TRANSACTIONS

OF THE

TEXAS ACADEMY OF SCIENCE

FOR 1902,

TOGETHER WITH THE PROCEEDINGS FOR THE SAME YEAR.

VOLUME V.

AUSTIN, TEXAS, U. S. A.:
PUBLISHED BY THE ACADEMY.
1903.

Regulation of the Issuance of Texas Railroad Securities by the State Government.

[ANNUAL ADDRESS BY THE PRESIDENT.]

R. A. THOMPSON, C. E.,
CHIEF ENGINEER RAILROAD COMMISSION OF TEXAS.

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CONTENTS.

THE TEXAS ACADEMY OF SCIENCE.

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REGULATION OF THE ISSUANCE OF TEXAS RAILROAD SECURITIES BY THE STATE GOVERNMENT.

R. A. THOMPSON, C. E.
Chief Engineer Railroad Commission of Texas.

Mr. James J. Hill, President of the Great Northern Railway, in an address delivered recently before the Illinois Manufacturers' Association, said: "Next to the Christian religion and the common schools, no other single work enters into the welfare and happiness of the people of the whole country to the same extent as the railway." Such an expression coming from one of the leading railroad men of the country and one of the foremost spirits of the financial world, renews the earnest attention of the people to those great highways of commerce, the railroads, and to their important influence on the public economy, and lends deeper significance to the question of their proper regulation and control by the government, and to the maintenance of a correct relation between them and their patrons.

While it is a well recognized fact that this country owes more to its railroads, as a factor in increasing its wealth and population, than to perhaps all other agencies combined, it has also become an established principle that laws must prevail and be enforced, subjecting them to governmental control and regulation, in order that the people may be justly and economically served, without discrimination as to individual or place, and in order that they may not imperil and dominate in their might the power that gave them being and under whose protecting care they have thrived so prosperously.

Leading up to a consideration of the subject of governmental regulation of railroad securities as pertains to Texas in particular, it will be not inappropriate to briefly discuss the general conditions that obtained in the United States prior to the enactment of any railroad legislation in this State, and to review the relations then existing between the rail-

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roads and the people on account of which the same had become necessary. It is well known that this legislation was but the continuation of a movement, as a protection against corporate greed and oppression, organized in the older States as soon as the problem of railroad transportation began to assume important proportions and when the effect of unjust rates and discriminations made itself felt and their influence on trade was appreciated.

Succeeding the Civil War a period of activity in railroad building was inaugurated throughout the United States, unprecedented in the history of the world. The possession of a large and fertile interior domain, practically undeveloped, prompted the people, and through them the government, to offer every inducement to promote railroad construction, and large tracts of land, valuable franchises and other property were donated by them. The railroad, in but a few years after it had been demonstrated to be a practical success, had become a commercial necessity for the speedy and economic transportation of freight and passengers. Without the railroad it had become apparent that the unoccupied territory could not be developed, and everywhere legislation, state and national, was enacted granting every favor and consideration to the railroad companies.

The cupidity of financial adventurers soon attracted them to this most fertile field of speculation, and companies were organized for the construction of a network of railroads covering the continent. Their prime purpose was to secure the valuable bonuses and donations offered as profits for the work. The prospects appearing for easy and rapid gains, with little outlay of capital, were flattering and no time was lost in securing the most favorable franchises. The services of the best and shrewdest legal and political talent were engaged and powerful lobbies were organized to aid in securing favors for the railroad companies from the several State Legislatures and from Congress. Perhaps a more clever, cunning, unprincipled and skillful set of manipulators never graced the arena of speculation. It was truly an era of gain. State Legislatures and Congress were lavish with their donations of large areas of the public domain; counties and municipalities granted issues of bonds and valuable properties; and cities vied with each other in offering bonuses of land and money. A legislator who would have advocated measures of control that would have in any way hampered or hindered the granting of a railroad franchise or donation would have been considered as an obstacle to public improvement and would have been upheld as an enemy of the public good.

