. reticulatus* and with adults of supposed *E. americanus* and *E. vermiculatus.*

An examination of the food of our ten specimens reveals crayfish and killifish as the major sources of prey.

Esox reticulatus (Le Sueur).

"Jack-fish," Green Pike, Chain Pickerel, Common Eastern Pickerel, Jack.

Only five specimens of this species are in our collection. While we were in the swamp the Lees caught several fine "jackfish." When the water is high this species is one of the forms which these people capture by "striking", a night method of fishing in the overflowed crossways and edges of the islands.

Fundulus cingulatus Cuvier and Valenciennes.

The recorded range of this form is from South Carolina to Florida. Our Okefinokee series of this species consists of ninety-five specimens of sixteen different collections. It is one of the most widespread species of the swamp and vies with Gambusia for the premier honors in abundance. Woolman [23] found it common in Santa Fe river of this same basin.

The difference between descriptions of *Fundulus chrysotus* Holbrook and *Fundulus cingulatus* Cuvier and Valenciennes in head, depth and eye measurements are so slight as to be non-distinctive.

This species was common in all the prairies and in every little pond or swampy spot in the islands or in transient pools which very quickly come and go. Like the other killifishes it is one of the main foods of the pikes, gars, and other fish carnivores of the swamp.

Fundulus nottii (Agassiz).

"Star-head Minnow," "Star-head."

It has been taken from South Carolina as well. In the Suwanee river basin, Woolman [23] took it in Santa Fe river to the south of the swamp and Jordan and Meek [19] describe it from Allapaha river, Nashville, Georgia, as *Zygonectes zonifer*.

We have only six specimens which might well be considered *F. nottii*. The natives know it as the "Star-head" and it is not uncommon in the swamp. The six longitudinal bands are very prominent and in most specimens the ten to twelve vertical bands are very obscure if not absent. One specimen (8714) has the coloration of *Fundulus zonifer* (Jordan and Meek) the types of which Taylor secured at Nashville, Georgia, in Allapaha river, a tributary of the Suwannee river system as is the Okefinokee swamp.

This Fundulus material shows how easily one might think of *Fundulus nottii* and *Fundulus zonifer* as intensely marked female and male *Fundulus dispar*.

These creatures are surface fishes of the prairies and have as associates *Lucania ommata, Fundulus cingulatus* (*chrysotus*), *Gambusia affinis*. This order is about the inverse of their relative abundance as revealed by our collections and observations. Our few specimens show the form to be widespread in the swamp.

Lucania ommata (Jordan)

We have sixty-three specimens of this rare form in thirteen different collections from the swamp. A description of this material has been reported [24]

Gambusia affinis Baird and Girard.

"Minnow" "Pieded Minnow."

This species ranges from Delaware to Mexico, along the Atlantic and Gulf coasts and is found in sluggish waters, brackish or fresh water indiscriminately. It is included in almost every fish list from these regions. In Florida, it has been collected from Escambia, Alligator, Peace, Hillsboro and Santa Fe rivers. Our series includes 283 (198 females and 85 males) forms which were collected in every month of the year and in most diverse places of the swamp.

In our material the dorsal is 7-9; anal 8-11; scales 29-34. The proportion of males to females in the whole 283 specimens was a little more than two females to one male, a high ratio of males as compared with most collections. In several separate collections when both sexes were taken they were about even, in others the ratios varied from one female to two males through two to one, three to one, to six and one-half to one. In some instances only females or males were collected. Very few of the females have the characteristic black spot above the vent. The presence or absence of the suborbital spot seems to be more or less independent of sex. We cannot agree with the statement that forms "from dark-colored water of swamps" are "with a distinct purple bar below eye." [22] Many of our specimens are without the suborbital spot. In Dr. Smith's figure of the male the caudal is represented as plain but some of our males have the three or four dark bars similar to the caudal of the female.

There was a group of ten mottled forms and we saw many of them in the swamp ("pieded minnow" of the natives). The whole side of body and fins is heavily blotched with black, the blotching being most notable on the caudal half of the body and on the caudal fin. At first we thought it might be a sexual character but six are males and four are females. Of this phase Löennberg [20] writes, "In some places certain varieties are predominant for instance Gambusia *patruelis* forma *melanops* in Lake Beauty not far from Orlando. This lake has rich vegetation and rather dark water. In clay springs and the sulphur springs round Lake Jessup melanistic forms were not scarce. It seems to be many more males than females struck by this melanismus which probably at least partly is due to the chemical composition of the water." The sexual suggestion does not apply in our material. These ten come from open prairies (Honey Island and Floyd's Island prairies), dense cypress ponds and other diverse places, also associated with normal forms. Peculiar localities or chemical composition of water cannot sufficiently explain it. These specimens certainly are of *Gambusia affinis* and are much more melanistic than those upon which Cope based his description of *Haplochilus melanops*.

In the middle of June we took several females with very advanced embryos and each female had from sixteen to twenty-five embryos. Some of the largest females in total length reached five or six centimeters.

Aphredoderus sayanus (Gilliams).

Pirate Perch.

Two specimens of the Pirate Perch were collected in the Okefinokee swamp.

Labidesthes sicculus Cope.

Brook Silverside, Skip-jack, Glass-fish.

Two specimens were taken at Mixon's Ferry, Suwannee river, June 18, 1912. These were taken by "striking" with a bush knife. F. Harper secured another on Chase Prairie, January 12, 1917.

Elassoma evergladei Jordan.

Pigmy Sunfish.

This diminutive species was collected at thirteen different times at various places in Okefinokee swamp.

This small fish is common on the islands, in cypress ponds, in hammocks, in crossways between islands and in more or less sphagnous bogs. At first we frequently mistook it for the young of a Centrarch.

Centrarchus macropterus (Lacèpéde).

"Shiner," "Sand Perch," "Sand Flirter," Flier.

Forty-eight specimens of this species of the Centrarchidae were collected in Okefinokee.

It is evidently abundant locally. It is reported in lowland streams and still waters from Virginia to southern Illinois and South to Louisiana and Florida.

Chaenobryttus gulosus (Cuvier and Valenciennes).

"Warmouth," "Perch," Goggle-eye.

We collected two specimens· The stomachs of these specimens were examined. The contents were however, badly mutilated. There seemed to be quite a quantity of mud mixed with crayfish claws in each case.

This species probably is the most common food fish of the swamp.

Enneacanthus obesus Baird.

Spotted Sunfish.

It is rather remarkable that our collection includes twenty-six specimens of this small and very beautiful sunfish. This is remarkable because of the fact that in lists of fishes collected from neighboring streams but two specimens of members of the genus have been reported. These come from Ogeechee river and one of the specimens is assigned to the species *obesus* while the other is classified as *gloriosus*. We believe that these species are synonymous and offer the following data to prove our contention.

We are not, however, the first to suggest this synonymy. Witness the following quotations. Abbott,[1] speaking of *E guttatus* and *E. obesus* says,—"We have very carefully searched for a trait characteristic of this fish as compared with *E. obesus* and have uniformly failed to do so." He allows them to retain their identity as species because they had "never been found associated." "The similarity of the two species," he says, "is so marked that unless living they can scarcely be distinguished," and considering the abundance of one and the scarcity of the other he suggests that *E. obesus* is washed down, occupies certain streams and drives out *E. guttatus*. He says that they are always found in streams with an unobstructed access to rivers. Holbrook,[12] in his descriptions of *Bryttus fasciatus* and *B. gloriosus* seems to separate them on the fact that the upper margin of the eye in the former is near the facial outline but does not encroach upon it while in the latter the upper margin of the eye is one-half the diameter of the orbit from the facial outline. By this token we would place all of our specimens in *B. fasciatus*. In his description of the dorsal fin of these two species he claims a formula of IX, 12 for *B. fasciatus* and IX, 11 for *B. gloriosus*. None of our specimens possess a dorsal formula of more than IX, 11 and all but five, (8654), (8655), (8647), (8639) possess a IX, 10 dorsal. The anal according to the same source is III, 11 in *B. fasciatus* and III, 10 in *B. gloriosus* and in our specimens but two have as high as eleven soft rays while nearly one-half of the remainder possess less than ten. Fin formulæ then would indicate that our specimens were *B. gloriosus*. Jordan and Evermann [18] claim that *E. obesus* and *E. gloriosus* are closely related but *apparently* not intergrading. They differ from Holbrook[12] as to the dorsal and anal formulæ thus adding weight to an argument that these are variable and consequently not of sufficient taxonomic importance to separate species, particularly on the basis of one or two soft rays. They separate the species on the grounds that the opercular spot of *E. obesus* is more than one-half the size of the eye while in *E. gloriosus* it is smaller. On this basis our seven largest specimens would all be *E. obesus* except (8640) and (8659) (mutilated). Otherwise, these two specimens are not greatly dissimilar from the other larger specimens. Jordan and Evermann [18] place *E. guttatus* (*Pomotis guttatus* Morris) and *E. obesus* as synonyms. *Bryttus fasciatus* is also given as a synonym of *E. obesus.* On the basis of the arguments given above we would place *E. gloriosus* also as a synonym.