It may be considered as but natural that the companies should have taken advantage of the sentiment of the times and endeavored to secure for themselves all of the favor and concessions possible, and also that the people should have encouraged to the limit of their capacity the development of their property and the advancement of the country's good, and the latter were indeed to be commended, but is it to be wondered at that as a result abuses of the most flagrant character crept into the early managements of railroads, whose officers had unlimited and unrestrained powers in the matter of regulating transportation rates and dispensing patronage.

Mr. A. B. Stickney, for a long time a railroad manager and a writer of considerable repute upon subjects of railroad economy, graphically describes the practice of railroad promoters in Minnesota during the early days of construction, in his book on "The Railway Problem," the following extract from which will serve to illustrate the methods then in vogue. He says: "Notwithstanding the value of the land grant (six sections per mile) had now been demonstrated and by law exempted from taxation, Capital still demanded more. Finally Congress granted four additional sections of land to the mile, but yet more was demanded. The Constitution must be amended so as to secure the immunity of these lands from taxation. The concession was made. Congress granted right of way through public lands. Then said Capital, "Congress has granted to the State millions of acres of swamp lands for internal improvements. What internal improvements are more useful than railways? Give us these swamp lands." They were given. "Individuals donate the right of way through their private tracts; we must have station grounds in the towns and grounds for the shops and terminals free," continued Capital. If the citizens demurred, they were threatened with change of location to such a distance from existing towns as to destroy them and build up rivals on the prairie; and in case of refusal this threat was ruthlessly carried into execution. It is needless to say that few had the temerity to refuse.

"By this time the power of the railway constructor had become almost autocratic. He demanded that towns and counties should vote bonds and under the pressure of threats of the same kind as have been mentioned, the bonds were authorized by the Legislature and voted by the people. But it should be stated that other means than threats were employed to produce these results. A paid 'lobby' attended every session of the Legislature. Judges of all grades, from the supreme to justices of the peace, the executive officers of the State, the members of the Legislature, the county and town officials, the 'striker' at caucuses and the 'pot-house' politicians, had free passes. Caucuses were 'packed' and laborers in construction gangs were compelled to vote as their 'bosses' directed, at least once, at each election. Thus early was the corrupting influence of money used to sap the foundations of public morality."

Such corrupt practices introduced into railroad management an entire—even contemptuous—and utter disregard for the rights of persons and communities. Discriminations of all kinds were carried on. Systematic methods of oppression were invoked against all who bowed not humbly before the decrees of unscrupulous agents, or shared not the spoils of discrimination with them. At the nod of a railroad manager, a merchant or broker could be made a millionaire or a pauper. Cities and towns prospered or were wrecked at his pleasure.

This abuse of prerogatives, conferred on them by a fair-minded and generous people, precipitated in the early seventies what was known as the "Granger" movement, which sought to regulate the rates, methods of operation and political relations of the railroad companies by legislation. The latter claimed that they were entitled to make such charges for the transportation of freight and passengers as would enable them in addition to paying expenses of all kinds, to pay interest on all bonded indebtedness and fair dividends on all stock. The people contended that they had the right to make only such charges as would enable them to earn a reasonable rate of interest on the actual value of the properties besides the cost of operation, maintenance and management. In other words, the railroad companies argued "that the commerce of the country must be taxed so as to reimburse them for all losses by improvident contracts, extravagance and shrinkage of values from whatever cause and from the effects of accidents and mistakes which may have entailed cost upon them, and to pay dividends on all stocks and bonds fraudulently issued." In regard to this contention Judge John H. Reagan, chairman of the Texas Railroad Commission says: "This proposition would seem so monstrous as not to call for argument or demonstration, and it is constantly made in behalf of corporations which represent eleven billions of dollars, including the fraudulent stocks and bonds and which are operated by nearly a million active, intelligent men, and controlled by thousands of the best business men of the country, and represented in the courts of the country and in the lobbies and halls of legislation by as many more of the ablest lawyers and most expert lobbyists, thus presenting a combination of wealth and power which may well cause every thoughtful and patriotic citizen to feel the most anxious solicitude for the future of our governments, Federal and State, and for our free institutions and the liberties of the people. Neither this nor any other government has ever taken upon itself or imposed on its people the protection of any class of property against such losses as may have arisen from improvident contracts, extravagance, the shrinkage in its value, or the results of mistakes or accidents. Nor has this or any other government, nor will any just government, force its people to pay dividends on stocks and interest on bonds fraudulently issued."

That the people were not ungenerous in their contentions nor inclined to oppress the railroads is upheld by Ex-Governor Larrabee of Iowa, who in his book, "The Railroad Question," says: "The American people have never ceased to be mindful of the conveniences afforded them by the modern mode of transportation. On the contrary, they have been too prone to credit railroad men with being benefactors instead of beneficiaries, and this spirit made them overlook, at least tolerate, the abuses that grew proportionately with the wealth and power of the companies."

However, the impertinent attempts at interference with the management of the affairs of the railroad companies by the "Grangers" were naturally resented and the laws passed were strenuously and bitterly contested in all the courts of the country. The final triumph of the "Grangers" came in 1877 when the Supreme Court declared the constitutionality of a law which delegated to the State the power of regulating the freight rates of railroads within its borders. Following this decision, laws were passed in a number of States placing the authority to prescribe and regulate freight rates in boards of Railroad Commissioners, but the enforcement of their rules, in the nature of things, was attended with varying degrees of success. The powerful railroad companies contested their rulings at every point and in many cases, aided by a friendly judiciary, greatly impaired their efficiency. Every means were exhausted in heaping opprobrium on the Commissioners and upholding their actions as futile and contemptuous to the public gaze. When rates were lowered, refuge was had by injunction in the courts—Federal, as a rule—the railroads declaring that the enforcement of such reductions would result in the practical confiscation of their property.

These contests between the railroads and the people virtually forced the courts to recognize some basis for rate-making, to lay down some rule that would serve for the guidance of the boards of commission in establishing and promulgating such schedules of rates as would enable the railroads to earn the necessary revenues. In 1888 Judge Brewer of the United States Federal Court handed down a decision, in effect, that the transportation rates promulgated by a Railroad Commission or a State Legislature that did not admit of the railroad companies paying their operatating expenses, fixed charges and some return on capital stock, would be set aside by the court.

Thus was the principle established by the Supreme Courts of the country that railroad companies were to be permitted to make such charges for the transportation of freight and passengers as would enable them to earn, in addition to all expenses of maintenance and operation, a reasonable rate of interest on all bonds outstanding and a fair dividend on all stock, no matter how they were issued. It was required that the people be taxed to pay returns on securities which they never had any voice in making and which bore no relation to the actual value of the properties that were represented.

The effect of these decisions was to put an entirely new phase on the whole subject of State regulation of railroads and to demonstrate that if control were to be had over the rate situation, the same tribunals must regulate and have jurisdiction over the issuance of the stocks and bonds. In accordance with this principle, the Legislature of the State of Texas in 1893 established the precedent in the matter of controlling the issuance of railroad stocks and bonds by enacting the stock and bond law, supplementing the Railroad Commission Act of 1891, which had been authorized by a constitutional amendment adopted in 1890.

Although the people of Texas began early to experience and suffer from the abuses of corrupt railroad management, the clamor for State regulation, corresponding to the "Granger" movement of the northern and western States, did not reach a culmination until 1890, when the amendment to the Constitution was adopted authorizing the establishment of a Railroad Commission. In view of the attitude and decrees of the Federal court mentioned, it was also seen that if the authority vested in the Commission was to be effective in the matter of regulating freight rates, it must also control the issuance of railroad securities which, as decreed, were to serve indirectly as the basis for rate-making. The current and fraudulent practice of "watering" stocks and bonds must be suppressed, otherwise the indebtedness of the railroad companies might be made as great as they choose, and sufficient to absorb any amount of surplus earnings in dividends and interest.

The State Democratic platform of 1892 contained the following "plank:" "No. 14. We demand a law that will effectually prevent the issuance of fictitious and watered stocks and bonds of railway companies in this State, believing that these great enterprises should be conducted upon commercial principles and not as gambling devices."

In accordance with the platform demands, the Legislature passed the Railroad Stock and Bond law, which was approved by the Governor on April 8, 1893, and which went into effect on August 7, 1893.