Our specimens range in size from a specimen (8658) nine-sixteenths of an inch long to two specimens (8639) and (8640) 3¼ inches long· Our description of the species will be based for the most part upon Nos. (8652), (8644), (8639) and (8640). These specimens we believe include most of the variations represented by the collection.

The table below summarizes some important data on seven of the twenty-three specimens collected.

Date	No.	Anal Fin	Length	Depth	Head
June 18-20, 1912...........	8644	III, 9	2	2	3
June 24, 1912...............	8641	III, 9	2¾	2	3
June 15-Nov., 1912........	8659	III,10	incom.	2½	2½
June-Nov., 1912............	8660	III,10	1½	2—	2½
July 15-Nov., 1913.........	8652	III,10	1⅜	2½	2½
Jan. 1-Oct. 1, 1914.........	8640	III,10	3¼	1 4/5	2⅔
Jan. 1-Oct. 1, 1914.........	8639	III, 9	3¼	2¼	2⅔

It is interesting to note that using head measurements we would place (8640) under *E. obesus* and (8639) under *E. gloriosus* which is exactly the opposite to the classification which would be made on the basis of the opercular spot.

The fins of the species of *Enneacanthus* are very prominent but vary through such a short degree that they are not of great taxonomic importance.

Unfortunately our preserved specimens cannot give us much information as to the color of the body. Considerable variety is present, however, and in most cases there is a rather pronounced tendency for from six to ten vertical bars to appear on the sides. These bars are for the most part dark olive brown. Between these bars and in those forms without the bars the body is light olive brown.

Lepomis punctatus Jordan

"Stump-knocker," "Log Perch," Brim.

One specimen was collected at Billy's Island, June 6 to 7, 1912. The body is almost oval in form, the depth being contained two times in the length, and it is strongly compressed. The profile is quite steep before and behind and there is a slight depression above the eye. The dorsal profile is much more strongly arched than is the ventral.

The head is short and deep and is contained three times in the standard length. It tapers quite abruptly to the snout and is so compressed that its greatest width is contained 1¾ times in the length. The snout is contained 3½ times in the length of the head. The lower jaw is slightly longer than the upper and the mouth is set obliquely. In our specimen, there is no supplemental maxillary bone and this character would exclude our specimen from Jordan and Evermann's [18] interpretation of the genus *Apomotis*. Bean and Weed,[2] however, proved in the case of *Lepomis holbrookii* that the presence and absence of the supplemental maxillary was not of taxonomic value. Our specimen adds further proof to their contention. Inasmuch as this is the principal basis for the separation of the two genera we contend with Bollman and others that *Apomotis* and *Lepomis* should be combined under the name of the latter. The maxillary extends to a distance one-third through the eye. We are inclined to agree with Boulenger [5] who states that the rakers are short, and to differ from Jordan and Evermann [18] who describe them as "rather long, stiff and strong."

The ventral fins extend slightly beyond the source of the anal. In this respect our specimen differs from the description given by others. They do not reach the anal and are uniformly light brown to dusky. The caudal fin is dusky and only slightly emarginate.

Lepomis megalotis (Rafinesque).

"Redbreast," Long-eared Sunfish.

In spite of the fact that Smith [22] remarks that North Carolina is the southern limit of the range of this species, we found it in Okefinokee.

Lepomis pallidus Mitchill.

Blue gill Sunfish.

The general distribution of this species is from the Great Lakes region south to Texas and Florida.

The one specimen, (8635) which we have in our collection was sent out by the Lees in 1914. The palatine teeth are absent and the lower pharyngeals are broad and concave· The teeth on the lower pharyngeals are pointed not paved or rounded and this should place our specimen in the genus *Lepomis* not *Eupomo-*

tis, providing, of course, the latter genus should retain its identity. An excellent figure of the pharyngeal teeth of this species is given by Bean and Weed.[2] The width of the pharyngeal teeth is contained 2½ times in the toothed portion or midway between the two of *Eupomotis* and the three of *Lepomis* which Forbes and Richardson [7] use to separate the genera.

The fins are quite characteristic and have been used by some for taxonomic purposes. Boulenger [5] for instance separates his genera *Lepomis* and *Eupomotis* on the ground that the pectoral fins of the former are rounded and those of the latter pointed. By this token, our specimen would come under the genus *Eupomotis.* We have found already, however, that it has the pharyngeal teeth of *Lepomis.* We are not surprised then to find Boulenger [5] combining *Lepomis pallidus* and *Eupomotis pallidus.* We would think it advisable, however, to have placed them under the genus *Lepomis* rather than under *Eupomotis.* We notice that Smith,[22] McKay[21] and Bollman[4] combine the three genera *Apomotis, Eupomotis* and *Lepomis* under the one genus *Lepomis.* Our specimen, which has the pectoral fin of Boulenger's [5] *Eupomotis* and the pharyngeal teeth of *Lepomis,* should add weight to the advisability of combining at least two of these genera. Bean and Weed [2] were unable, unfortunately, to obtain specimens of the so-called *E. pallidus* when making their notes on the pharyngeal teeth of *Lepomis.* We believe that this may be due to the fact that, as Boulenger suggests, they are synonymous and, together with other writers already mentioned, we believe that the genius *Lepomis* proposed in 1816 should include the genus *Eupomotis* proposed in 1860. Our grounds for this, based on our specimen, are summarized as follows: It has pharyngeal teeth such as are ascribed to the genus *Lepomis* by Bean and Weed.[2] It has a pointed pectoral such as is ascribed to the genus *Eupomotis* by Boulenger.[5] It has the width of the toothed portion of the pharyngeals 2½ or midway between the width of two for *Eupomotis* and three for *Lepomis* which Forbes and Richardson [7] use as a criterion.

Lepomis heros (Baird and Girard)·

"Bream," Pumpkin-seed Sunfish.

Two specimens of this species were collected June 24, 1912, at a cypress crossing one-half mile from camp. This species is not generally considered as common and the range given for it by all authors classifies it as a southern form.

As in other sunfishes of the *Apomotis, Eupomotis* and *Lepomis* group one finds considerable ambiguity and difference of opinion as to the characters best describing the species.

The palatine bones are without teeth and the lower pharyngeals are broad and slightly concave. The teeth on the lower pharyngeals are rounded at the top not pointed as in *L. pallidus.* This characteristic, according to Jordan and Evermann,[18] should place our specimens in the genus *Eupomotis.* Other characters which others ascribe to the genus do not, however, agree with our specimen. Bean and Weed [2] figure the pharyngeals.

The fins, which have been of considerable taxonomic importance, are here interesting because they do not always agree with descriptions given. Boulenger [5] states that the pectorals are acutely pointed in the genus *Eupomotis* and not in *Apomotis* and *Lepomis.* By that token our specimens are *Eupomotis.* Jordan and Evermann [18] say that the pectorals of *Eupomotis* are longer than the head in all species except in *E. pallidus* and Forbes and Richardson [7] claim that the pectorals of *E. heros* reach to a vertical from the base of the last anal while in *E. gibbosus* they scarcely reach the front of the anal. Since the pectorals are shorter than the head and do not reach beyond the insertion of the anal and since the scale formulæ of our specimens do not agree with those of either *E. pallidus* or *E. gibbosus* it is patent that there must be some trouble. Since our specimens agree with the description of *Lepomis heros* Jordan and Gilbert in practically every respect other than those mentioned above it is believed that our specimens belong to that species. Our specimens show, then, that the length of the pectorals may be variable and consequently is not of the taxonomic importance placed upon it by some.

Micropterus salmoides (Lacepede).

"Trout," Large-mouthed Black Bass.

In our whole stay within the swamp (1912) we saw none of this species nor have the Lees sent us out any specimens. Just before our entrance into the swamp we saw some nice examples of "trout" (one foot long) which were caught in Suwannee river at Fargo where we were assured they were not uncommon. (This species was quite commonly collected by the party in 1921.)

Boleichthys fusiformis (Girard).

Darter.

The descriptions of this species are very confusing. We show in the discussion below conflicting statements not only in the description of *Boleichthys fusiformis* but in the original descriptions of *Poecilichthys quiescens* Jordan or *Copelandellus quiescens* Jordan [15] which appears in the Proceedings of the United States National Museum for 1884, page 478, together with the description of the same species which appears in Jordan and Evermann's Fishes of North America, page 1100. It was with some hesitancy that we compared these descriptions, but when it was all done the evidence against the separation of *Copelandellus* from *Boleichthys* was so strong that we are convinced that the former is a synonym of the latter. The most striking differences did not occur between the descriptions of *Boleichthys fusiformis* and either species description of *Copelandellus* but rather between the two separate descriptions of *Copelandellus.*

An examination of the characters given in these descriptions should show that the main differences between *Boleichthys fusiformis* and *Copelandellus quiescens* are that the former has a naked area on top of the head and a maximum of X spines in the dorsal while the latter has the top of the head scaled and a maximum of XII spines in the dorsal. If we are to believe the descriptions given by Jordan and Evermann [18] for *B. fusiformis* it is manifest that the scalation about the head is variable, for we read, "opercles, nape and breast usually well scaled, *sometimes* partly naked." Since this is a variable character it would seem to us unwise to separate species or genera fundamentally upon such characters. If the descriptions of other characters were consistent, we might be more prone to recognize *Copelandellus* but Jordan and Evermann's[18] description is at variance with Jordan's[15] original description to such an extent that one must question the accuracy of observation or the interpretation used. It is evident that there must be error when we read that the body is extremely elongate and not greatly elongate; the gill membranes are separated and yet united; and that there is a black humeral spot and no black humeral spot. Added to this is the assertion that the anal fin is finely barred and yet plain.