THE STOCK AND BOND LAW.

The Railroad Stock and Bond law, as published in the Revised Statutes of Texas for 1895, Chapter 14, Articles 4584a-m, declares: "That, among other things, the power and authority of issuing or executing bonds, or other evidences of debt, and all kinds of stock and shares thereof, and the execution of all liens and mortgages by railroad corporations in this State, are special privileges and franchises, the right of supervision, regulation, restriction and control of which has always been, is now, and shall continue to be vested in the State government, to be exercised according to the provisions of this and other laws."

It provides: "That hereafter no bonds or other indebtedness shall be increased or issued or executed by any authority whatsoever, and secured by lien or mortgage on any railroad or part of railroad, or the franchises or property appurtenant or belonging thereto, over or above the reasonable value of said railroad property; provided, that in case of emergency, on conclusive proof shown by the company to the Railroad Commission that public interests or the preservation of the property demand it, the said Commission may permit said bonds, together with the stock in the aggregate, to be executed to an amount not more than 50 per cent over the value of said property."

The execution of the provisions of the Stock and Bond law was placed under the jurisdiction of the Railroad Commission. The basis for valuation, to be adopted, was the actual physical value of the property or practically the cost of its reproduction at the time of its valuation, allowing current prices for labor, material and real estate. This basis was laid down by the statute in the following language, Article 4584f: "Should any company or corporation authorized to construct, own or operate a railroad in this State desire to issue bonds or other indebtedness, to be secured by lien or other mortgage on its franchises and property, in advance of the completion of the said railroad, it shall make application to and first procure the consent of the Railroad Commission thereto. In said application it shall exhibit to the Commission its contract with the construction company, if it have any; the profile of its completed road or part of road, the evidence of its right of way, depot grounds, terminal facilities; the extent and value of work done or in process of completion; the amount of property received; the amount of stock subscribed and the amount paid in; and all other necessary facts showing the value of the franchises and property proposed as security for said contemplated debts. If, on investigation, the Commission is satisfied that the company is acting in good faith, and that the contract with the construction company is reasonable and fair to the public, then it shall authorize the execution of said indebtedness and lien to the extent necessary for the demands of the work, at no time to be more than 50 per cent over the value of the whole property and franchises."

In pursuance of the law, the Commission has issued rules and regulations controlling it in the matter of issuance and registration of railroad stocks and bonds which, among other things, requires that there must be filed with an application for issuance of stocks or bonds, the maps and profiles of the road, the estimate of its cost, the deeds, contracts and other evidence of right of way, depot and terminal grounds, all contracts for construction, and all plans and specifications for construction and structures of all kinds. These exhibits can be filed in advance of the actual construction of a railroad, as soon as its location has been completed and right of way and depot and terminal grounds secured, and upon the estimate of the cost of the proposed road, the Commission will enter an order authorizing the issuance of bonds to the amount of the estimated cost and value, less the stock which has been issued, which must be not less than $1000 per mile. This order does not carry with it any obligation on the part of the Commission, except to guarantee that it will approve and direct their registration in the office of the Secretary of State, the bonds that have been authorized issued, as soon as the road has been completed in accordance with the plans, specifications and exhibits filed. However, as sections of the road are completed and ready for the operation of trains, upon application the Commission will direct its engineer to inspect the completed portions and value same in accordance with the former estimates upon which issuance of bonds was authorized, and so much of said bonds as will represent the value of the completed property will be approved and directed registered. As other sections are completed, additional bonds will be approved and directed registered, to the value of the property.

Any railroad company can at any time, upon filing the exhibits required, make application to the Commission for approval and authority to register in the office of the Secretary of State bonds to the actual physical value of its property, to be determined by the Commission, less the capital stock which has been issued and less any previous bonds or other indebtedness that may be outstanding and which is regarded as a lien on the property. After the bonds have been duly registered, then, and then only, do they constitute a lien on the railroad property. As provided in the statute, which was quoted above, the total sum of the stocks and bonds must not exceed the value of the road, except in cases of emergency, when the Commission has power to authorize additional stocks and bonds to an amount not exceeding fifty (50) per cent of its estimated value. However, in no case up to this time has the Commission considered this emergency provision ruling that it was the intention of the law that same should be invoked only to cover losses from extraordinary causes, such as storms, fire, etc.

The Stock and Bond law further provides for the issuance of certificates and shares of stock, complete statements of which must be duly certified to and filed with the Commission. It also provides severe and drastic penalties for the fraudulent issue of any stocks, bonds or other indebtedness in violation of its provisions and for the making of any false statements in regard to same by railroad companies thereby securing the Commission's sanction of fraudulent securities. That the law only contemplates the regulation of the issuance of stocks and bonds and in no sense guarantees them, appears in Article 4584m, which provides: "That nothing in this law, and no act done or performed under or in connection with it, shall be held or construed to bind or make the State of Texas liable to pay or guarantee, in any manner whatsoever, any obligation, debt, or claim executed or assumed under or by virtue of its provisions."

STOCK AND BOND "WATERING."

The greatest evil connected with the unlawful manipulation of railroad securities, and the one which the Stock and Bond law was designed to circumvent, is the ingenuous device called "watering;" that is, the voluntary increase of the indebtedness of a railroad by its directors without compensation to the property. Additional securities are issued and loaded on the road, for which it receives no benefit and, further, must be taxed for their support. This is done for several reasons; one, in order to pay fictitious dividends; another, to reduce dividends on stocks outstanding; another, to throw the stock into certain hands for the purposes of manipulation; and another, in order that the indebtedness of the road may keep pace with the earnings and maintain the dividends at what might be considered a reasonable figure—this when the net earnings are constantly increasing. Still another reason for stock and bond "watering" was experienced in Texas immediately prior to the enactment and date of going into effect of the Stock and Bond law, which was that since the Commission must maintain rates sufficient to pay interest and dividends on all indebtedness, by increasing this indebtedness the railroad companies would be provided with additional weapons for opposing any reduction of rates, and therefore several million dollars worth of "water" was injected into the already muchly "irrigated" stocks and bonds of the State; also the creditors of several railroads that were at that time in the hands of receivers hastened to compromise with the companies, discharged the receivers and reinstated the former indebtedness, which had been copiously "watered" and which was more than would have been granted to them had the properties been sold and reorganized. They were content to absorb what the properties were making, hoping for better days, when all, including the defaulted interest, would be paid.

Speaking of the general practice of stock and bond "watering," Governor Larrabee says: "Nearly all railroads in time become the footballs of shrewd manipulators. They are bonded before they are constructed, and often for far more than they are worth. Stocks at best only represented nominal values and were given as premiums to the bondholders or promoters of the road. * * * It is a notorious fact that the stock of a large number of railroad companies represents little or no value, having been sold at a mere nominal price or been donated as a premium or a bonus to those who purchased the bonds. * * * By the creation of fictitious values the managers of the companies have attempted to levy an exorbitant tax upon the commerce and travel of the country for all time to come. The Government guarantees to an inventor a monopoly only for a limited space of time, at the expiration of which his invention becomes the common property of the people; but railroad managers endeavor to collect under the protection of the laws an exorbitant royalty from our people for all time to come."

The science of stock and bond "watering" reaches its highest development when the consolidation of several lines into one system takes place. All indebtedness of the former companies is absorbed and new securities issued to cover it, usually far in excess of the original amount. Various reasons are assigned for this, among others, for the purpose of improving the properties and building new extensions, but, as a rule, the "watered" securities are divided out as profit to the promoters of the consolidation. Another favorite method of absorbing the fictitious issues is for the promoters, who are, as a rule, the directors of the consolidated company, to organize among themselves construction companies for the purpose of building new extensions, and to contract with themselves to deliver to themselves these constructed extensions for specified amounts of these "watered" stocks and bonds, largely in excess, as large as they choose, of their actual cost and value of the extensions. These bonds, whose interest is guaranteed by the railroad company, have previously been contracted for and are sold. In this way the profits of the transaction can be made as large as the cupidity of the speculators permits. Large amounts of the securities of the new company are divided out among the promoters in the guise of fees, bonuses, dividends, etc. "Watered" stocks and bonds are "watered" again and again at the will of the manipulators, and immense private fortunes have been built up, the expense of which the public is today maintaining in the form of freight tolls.