The presence of a maximum of XII spines in the dorsal of *Boleichthys* is easily accounted for. The original description of *Copelandellus* was made from a single specimen which may have had twelve spines. We believe this to be exceptional as of seven specimens collected by Woolman,[23] six had nine and one ten. Even if XII spines is characteristic of *Copelandellus* it should not be sufficient to separate it from *Boleichthys* for if we interpret Fowler's [8] formulæ correctly we find him attributing XII spines to *Boleichthys fusiformis*.

An examination of the figures of the two supposed forms should convince one of their identity, providing, of course, that the figures agree with the descriptions. Smith [22] places the two figures on opposite pages so that a comparison is simple. One of the characters which is considered as common to the two supposed species is the vertical rows of four spots at the base of the caudal and yet neither figure shows this character. *Copelandellus quiescens* is described by Smith [22] as having a barred anal fin and yet the figure omits this character. Our specimens show that the anal may be either barred or not. This is, therefore, not of great importance. Jordan and Evermann [18] describe a broad black lateral band in *C. quiescens* which the figures do not show and which we do not find in our specimens. Smith [22] describes three black bars below the eye in the same species while the figure shows but one large spot. The figures of *Boleichthys fusiformis* are also subject to criticism when compared with the descriptions although these are less noticeable than in *C. quiescens*. The most prominent of these exceptions is the already mentioned absence of vertical rows of spots at the base of the caudal. The species is claimed to be extremely variable by Jordan and Evermann [18] so allowances must be made. It should be evident that this variableness does occur when one attempts to reconcile figures with descriptions and with specimens.

A comparison of our specimens with the descriptions shows that in regard to the number of spines in the dorsal and the absence of scales on the head we should consider the darter of Okefinokee to be *B. fusiformis*. Inasmuch as we believe that we have shown these characters to be variable we regret but believe that *Copelandellus* cannot stand as a separate genus. The descriptions of *Copelandellus* are as variable as in the species *B. fusiformis* and since it is admittedly "an extremly variable form" we suggest the placing of *Copelandellus quiescens* (Jordan) in its synonomy.

We point out that our material comes from the same river system (Suwannee) as the type (Allapaha river, a tributary of the Suwannee) of *Copelandellus quiescens*.

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Department of Zoology,
Cornell University,
Ithaca, New York.

BIRD RECORDS FOR THE SEASON 1919-1920 IN THE VICINITY OF IOWA CITY

DAYTON STONER

Although the present report is based on notes and observations made, for the most part, in the vicinity of Iowa City, a few records are included from points some distance away. The records herein given cover the time between May 1, 1919, and March 10, 1920.

This paper does not purport to contain a complete list of the birds seen during this period but is a composite one made up largely of the more unusual findings of the season which have come to the writer's attention along with some notes on several of the more common species of the region. It is intended to supplement the information on migration and distribution which is already available and will, it is hoped, stimulate further local observations and studies in this branch of natural history.

Most of the observations have been made by the writer but acknowledgement is given in the proper places for whatever additional information has been furnished.

Among the more unusual and interesting records here reported are those of the Long-billed Dowitcher and Clarke's Nutcracker and the occurrence in winter of the Sparrow Hawk, Northern Flicker and Towhee.

Two important points with reference to bird distribution receive further corroborative evidence from the observations herein recorded: (1) The eastward dispersal of some of the typically western forms is further demonstrated; such an extension of range is to be noted also in other groups of animals of our state. (2) In spite of the fact that the past winter has been long and severe, some species not usually with us during the cold months chose to remain over. While the temperature has been extremely low but once, and below zero a comparatively few times, the local weather records show that between November 23, 1919, and February 20, 1920, not a 24-hour period passed when the mercury did not go as low as 32° Fahr. Usually at least one general thaw occurs during the winter. On February 8, 1920, the minimum was 32° and the highest maximum between November 23, 1919, and February 20, 1920, was 42° on November 9.

1. Bonaparte's Gull. *Larus philadelphia* (Ord). On October 29, 1919, a specimen in the flesh and showing typical immature plumage was sent the writer for examination by Miss Ruth Nissen, a teacher in the schools of Norway, Iowa. The bird was killed just south of the town of Norway in Benton county by some boys on October 27.

2. Merganser. *Mergus americanus* Cassin. An adult female in winter plumage, taken at Iowa City, November 19, 1919, was brought into the laboratory of Prof. H. R. Dill. In addition to this record Professor Dill has kindly furnished several others herein mentioned and a number of specimens here recorded have been mounted by him and are in the University Museum.

3. Long-billed Dowitcher. *Macrorhamphus griseus scolopaceus* (Say). An adult male which the writer had the privilege of examining was killed along the Mississippi river near Muscatine on October 27, by Dr. L. W. Dean. The specimen is in the typical winter plumage.

4. Ruffed Grouse. *Bonasa u. umbellus* (Linn.). Two specimens, a male and a female, were taken by F. E. Horack early in December, 1919, in the woods near Wray's crossing about ten miles north of Iowa City. Both birds are mounted and are in the University collection. While this form is rare in this region, one is not unlikely to come across a single individual or a pair in or near heavily wooded areas.

5. Ferruginous Rough-leg. *Archibuteo ferrugineus* (Licht.). A male which had been caught in a steel trap was sent to the University Museum December 7, 1919, by A. F. Rahfeldt of Zearing, Iowa. This is another bird characteristic of western United States which only occasionally straggles into Iowa. It is reported as accidental in Illinois (Cory).

6. Golden Eagle. *Aquila chrysaëtos* (Linn.). One individual of this species was shot near Solon in Johnson county about October 10, 1919. Occasionally a specimen of this bird is seen in the region and if the observer carries a gun the number of golden eagles in the state is usually decreased by one. Although the statement is trite it may be worth repeating here that 'the shooting of large and striking birds should be discouraged.'

7. Sparrow Hawk. *Falco s. sparverius* Linn. One example of this species, a male, was seen by the writer on December 26, 1919, along a wooded roadside about one-half mile west of Iowa

City. Anderson (Birds of Iowa, 1907, 257) lists this form as a common migrant in all parts of the state and a somewhat less common summer resident. He records a male taken at Iowa City, November 28, 1905. Bailey (The Raptoral Birds of Iowa, 1918, 170) indicates that this bird is rarely found in the state during the winter and mentions one specimen that was killed at Cedar Rapids in January.

8. Barn Owl. *Aluco pratincola* (Bonap.). An adult male was taken at Iowa City, November 1, 1919, by W. F. Kubichek.

9. Screech Owl. *Otus a. asio* (Linn.). A not uncommon winter resident about Iowa City, one individual frequenting a hollow maple tree near the writer's home all during the winter.

10. Red-bellied Woodpecker. *Centurus carolinus* (Linn.). This form has been noted in unprecedented numbers during the past season and several individuals have been seen at local feeding stations during the winter.

11. Northern Flicker. *Colaptes auratus luteus* Bangs. On December 26, one individual was seen in the woods along Iowa river a mile south of Iowa City. Although this form has been recorded locally a number of times in winter it is not commonly observed at that season. Anderson (*l.c.*) says that this form is but rarely seen in Winnebago county and Spurrell (Wilson Bulletin, XXI, No. 4, 1919, 120) gives it as a rare winter resident in Sac county. Stephens (Proceedings Iowa Academy Science, XXIV, 1917, 250) says: "This is not a common winter species" [in northwestern Iowa]. He records three specimens seen in January and four in February.

12. Clarke's Nutcracker. *Nucifraga columbiana* (Wilson). On November 30, 1919, an adult male was taken by A. W. Hemphill, near Tiffin in Johnson county about eight miles west of Iowa City. This is a bird of the western coniferous forest areas of North America and, so far as the writer is aware, this is the second specimen recorded from the state. The first record of the occurrence of this form within our borders was published by Prof. C. C. Nutting in 1895 (Proc. Ia. Acad. Sci., II, 1894, 44). The single specimen recorded at that time was taken at Boone, September, 1894, by C. F. Henning. It is now in the collection of the museum of the State University. The specimen here recorded is deposited for the present in the University Museum. General color almost uniform gray, a little lighter on the head and without brownish tinge.

13. Red-winged Blackbird. *Agelaius p. phoeniceus* (Linn.).

During the spring of 1919 this species was more than usually abundant in the vicinity of Iowa City and one of the places most frequented was a mud flat about 100 yards long by 20 yards wide on the west bank of the Iowa river just west of the University campus. This flat is thickly grown up with small willows and long, heavy water-grass and rushes grow in a tangled mass around them. Here, morning after morning, in late March and early April the noise made by the thousands of red-wings seemed almost deafening as one stood among the trees. And in the early morning before the birds began flying away to feed, the trees, grass and reeds seemed literally black with them. The sudden and uniform cessation of singing at irregular intervals when groups of twenty-five to one hundred birds rose in the air and flew slowly away was particularly noticeable. It was estimated that over 5,000 birds roosted in this small area when the number was at its maximum. Usually by 7:30 A.M. comparatively few of the birds remained and after April 3 fewer and fewer of the birds returned each succeeding evening.