It can be shown that, almost without exception, the railroads of the country have inflated their securities with fictitious issues. The commerce of the land is being taxed to pay dividends and interest on them, and further, the people, except indirectly, derive no return from the vast and liberal donations made by the State governments, nor from the gifts of property and money made by counties, towns and individuals. Neither do the present companies themselves derive benefits from these donations, as the same have long since been absorbed by the railroad promoters or were distributed among them as a part of the profits of construction and a reward for magnanimity and beneficence.

The annual report of the Interstate Commerce Commission for the year ending June 30, 1901, gives the total amount of railway capital outstanding in the United States, against 189,965 miles of road, as follows: Capital stock, $5,806,597,107, or $30,566 per mile; bonds and other indebtedness, $5,881,580,887, or $30,962 per mile; total, $11,688,177,991, or $61,528 per mile.

According to Mr. Henry V. Poor, author of *Poor's Manual on Railroads,* the average cost of the railways of the United States was not more than $30,000 per mile. Hence, it is easily represented by the bonded debt, leaving the stock "as a simple token of proprietary interest." Mr. Poor further says that "if all of the 'water' were squeezed out of the railway securities now outstanding, no better paying investment could be found in the country." The total income of the railroads of the United States for the year ending June 30, 1901, was $737,875,215, which was equivalent to 12½ per cent of the total bonded debt, or 6⅓ per cent of the total stocks and bonds.

The report of the Railroad Commission of Texas for the year ending June 30, 1902, gives the amount of stocks and bonds outstanding against 10,616 miles of railroad as follows: Capital stock, $131,521,570, or an average of $12,389 per mile; bonded debt, $231,224,397, or an average of $21,781; total, $362,755,967, or an average of $34,170 per mile.

The Commission has valued 9786.3 miles of this property on a physical basis at $156,336,763, or an average of $15,975 per mile, which is equivalent to less than one-half of the total stocks and bonds as noted above. The railroads of Texas were assessed for taxation in 1901 at an average value of $8,742 per mile.

The bonded debt of these railroads, therefore, represents more than their actual cost, inclusive of liberal discounts to the purchasers, leaving the capital stock and all of the immensely valuable donations as profit to the constructors and promoters. The Commission's report for the year ending June 30, 1902, further states that the total net income from operation for the year was $12,811,900 for 9714.7 miles, which is equivalent to 3.58 per cent of the stocks and bonds, 8.29 on the Commission's valuation and about 15.3 per cent on the value assessed for taxation.

The evil effects of fraudulent issues of stocks and bonds does not rest with the mere issuance and sale of same. Upon these the people do not base their demand that the issuance of railroad securities be regulated by the State, but from the fact that the investors in these securities claim the right to charge rates for transportation sufficient to earn a fair rate of interest on their face value, in addition to the amounts necessary to operate, equip and maintain the properties. Governor Larrabee says: "The managers claim a right to earn dividends upon the fictitious capital and it is their constant effort to accomplish this object. So far as they succeed, they exercise an utterly unjust taxation upon the public by exacting compensation in excess of a fair return on the capital invested."

The Railroad Commission of Georgia, in its report for 1892, says: "Railroad companies ought to have the opportunity of earning reasonable reward upon the fair and just valuation of the property. On a just basis they ought to be able to earn a dividend. Interest and dividends ought not to be computed on overissue of stocks and bonds, nor on floating debts that result from extravagance and mismanagement, nor for purposes of speculation. * * * Railroads are loaded with 'watered' stock and bonded far in excess of their value, from which collossal fortunes are made by reprehensible methods—methods not reached by laws, either to punish the guilty or protect the innocent. The 'railroad wrecker,' with a bare majority of the stock and a board of directors, 'waters' the stock and makes overissues of bonds, which are bought by innocent purchasers until the overburdened road is broken down in credit under enormous debt and disproportional capitalization and goes into the hands of a receiver. * * * The evil does not stop here. The innocent holders of these excessive issues of stocks and bonds demand rates for transportation sufficient to pay dividends and the interest on such bonds. If the rates are allowed, commerce is injured and the people oppressed; if denied, the road is again forced into the hands of a receiver and again sold to the loss of the innocent holders. Such a failure is the result not of small tonnage and low rates, but of false capitalization."