It seems likely that the abundance of this as well as many other species of our common birds may be attributed, at least in some measure, to the dissemination and influence of knowledge relative to the value of our birds and a consideration of the laws that have been enacted to protect them.

14. Baltimore Oriole. *Icterus galbula* (Linn.). Ordinarily this bird arrives at Iowa City about May 6 to 8 but in 1919 several specimens were observed on May 2. This is the writer's earliest spring record for observations lasting over a period of seven years.

15. Bronzed Grackle. *Quiscalus quiscala aeneus* Ridgway. In the early autumn of 1919 this species appeared in unusual numbers about Iowa City and a great flock roosted each evening in the willow trees above described where the red-wings held forth in the spring. In late afternoons and early evenings groups of from a dozen to as many as 300 could be seen making their way to this roosting place. In the morning they were off again dispersing in all directions.

Groups of a hundred or more often visited the lawns in town. Flying down *en masse* from the tree tops they would begin at one end of a lawn and work across it rapidly, searching under the leaves and grass and no doubt in this way destroying thousands of insects and their larvæ. Never before had the writer observed this species in the city in such numbers; the notable increase may be due in large part to the influence of bird protection propaganda which has been spread broadcast.

16. Purple Finch. *Carpodacus p. purpureus* (Gmel.). Small flocks containing both males and females have been observed all winter just west of town by Dr. R. W. Chaney. They were often to be seen with the goldfinches which frequented that locality.

17. Harris's Sparrow. *Zonotrichia querula* (Nutt.). An adult male in winter plumage was taken at Iowa City, November 11, 1919, by Russell Hendee. This species seems to be a rather rare and irregular spring and fall migrant in this part of the state.

18. Cardinal. *Cardinalis c. cardinalis* (Linn.). During the autumn of 1919 this species seemed less common than usual about Iowa City and the writer heard it but once between September 1 and October 17. However, during the past winter the birds have been plentiful enough and on a six hour field trip in late December ten individuals were seen.

19. Rose-breasted Grosbeak. *Zamelodia ludoviciana* (Linn.). At Iowa City the first arrivals in the spring of 1919 were noted on May 2, an unusually early seasonal record. Ordinarily they arrive from three to six days later.

20. Bohemian Waxwing. *Bombycilla garrula* (Linn.). One specimen, a female, was taken from a flock of four individuals seen at Brooklyn, Iowa, February 21, 1920. The specimen is now in the University collection. This species is very erratic in its appearance and irregular in its distribution. While it has been reported in most sections of Iowa these records have been mostly from the northern part of the state.

21. Cedar Waxwing. *Bombycilla cedrorum* Vieill. A flock of about twenty individuals was observed on North Capitol street just north of the University campus on March 9, 1920, by Mrs. C. B. Wilson. This form is also somewhat irregular in its appearance but at least a few are seen here every spring and fall.

22. Myrtle Warbler. *Dendroica coronata* (Linn.). At 8:00 A.M. on May 2, 1919, the writer, while walking along the banks of Iowa river west of the City Park at Iowa City, noticed a considerable number of myrtle warblers busily pecking in the sand under a large elm tree; this group was joined from time to time by other individuals. At the beginning of the observation the

group was composed of from twenty to twenty-five birds, one female myrtle warbler, one female black-throated green warbler and the rest of the company of male myrtle warblers.

So busily were the birds engaged that the observer approached within a few feet of them and watched them for several minutes. After examining the sand closely for insects and for the seeds of trees or plants the writer was led to the conclusion that the birds were eating minute grains of sand probably to assist the crop in the comminution of food. Never before had the writer observed this habit in the species.

23. Red-breasted Nuthatch. *Sitta canadensis* (Linn.). This species has been increasing in numbers in and about Iowa City and is occasionally seen during the winter. The writer's first autumn record was October 27, 1919.

24. Robin. *Planesticus m. migratorius* (Linn.). Robins were common about Iowa City until October 15, 1919, the autumn up to this time having been unusually warm and with but two or three light frosts. In spite of the severity of the past winter a few remained over. Mrs. C. B. Wilson reports that one individual visited her feeding table consistently all through the fall and winter.

25. Bluebird. *Sialia s. sialis* (Linn.). This species was with us until late in the fall. A flock of between fifteen and twenty is reported near Sharon, about ten miles south of Iowa City on February 13, 1920, by Dr. C. S. Grant.

Department of Zoology,
State University of Iowa.

AN INTENSIVE ORNITHOLOGICAL SURVEY OF A TYPICAL SQUARE MILE OF CULTIVATED PRAIRIE

ARTHUR R. ABEL

The present paper is a report on an intensive ornithological survey of a typical section of prairie farm land in northwestern Iowa. In making the survey several objects were in view. Besides merely making a census, it was hoped that some light might be thrown on the relation of birds to various crops, the effect of constant tillage on bird life, etc. It was thought that the exact data accumulated now would furnish a basis for comparison at a future time. With some such means of measuring the actual increase or decrease of the bird population, we will be in a better position to determine the problems of our bird life.

Methods.—It was first planned to divide the section into twenty-four equal strips, extending east and west; and it was expected that one trip through each of these strips would be sufficient to gather complete information as to the number of birds within its area.

However, when the work was begun it was found that the birds were very unequally distributed, that certain areas were without any individuals, while other areas were densely populated. Consequently greater attention was given to the latter areas and less to the former, which consisted chiefly of corn-fields. It is possible that a very few birds may have been missed (not over half a dozen) in the corn-fields because of their being less carefully worked. There was another chance for error in the region of the swamp; for here the slough grass was so dense and high that a few sparrows may have been overlooked. However, for the greater part of the section the results are reasonably accurate.

Topography.— The section selected for the study is about three miles southeast of Sioux City, and forms a part of the W. A. Hickman farm. For identification its location is given thus: section 11, Woodbury township, T. 88 N., R. XLVII W. This particular section was chosen because it was believed to be typical of the upland prairie, as distinguished from the lowland prairie, or river bottom. It was the "rolling prairie" of the earlier days, when it was covered with the native prairie grass. The northeast quarter is crossed diagonally by a creek which drains from the southeast to the northwest. In the summer only a small rivulet of water flows through this. But in the spring there is usually an overflow which inundates a considerable surface in this quarter, and converts it into a dry slough; that is, one which is wet in the spring and early summer but becomes dry later. The slough grass in this area grows to a height of six feet, and is usually mowed for hay. The ground has never been cultivated. This uncultivated slough has an area estimated at about eighteen acres.

The other three-quarters are practically alike topographically. There is no level stretch, but the surface is alternately high and low with gentle slopes intervening. These areas were under cultivation or used as pastures.

Figure 63 is a diagram of the section as it was planted to crops at the time the survey was made, viz., July 25 and 26, 1916.

Crops and Habitats.— The untilled portions of the section

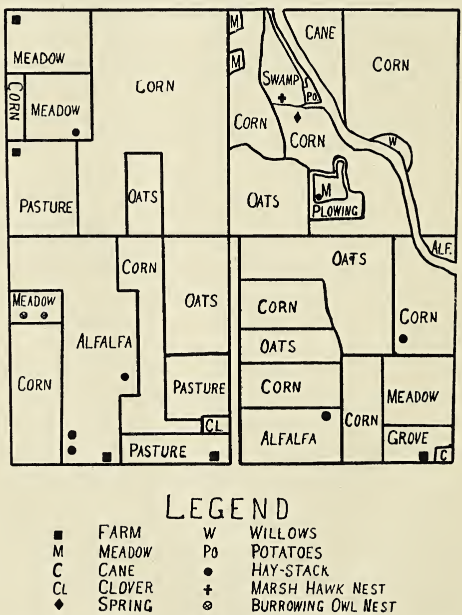

Fig. 63. Diagram of the surface of the section studied showing the crop plantings and certain topographical features. In general, it also is a diagram of the ecological habitats of the area.

were of four kinds: (a) swamp and creek; (b) artificial grove and orchard; (c) pasture; (d) meadow. The slough has already been described sufficiently. The grove was composed of large maple trees with a few boxelders; these had been planted to serve as a windbreak. The orchard consisted of about fifty small, scraggly apple trees. The term "meadow" is used for the areas from which cattle were excluded and from which hay is cut. The term "pasture" is applied to those grass fields in which horses and cattle are allowed to graze.

The principal crop was corn, there being about two hundred and ninety acres of this out of the total of six hundred and forty. The next largest acreage was in oats. And it will be noted from the table that the percentage of bird life in both these areas was very low.

The crops were all mature or nearly so. Corn was over-head high, but still green. The corn fields were so hot and dusty that to walk through them at mid-day was very uncomfortable. And it is likely that they were just as uninviting to the birds as they were to man. The cane field was about four feet high, and so dense that in walking through it one constantly stumbled in the thick growth. The oats and alfalfa were all harvested, with the exception of one field (of probably fifteen acres) of alfalfa.

Distribution.— The total number of birds found on the section was four hundred and eighty. This included thirty-two species with the Dickcissel leading numerically. Following the Dickcissel in order of abundance were the English Sparrow, Western Meadowlark, Barn Swallow, and Bank Swallow. With one exception the birds were not found in flocks, but were more or less evenly distributed in pairs and small groups. However, one mixed flock of Barn and Bank Swallows was found circling low over an alfalfa field which was being mowed at the time. These birds probably were attracted by insects arising from the newly cut alfalfa.

One fact of interest is demonstrated by the density map. This shows very well that the greatest number of birds was found along the roadsides, along the creek, and near farms. The creek probably attracted birds by means of the shade and water which it provided. The farm yards furnished food and nesting sites for the numerous English Sparrows. But the cause of the dense population along the roadsides is not so easy to explain. It might be assumed that the birds were attracted to the brush and weed thicket along the fences; but this is not a sufficient

Fig. 64. This may be called a population density map, and becomes intelligible when superimposed upon the habitat map.

explanation, because of the fact that the fence rows between grain fields did not seem to be especially rich in bird life. Of course the untilled strip between the fields was not as wide as that along the roads, nor did it, as a rule, contain as varied a group of plants. In these respects the roadsides would have an advantage. Besides these factors there might be mentioned the telephone poles along the roads which offered nesting sites to such birds as the Flicker and the Red-headed Woodpecker. The Dickcissel also was very frequently seen perching on the telephone wires; and it is possible that many of the numerous Dickcissels thus noted came to the wires from farther back in the fields. The same reasoning might also be applied to several other species as well. However, I do not think it can be denied that the strip of untilled and relatively undisturbed ground along the fence and road was so well adapted to nesting and feeding that birds were drawn to it. Perhaps the fact of greater density along the roadsides, as distinguished from the fence rows within the section, needs verification. This phase of the problem was not particularly in mind when the work was done.

Table I gives a summary of almost all the data taken during the survey. The species are listed from top to bottom in order of their abundance. The crop and habitats are given at the top of the table. Thus by tracing over from the name of the species its abundance in a given crop may be found. The list is headed by the Dickcissel, which was, as may be seen from the table, very generally distributed over the section. The English Sparrow stands second in rank largely because of its abundance around farms. The large flock of Barn and Bank Swallows already mentioned accounts for their position near the top of the list. No birds were recorded for the potato, cane, or clover fields. The list of thirty-three species may be regarded as a typical list of this locality's summer birds.

Table II shows the acreage of each crop and habitat. The acreage is, of course, estimated, but is based upon the testimony of those familiar with the land. The number of birds in each habitat is also given, as well as the ratio of the birds to the area, and the number of birds per acre. Several interesting facts are shown, among them being the one that in the farm yards there were twice as many birds per acre as in the pastures. Each bird in farm yards had one-fifteenth of an acre to itself as contrasted with the birds in the corn-fields, where each bird had fifty acres to forage over. The table also shows that the average number of birds per acre, taking the entire square mile into account, was three-fourths of a bird per acre; or, putting it differently, each bird had an average of one and one-third acres to itself. The only birds found in or near corn fields were Dickcissels. The small number (five) seems to show that the corn was not inviting even to this well distributed species.

Oats had a slightly larger number, but the average per acre was very small. The oats had just been harvested, and it might be expected that the field would contain more than the alfalfa fields. However, this was not the case either as to individuals or as to species. Large numbers of Swallows were flying over the alfalfa; and Dickcissels, Field Sparrows, and Meadowlarks were quite numerous. Pastures were excellent feeding places. The average per acre in meadows was slightly larger than in the pastures. The bird life in the two habitats was very similar, however. Such birds as the Grasshopper Sparrow and Prairie Horned Lark were found in the meadows. The meadows were well adapted to the nesting of Sparrows and Larks, as well as to the Burrowing Owls.

The swamp and creek were very attractive to bird life. Not only did birds breed there in considerable numbers, but it served as a shelter from the hot sun and a source of drinking water.

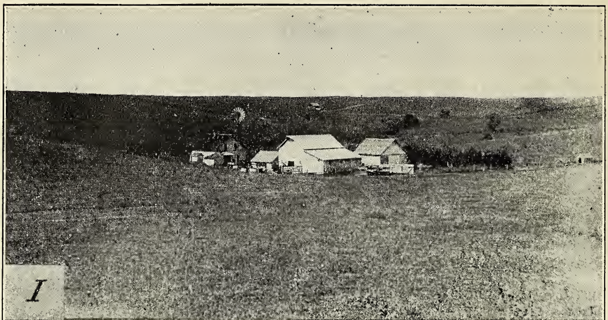

Fig. 1. A photograph which shows the rolling character of the area.
Fig. 2. A cornfield is dense, and while it may not be called impenetrable, the results of the present study show that it is not frequented by birds.
Fig. 3. A view of the willow thicket along the creek. It affords shelter, concealment and nesting sites, with water near by.

Red-winged Blackbirds were common in the swamp, and a pair of Marsh Hawks had a nest there.

Several birds were feeding in the plowed field, among them being the Prairie Horned Lark and Field Sparrow. The young apple trees in the orchard contained many birds. Some of them were feeding in the foliage, others were merely resting in the branches. The grove had a representative group of woodland birds, such as the Flicker, Bluejay, Red-headed Woodpecker and Chickadee.

In closing I wish to express my obligations to the W. A. Hickman family for their kind hospitality, and to Prof. T. C. Stephens for the suggestion of undertaking the work and for aid during its progress.

Department of Biology,
Morningside College,
Sioux City, Iowa.

TABLE I. SUMMARIZING THE CENSUS BY CROPS

	Farm	Roadsides	Grove and Orchard	Alfalfa	Pasture	Oats	Meadows	Plowing	Corn	Swamp and Creek	Flying	Clover	Cane	Total
1. Dickcissel	..	11	3	18	5	7	12	..	5	10	2	..	..	73
2. Western Meadowlark	..	2	..	9	16	9	6	..	..	..	6	..	..	48
3. Barn Swallow	2	..	..	35	2	..	2	..	..	..	2	..	..	43
4. Bank Swallow	..	..	..	40	..	..	2	..	..	..	..	..	..	42
5. Kingbird	6	2	3	4	14	..	..	..	..	..	..	..	..	29
6. Goldfinch	..	..	..	11	4	..	3	..	..	2	3	..	..	23
7. Red-winged Blackbird	..	..	..	..	..	..	..	..	..	21	..	..	..	21
8. Mourning Dove	..	2	..	..	2	..	2	..	..	2	9	..	..	17
9. Prairie Horned Lark	..	..	..	..	2	..	8	5	..	..	..	..	..	15
10. Field Sparrow	..	4	1	7	1	..	..	..	..	..	..	..	..	13
11. Grasshopper Sparrow	..	2	..	..	2	..	7	2	..	..	..	..	..	13
12. Robin	..	2	1	3	1	..	..	..	..	1	1	..	..	9
13. Red-headed Woodpecker	..	5	2	..	..	1	..	..	..	..	..	..	..	8
14. Maryland Yellowthroat	..	..	..	..	..	..	..	..	..	7	..	..	..	7
15. Cowbird	..	..	..	2	..	..	..	..	..	1	3	..	..	6
16. Flicker	..	2	2	..	1	..	..	..	..	..	..	..	..	5
17. Burrowing Owl	..	..	..	..	..	..	5	..	..	..	..	..	..	5
18. Chickadee	..	..	5	..	..	..	..	..	..	..	..	..	..	5
19. Marsh Hawk	..	..	..	..	..	..	..	..	..	2	3	..	..	5
20. Yellow-billed Cuckoo	..	1	1	..	..	..	..	..	..	2	..	..	..	4
21. Brown Thrasher	..	3	..	..	..	..	..	..	..	..	..	..	..	3
22. Bluejay	..	..	3	..	..	..	..	..	..	..	..	..	..	3
23. Yellow Warbler	..	..	..	..	..	..	..	..	..	2	..	..	..	2
24. Indigo Bunting	..	..	..	..	..	..	..	..	..	1	..	..	..	1
25. Screech Owl	..	..	..	..	..	..	..	..	..	1	..	..	..	1
26. Lark Sparrow	..	..	..	..	1	..	..	..	..	..	..	..	..	1
27. Catbird	..	..	..	..	..	..	..	..	..	1	..	..	..	1
28. Bronzed Grackle	..	..	..	..	..	..	..	..	..	..	1	..	..	1
29. English Sparrow	55	..	..	..	..	..	..	..	..	..	5	..	..	60
30. Unknown	..	..	..	..	2	..	..	..	..	3	8	..	..	13
31. Swamp Sparrow?	..	..	..	..	..	..	..	..	..	1	..	..	..	1
32. Cuckoo sp.	..	..	1	..	..	..	..	..	..	..	..	..	..	1
33. Shrike sp.	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Totals	63	36	22	129	53	17	45	7	5	59	44	..	..	480

TABLE II.

	Corn	Oats	Alfalfa	Pasture	Meadow	Grove and Orchard	Cane	Creek and Swamp	Plowing	Farm	Clover	Potatoes	Roadside	Flying	Total
Acres per Crop..........	290	111	70	70	45	14	12	12	7	6	2	1	0	0	640
Birds per Crop..........	5	17	129	53	45	22	0	59	7	63	0	0	36	44	480
Birds per Acre..........	.017	.15	1.84	.075	1	1.51	0	4.91	1	10.5	0	0	..	..	.75
Area per Birds in Acres..	58	6.5	.54	1.32	1	.63	..	.20	1	0.95	..	..	..	..	1.33

BIRD RECORDS OF THE PAST TWO WINTERS, 1918-1920, IN THE UPPER MISSOURI VALLEY

T. C. STEPHENS

The area here considered includes northeastern Nebraska, northwestern Iowa, South Dakota, and southwestern Minnesota. From scattered points throughout this region specimens have been sent in to A. J. Anderson to be mounted, and it is through his courtesy that many of the records are here presented. Local records, in the vicinity of Sioux City, are made by the writer unless otherwise credited.

The winter of 1918-1919 presented a minimum of ornithological interest, locally. The usual winter birds were here, but practically none of the less common smaller birds were noted. Among the larger birds a number of valuable records were obtained, both locally and from the surrounding area. Perhaps the most important for this season are those of the Duck Hawk, Snowy Owl, White-winged Scoter, etc.

The winter of 1919-1920 was much richer in its yield of material. Attention might be especially called to the flight of Bohemian Waxwings, and the records of the Crossbills, the Magpies, the Kingfisher, and the Tufted Titmouse. Among the larger birds which are especially noteworthy are the Common Tern, the Laughing Gull (though both of these are rather early to be considered as winter records), the Surf Scoter, the Red-breasted Merganser, and the hybrid duck. Concerning the latter specimen, the writer is very much indebted to Dr. C. W. Richmond for otherwise inaccessible information, and also for permission to present it in this paper.

Many of the common birds which are found every winter are not mentioned in the following list.

1. Pied-billed Grebe. *Podilymbus podiceps*. This species was seen at McCook Lake, South Dakota, as late as November 2, 1919, and November 10, 1918 (Allen).

2. Loon. *Gavia immer*. The Loon is seen on the lakes in this locality only as a migrant, and is not at all common. On April 19, 1919, Mr. Anderson mounted one which had been sent in from Le Mars, Iowa. And on Nevember 15, 1919, another was

sent in from Badger Lake, Monona County, Iowa. Both were females.

3. Laughing Gull. *Larus atricilla*. On September 29, 1919, Mr. A. F. Allen found the carcass of a recently killed gull in immature or winter plumage at Lake Goodenough, Union County, South Dakota. Considerable difficulty was experienced in identifying this specimen, and the writer, though now satisfied, is subject to correction in the above determination. It is deemed advisable to publish the chief diagnostic characters, since this is the first local record of this species.

The back is pearl gray; the wings, except the primaries, are similar, but with more of an ashy tinge. The head is mottled, the forehead having more white; the nape is blackish; the back of the neck between nape and back, is grayish. The throat, under neck, and all underparts are pure white — no pinkish being noticeable. The tail is white above, with a sub-terminal black band of one inch width, and very slightly tipped with white. The eye is margined above, below, and behind with white, making three-quarters of an eye-ring; the other quarter of the eye-ring in front is distinctly black. The first and second primaries are wholly black, or blackish, except for a visible white spot at the tips scarcely as large as a pin-head. The other primaries (third to sixth) are also black with a distinct white tip, the latter increasing slightly in area to the size of the nail of the little finger. The feet were black; the bill is black now, though Mr. Anderson describes it as of "dark umber" color when fresh. The sex was undetermined.

In the diagnosis *franklini* and *philadelphia* have been excluded because of the color of the primaries; *sabini* has been excluded because the tail is not forked.

4. Common Tern. *Sterna hirundo*. On October 5, 1919, Mr. Anderson received and mounted a Common Tern which had been sent in from Le Mars, Iowa. This is the only authentic specimen of this species of which I know for northwestern Iowa. The relative abundance of *fosteri* and *hirundo* can be determined only by taking a larger number of specimens.

5. Double-crested Cormorant. *Phalacrocorax auritus*. The writer saw a mounted specimen of this species among a small collection in one of the cottages at Crystal Lake, Dakota county, Nebraska. The young man who had mounted it said that it had been shot at Crystal Lake in the fall of 1919, the exact date not being remembered.

6. Red-breasted Merganser. *Mergus serrator.* On November 25, 1919, Mr. Anderson received two mergansers from Wakefield, Nebraska. One of the specimens was clearly a female of *americanus,* having a deep red color on the head, with no gray; the bill was one and seven-eighths inches long, with one and three-eighths inches between the tip and the nostril. The other specimen was quite different. The plumage on the crown of the head contained some gray color; the bill was two and a quarter inches long, with one and five-eighths inches between the tip and the nostril. This specimen, we concluded, was a female of *Mergus serrator,* which makes about the sixth specimen of this species which Mr. Anderson has mounted.

7. Hooded Merganser. *Lophodytes cucullatus.* On November 11, 1918, Mr. Anderson received and mounted a male taken at Brown's Lake, Woodbury county, Iowa. On October 31, 1919, he received two females and an immature male from the same locality. And on November 3, 1919, he received a male which had been taken a short distance up Big Sioux river.

8. Hybrid. On November 4, 1919, two birds flying together (as reported) along Big Sioux river were shot by a hunter, who had them both mounted. One was a Black Duck, and the other proved to be an interesting hybrid between the Mallard and the Muscovy Duck. This bird was thirty-three inches long (tip of tail to tip of bill), and weighed six and a quarter pounds. The length of wing was thirteen and three-fourths inches; culmen, two and one-fourth inches; width of bill, one and one-eighth inches. The hind toe is lobed.

The head, back and upper tail are blackish with dark green iridescence. The breast is dark chestnut brown, grading darker above and lighter below. The belly is whitish, mottled heavily with black. A description, with samples of the plumage, was submitted to the Smithsonian Institution for identification. A very full reply was received from Dr. Chas. W. Richmond, Associate Curator of Birds, which, by kind permission, is reproduced, in large part, herewith.

"In reply to your letter of the 7th, enclosing sketch of a strange duck, I beg to say that there is little doubt that the bird represents what is known as a hybrid between the Muscovy Duck and the Mallard. Specimens of this hybrid are not common, and appear to be usually found in a wild state, though the cross must occur in a state of captivity, inasmuch as the breeding ranges of the wild birds are separated by hundreds of miles.

"The bird was first described in England by Donovan, in 1818, as *Anas bicolor;* later from the Continent by Schinz (1837) as *Anas purpureo-viridis;* by Bonaparte in 1841, as *Anas aeneo-rufa*; Gosse named it from Jamaica, in 1847, as *Anas maxima*; Bell called it *Fuligula viola* in 1852, from New York, and Philippi in 1860 named it *Anas iopareia,* from Chile.

"It thus appears to have been found in the Old World, where the Muscovy does not occur in the wild state, and it is not at all improbable that some, at least, of the crosses have been between domestic ducks and Muscovies; possibly all of them, as there is quite a range of variation in the colors of the various specimens. . . . All of the birds I have seen have been very large."

In a later letter the same correspondent adds that he has "since been informed that some observers have seen these birds in a domestic state, but our taxidermist, Mr. N. R. Wood, tells me that while he has seen hundreds of them in domestication, they all showed the characters of the Muscovy, and were probably crosses between the male of that species and the female of the mallard or the domestic bird. Possibly the wild birds that crop up from time to time are crosses between the female Muscovy and the male of the other."

9. Black Duck. *Anas rubripes.* In a preceding paragraph mention is made of a Black Duck taken up along Big Sioux river on November 4, 1919.

10. Wood Duck. *Aix sponsa.* Mr. Anderson mounted two specimens, as follows: a male, taken at Brown's Lake, Iowa, October 14, 1919; a male, taken at Lake Goodenough, South Dakota, September 22, 1919.

11. Ring-necked Duck. *Marila collaris.* One taken at Brown's Lake by a hunter on October 26, 1919, and mounted.

12. Bufflehead. *Charitonetta albeola.* The following specimens were mounted by Mr. Anderson:

November 6, 1918, a male from Orchard, Nebraska.
October 14, 1919, one from Winside, Nebraska.
October 31, 1919, one from Winside, Nebraska.

13. White-winged Scoter. *Oidemia deglandi.* An immature male was taken at Brown's Lake on December 3, 1918, by a hunter; mounted by Mr. Anderson, No. 3306.

14. Surf Scoter. *Oidemia perspicillata.* Mr. Anderson received a female specimen of this species from Mr. O. W. Remer, of Le Mars, Iowa, on November 16, 1919. The bird was taken

at Blue Lake, Monona county, Iowa. It was mounted as No. 3514, and probably still remains in Mr. Remer's private collection.

15. Whistling Swan. *Olor columbianus.* Three specimens are to be recorded as follows:

November 1, 1919, a female from Dakota City, Nebraska. No. 3489.
November 7, 1919, a female from Winside, Nebraska. No. 3497.
November 20, 1919, (sex ?) from Valentine, Nebraska. No. 3517.

16. Trumpeter Swan. *Olor buccinator.* (?). A swan was brought to Mr. Anderson on November 19, 1919, which he identified as *buccinator.* It was shot along the Nebraska side of the Missouri river between South Sioux City and Dakota City on, or about, November 14. When received by Mr. Anderson it was in too bad shape to mount, but he took the following description: Length of bill, three and seven-eighths inches; tip of bill to nostril, two and one-eighth inches; no yellow spot on the bill; number of tail feathers, fourteen. These points are not conclusive, of course; but Mr. Anderson felt quite sure that this bird differed from *columbianus,* of which he had three specimens on hand for comparison. He has also mounted *buccinator* in previous years. The facts are here presented for what they are worth.

17. Black-crowned Night Heron. *Nycticorax nycticorax naevius.* On October 19, 1919, Mr. G. O. Ludcke saw a large number of these herons at Woonsocket, South Dakota. He estimated that there must have been two hundred, at least, roosting in the tall grass, there being no trees in that vicinity.

18. Sandhill Crane. *Grus mexicana.* On September 15, 1918, a Sandhill Crane was shot near the "High Bridge" over the Missouri river, within the city limits of Sioux City, and delivered to Mr. Anderson. It was too badly damaged for mounting.

19. Avocet. *Recurvirostra americana.* On September 28, 1918, three of these birds were shot out of a flock of eight at a point about thirty miles southwest of Atkinson, Nebraska. All three were mounted by Mr. Anderson.

20. Wilson's Snipe. *Gallinago delicata.* Mr. G. O. Ludcke saw a large number of these birds on the bottom land near Hornick, Iowa, on September 26, 1919.

21. White-rumped Sandpiper. *Pisobia fusicollis.* A great many were seen at Lake Goodenough on September 22, 1919, by Mr. Ludcke. Several were taken, but none were preserved.

22. Sharp-shinned Hawk. *Accipiter velox.* One was shot by

G. O. Ludcke near McCook Lake in South Dakota on September 29, 1919.

23. Broad-winged Hawk. *Buteo platypterus.* A female was sent in from Plainview, Nebraska, and mounted by Mr. Anderson on April 27, 1919 (No. 3372). Another specimen (sex?) was taken on September 28, 1919, in Greenville, Sioux City (No. 3456).

24. American Rough-legged Hawk. *Archibuteo lagopus sancti-johannis.* The following specimens were received by Mr. Anderson:

October 20, 1918, one shot by Anderson near Sargeants Bluff, but not mounted.
November 27, 1918, a male taken south of Crystal Lake, Nebraska. No. 3300.
November 27, 1918, a female taken at the same place. No. 3301.
December 3, 1918, a female from Lester, Iowa. No. 3305.

25. Ferruginous Rough-legged Hawk. *Archibuteo ferrugineus.* A male was sent in from Ponca, Nebraska, on February 11, 1919, and mounted by Mr. Anderson (No. 3347).

26. Golden Eagle. *Aquila chrysaëtos.* The following specimens are to be recorded from Mr. Anderson's shop:

October 29, 1918, a female from Plainview, Nebraska. No. 3285.
December 31, 1918, a male from Winside, Nebraska. No. 3320.
February 28, 1919, (sex ?) from Jackson, Nebraska. No. 3557.
February 8, 1920, a male from Beresford, South Dakota. No. 3561.

27. Bald Eagle. *Haliæetus leucocephalus.* The following specimens are to be recorded:

October 12, 1918, a male from Leeds, Sioux City, Iowa.
November 3, 1918, a female from Akron, Iowa. No. 3291.

28. Duck Hawk. *Falco peregrinus anatum.* On November 4, 1918, Mr. Anderson collected and mounted an immature female Duck Hawk, this being taken near Badger Lake, Monona county, Iowa (No. 3286). This is the second record of this species in the Sioux City area.

29. Sparrow Hawk. *Falco sparverius.* One sent in from Bridgewater, South Dakota, was mounted by Mr. Anderson on September 15, 1918.

30. Osprey. *Pandion haliaëtus carolinensis.* A male Osprey was shot at Jackson Lake, Nebraska, on October 9, 1919, and mounted by Mr. Anderson.

31. Barn Owl. *Aluco pratincola.* An unusual number of these birds were mounted during the period covered by this report, as follows:

October 19, 1919, a female from Walthill, Nebraska.
November 6, 1918, a male taken locally. No. 3288.
November 27, 1918, a male from Winside, Nebraska. No. 3299.
November 29, 1918, a female from South Sioux City, Nebraska, No. 3302.
April 13, 1919, a male taken locally. No. 3370.
October 15, 1919, a female from Dakota county, Nebraska. No. 3473.
October 20, 1919, a female from Ethan, South Dakota. No. 3469.
November 17, 1919, a male from Leeds, Sioux City, Iowa. No. 3513.

32. Long-eared Owl. *Asio wilsonianus.* A male captured on the grounds of the Sioux City Country Club on October 25, 1918, was mounted (No. 3284).

33. Short-eared Owl. *Asio flammeus.* A female was taken at Riverside Park, in Sioux City, on November 18, 1918, and mounted by Mr. Anderson (No. 3294). On December 21, 1919, three or four Short-eared Owls were seen at Pierson, Iowa, by E. W. Johns. Mr. W. R. Mills saw eleven at the same place on December 26, and Mr. L. B. Snyder counted twelve on the same date. Mr. Johns saw seven or eight again on March 2 and 4, 1920. At this time they seemed to spend the day in the Red Cedar trees of the town park. Mr. Mills last saw these birds on March 14, 1920, at which time there were only two individuals.

34. Barred Owl. *Strix varia.* This is a very unusual species in most of this area. On November 23, 1919, Mr. Anderson received a female which had been shot in Mulhall's pasture, near Riverside, Sioux City (No. 3522).

35. Saw-whet Owl. *Cryptoglaux acadica.* Mr. Wier R. Mills, of Pierson, Iowa, kindly furnishes the following note: "On March 13, 14, and 18, 1919, I saw a Saw-whet Owl in a pine tree in our yard. I am positively sure of my identification in this instance; and Johns saw the bird and said there was no question whatever about it."

36. Screech Owl. *Otus asio.* These birds have been present during both seasons, but are becoming less numerous in town, because many people dislike them for one reason or another and destroy them.

37. Great Horned Owl. *Bubo virginianus.* The three specimens received during the two seasons seem rather meager in comparison with the records of the preceding season. Considering the number of specimens and the localities, there is no evidence of an invasion of these birds.

December 31, 1918, a female from Greenville, Sioux City. No. 3321.
March 21, 1919, a female from Wynot, Nebraska. No. 3363.
May 16, 1920, a female from McCook Lake, South Dakota. No. 3620.

38. Snowy Owl. *Nyctea nyctea.* The winter of 1917-1918 witnessed a very remarkable flight of Snowy Owls in this area, which was reported in detail in a previous volume of these Proceedings.[1] During the winter of 1918-1919 there was still evidence of a southward movement of these birds. But during the winter of 1919-1920 none were reported or brought in. These facts seem to cast a shadow of doubt upon the weather conditions being the primary cause of the movement. If the owl invasion of 1917-1918 was due to the failure of their food supply in the north (rabbits and hares) the partial movement of 1918-1919 would suggest a slow and proportionate recovery of the normal rabbit population in the north. The following records are to be reported for the season of 1918-1919 in the area being considered:

November 7, 1918, a male from Parkston, South Dakota. No. 3290.
November 21, 1918, a female from Westfield, Iowa. No. 3295.
November 26, 1918, a male from Cole's Addition, Sioux City. No. 3298.
December 4, 1918, a female from Renville, Minnesota. No. 3307.
December 5, 1918, a female from Bridgewater, South Dakota. No. 3308.
December 5, 1918, a female from Alta, Iowa. No. 3309.
December 8, 1918, one at McCook Lake, South Dakota, Field Record.
December 27, 1918, a female from Artas, South Dakota. No. 3317.
January 20, 1919, one from Anthon, Iowa.
February 3, 1919, a male from Hudson, South Dakota. No. 3340.
February 3, 1919, a male from Hudson, South Dakota. No. 3341.
February 3, 1919, a female from Hudson, South Dakota. No. 3342.

Specimen No. 3298 was shot while in the act of killing a quail. The record of December 8, 1918, was made by A. F. Allen. The specimen from Anthon, Iowa, was sent in alive to the Stone Park collection.

39. Kingfisher. *Ceryle alcyon.* The kingfisher has never been recorded here as a winter bird, so far as the writer is aware. The following note of Mr. Weir R. Mills will, therefore, be of interest: "I saw a Belted Kingfisher on January 1, 1920, near Pierson (Iowa). Although the day was cold and there was considerable snow on the ground, there were a few spots where the stream was not frozen over, and this was where I saw the bird. I had a fine opportunity for observation, and I am absolutely sure of the identification — never was more sure of anything."

40. Pileated Woodpecker. *Phloeotomus pileatus.* Mr. Anderson received a specimen of this bird on November 22, 1918, from Hill City, Minnesota. It would probably be *abieticola.*

1 Proc. Iowa Acad. Sci., XXV, pp. 71-84, 1918.

41. Magpie. *Pica hudsonia.* Magpies seemed to be more numerous than usual during the winter of 1919-1920. There seems to be no way of determining at present whether these are Dakota birds which are driven south by the severity of the weather, or whether they have moved eastward in Nebraska along the Niobrara valley. Newspaper accounts indicated that Magpies were unusually numerous this winter in the vicinity of Ainsworth, along the Niobrara.

The Magpies were first brought to our attention on November 28, 1919, when a male was sent in to Mr. Anderson from Dakota City, Nebraska. It was later ascertained that this one was shot out of a flock of "two dozen or more" along the bluffs three or four miles north of Homer, Nebraska. Mr. Fred H. Schmidt, who sent the bird in, said that he had never seen that kind around there before; although he saw one or two around his farm nearly every day for some time afterward.

On January 4, 1920, Mr. Youngberg saw six Magpies at McCook Lake. On March 13, 1920, a female was sent to Mr. Anderson from Plainview, Nebraska, and mounted (No. 3578).

42. Purple Finch. *Carpodacus purpureus.* This species has now been seen in the field during the month of November for the last three years. The 1917 record was previously reported. On November 3, 1918, the writer, with A. F. Allen, saw one female near Stone Park. Mr. Allen saw a male on November 2, 1919, at McCook Lake, South Dakota, and a pair on November 23, 1919, in Dakota county, Nebraska.

43. Red Crossbill. *Loxia curvirostra minor.* This rather irregular species was noted four times last winter. One male and three females were seen by Mr. Anderson in the north part of the city on October 18, 1919. On November 2, 1919, Mrs. H. M. Bailey and Miss Aiken saw two males and four females feeding on wild hemp seeds in the Cardinal Glen. On the same date Mr. Allen saw a male and a female at McCook Lake, the male having been shot. Again on February 29, 1920, Mr. Allen saw a male and three females in the vicinity of Stone Park. Miss Ada B. Wendell, of Smithland, Iowa, writes that "American Crossbills were seen last Saturday, April 10, 1920.

44. White-winged Crossbill. *Loxia leucoptera.* The writer is also indebted to Miss Ada B. Wendell for the following record of occurrence at Smithland, Iowa.

"The White-winged Crossbills were first seen at our place December 10, 1919, but were reported a week or two before that.

I had a splendid opportunity to study them, as they came in small flocks of eight or twelve each day about four o'clock and ate the cones on our spruce trees, not over thirty feet from our door. They were dark red — more the color of the orchard oriole, and not as pink as shown in Reed's Guide. The white wing bar was very distinct. Could not give date when last seen, but think they were here most of the winter and seemed to be in small flocks here and there about town."

45. Redpoll. *Acanthis linaria.* The big flight of Redpolls was in the winter of 1916-1917. Since then there have been only a few stragglers. On January 19, 1919, a flock of six were seen in Logan Park Cemetery by Messrs. Allen, Ludcke and the writer. Three small flocks were reported by Mr. Allen in February and March, 1920.

46. Goldfinch. *Astragalinus tristis.* These birds, which are usually common throughout our winter season, were notable in their absence in the winter of 1919-1920. None were reported from the last of November to the last of February; while in most years at such a time they are hardly missed on any trip. Late in the spring local newspapers carried items referring to large flocks of Goldfinches in the southeastern corner of the state (Iowa). The following observations by Mr. Frank C. Pellett refer to the vicinity of Hamilton, Illinois, and Keokuk, Iowa.

"We are now having the most remarkable visitation of Goldfinches that I ever saw. The whole town is talking about the 'wild canaries' which appear in flocks of hundreds on the lawns eating seeds of the dandelion. All my life I have been accustomed to seeing these birds in small flocks of a dozen or more; but this spring thousands of them are present hereabout, and have been here for a number of days. One will see a big flock in the trees and on the grass, and walking a few blocks will see a similar flock; going into the country still other flocks will be seen."

One wonders to what extent this assemblage of one species took place.

47. Pine Siskin. *Spinus pinus.* Mr. Allen noted small flocks at McCook Lake in December and February. They were frequently seen by others during March and April, and as late as May 2, 1920.

48. Gambel's Sparrow. *Zonotrichia leucophrys gambeli.* The writer saw four Gambel's Sparrows on October 5, 1919, in the

ravines east of Morningside. This is believed to be the first record of this species in the Sioux City area.

49. Tree Sparrow. *Spizella monticola.* This species did not seem to be present in the usual numbers during either season.

50. Cardinal. *Cardinalis cardinalis.* The Cardinal seems to be holding its own at least. A trip in the proper environment seldom fails to list several of them in almost any season.

51. Bohemian Waxwing. *Bombycilla garrula.* The last important visitation of Bohemian Waxwings was in the spring of 1917. None were noted during 1918-1919. In 1919-1920 they first appeared on December 16, and were seen in flocks of varying size throughout the winter and early spring, the latest date being May 4. No one reported any during March, but they were abundant in February, and were noted in small flocks throughout April. The largest flocks seen at any one time were estimated at about one hundred. The fact of interest is not so much the largeness of the flocks, as the large number of small flocks which were very generally distributed.

The writer has learned, through correspondence, of the occurrence of this species at other points. On December 15 a flock estimated at a hundred or more visited Trenton, in southwestern Nebraska. Miss Aiken observed a flock of about thirty at Carroll, Iowa, on the 25th and 26th of December; they were feeding on frozen apples. Mr. N. W. Williams told me of a flock at Ames, Iowa, during the last week of January. A flock of about twenty were reported by E. W. Johns at Pierson, Iowa, from the tenth to the twentieth of February.

The Bohemian seems to be chiefly frugivorous in diet in the winter season. I have never seen them eating seeds, and have searched through much literature for mention of it, but without success. In this immediate locality the most important item of food seems to be the fruit of the artificially planted Russian Olive trees in the public parks of the city. The large number of these trees scattered in the various large and small parks throughout the city no doubt plays an important part in holding these birds for so long a period of the winter. Among the other winter fruits which the Bohemian Waxwing has been observed to eat in this region may be mentioned the bittersweet berries, hackberries, wild grapes, frozen apples, and asparagus berries. The use of the last named fruit was observed twice in December by the writer, and once in January by Mrs. Bailey, and all in different localities. This was thought to be a novel observation, but the writer has since found that a similar observation was made by F. A. Pennington in Chicago, and reported in Bird-Lore (XIII, page 305, 1911).

The writer has examined a good many published accounts of the Waxwing in a search for notes on the food habits. The following table indicating the number of writers who have mentioned various food items may be of general interest.

Mountain Ash Berries	18
Juniper and Cedar berries	13
Insects	7
Hawthorne apples	4
Cultivated apples	4
Wild grapes	3
Rose hips	3
Bittersweet berries	2
Persimmons	2
Dogwood berries	1
Sumac berries	1
Buffalo berries	1
Smilax berries	1
Laurel berries	1
Asparagus berries	1
Hackberries	1
Barberries	1
Bearberries	1
Wolfberries	1
Cranberries	1
Chokeberries	1
Madrona tree berries	1
Russian Olives	1
Currants	1
Figs	1

A number of writers have seen the Waxwings catch and eat insects in true flycatcher style; this is usually late in the season, of course, or in the northern states where these birds may linger longer.

We wish to mention one other habit observed in these birds which seems to be peculiar. Two observers, at different times, told the writer of seeing Bohemian Waxwings alight in the snow and eat of it. One of the observers describes the method by saying that the birds lowered the head and scooped up the snow with the lower mandible. It is assumed that the snow was swallowed, although the action of the throat muscles was not noticed. In both cases the birds had just previously been feeding on berries, and there might be some who would explain the procedure as a method of washing the beak; but why lower the mandible, as stated? The only mention I find of this habit is that by W. H. Bergtold, viz., "the birds (Bohemian Waxwings) were feeding on Russian Olives and snow." (Auk, XXXVI, page 342, 1917).

52. Brown Creeper. *Certhia familiaris americana.* About as usual in 1918-1919, but more scarce in 1919-1920.

53. Red-breasted Nuthatch. *Sitta canadensis.* Mrs. F. W. Marshall had one of these nuthatches as a daily visitor at her feeding shelf throughout the winter, and it remained as late as May 4, 1920. Miss Ada B. Wendell also reported the Red-breasted Nuthatch at suet stations in Smithland, Iowa. They would sometimes come in pairs.

54. Tufted Titmouse. *Baeolophus bicolor.* Miss Wendell also reports the Tufted Titmouse at Smithland during the winter of 1919-1920. She writes as follows: "The Titmouse has been reported by bird observers here for years. This winter they were seen the first week or so in January, one at a time. A few weeks later they came continuously to eat meat placed on the wood-pile, and usually appeared in pairs."

The Titmouse has never been observed in the western part of the county (Woodbury) so far as the writer knows. This is another species which presents a problem in distribution. Smithland is located in the valley of the Little Sioux river, and is surrounded by a heavier growth of timber than is to be found, perhaps, in any other part of the county. The question is whether these birds have reached this point by overland flight, or by closely following the wooded valley.

Department of Biology,
Morningside College.

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