EFFECT OF THE TEXAS STOCK AND BOND LAW.

The Railroad Commission, in its second annual report for 1893, with reference to the passage of the Stock and Bond law, says: "It is believed that the Act of the Legislature regulating the issuance of stocks and bonds, if fully and fairly enforced, will prove to be a very great benefit to both the people and the companies operating the railroads of this State. This law will prevent the unlawful and fraudulent issue of stocks and bonds of railroad companies in the future in this State and protect the people from the exactions necessary to satisfy them. It will protect the purchasers of such securities from being imposed on by them and it will secure to the companies who may hereafter build railroads a real value to their property and securities instead of a merely speculative and fluctuating value. And it will, as to such roads, defeat one of the most powerful agencies for the accumulations of vast fortunes by unscrupulous and dishonest men at the expense of the public."

The most noticeable effect of the Texas Stock and Bond law secured since its inauguration in 1893 is the gradual reduction per mile of the indebtedness of the railroads on the average from year to year, resulting in a gradual reduction of the fixed charges. Although all capitalization outstanding at the time of its passage remained in effect, no new indebtedness has been authorized created on the old roads, and all new lines constructed have had their issues limited to approximately the actual cost and physical value of the properties. The old roads that have been sold out at receiver's or other sale have also come under the Act, and their securities were limited by the same basis. As all of the old mortgages now outstanding expire, and when new mortgages are made to retire them, the latter will be limited according to the provisions of the law. Thus we have the paradoxical situation in Texas of the railroad properties continually increasing in value and their earnings constantly increasing, while the securities which represent their value in the markets are constantly diminishing. And this will continue, as to the railroads of Texas, so long as the present Stock and Bond law remains in effect until their capitalization approaches their actual physical value, as it is determined by the Commission.

The following table, compiled from the annual statistical reports issued by the Commission, will indicate the reduction per mile, on the average, of the indebtedness of the railroads of Texas, above mentioned, from June 30, 1894, approximately the date of the going into effect of the Stock and Bond law, until June 30, 1902:

On June 30th.	Miles of railway in operation.	Stocks outstanding per mile.	Bonds outstanding per mile.	Total stocks and bonds outstanding per mile.
1894	9,154	$15,076 00	$25,726 00	$40,802 00
1895	9,291	14,874 00	25,420 00	40,294 00
1896	9,437	14,647 00	25,302 00	39,949 00
1897	9,484	14,320 00	24,793 00	39,113 00
1898	9,540	14,205 00	24,036 00	38,241 00
1899	9,702	13,997 00	23,562 00	37,559 00
1900	9,867	13,724 00	23,202 00	36,926 00
1901	10,154	12,922 00	22,649 00	35,571 00
1902	10,617	12,388 00	21,779 00	34,167 00
Total reduction for eight years		$ 2,688 00	$ 3,947 00	$ 6,635 00
Average reduction per year for eight years.		336 00	493 37	829 37

Receivers of railroads have been practically unknown in Texas since the passage of the Stock and Bond law. In 1891 there were approximately 3357 miles of railroad in the hands of receivers, or about 39 per cent of the total mileage, while today there is only one road of about seventy miles in length, and this because it was almost entirely wrecked during the terrible storm at Galveston in 1899 and dismantled. The chief reason for this dearth of receivers is because of the fact that the principal railroads of the State were stocked and bonded at the time of the passage of the law for amounts greater than would be the Commission's valuations. Upon sale and reorganization they would come under the provisions of the law and the issuance of their securities would be limited to their physical value. So the present holders are content to absorb the earnings of the roads, whatever they may be, and trust to better times in the future, when the full interest may be paid, together with such interest as has been defaulted on the bonds, and also some dividends on the stock.

As has been heretofore stated, the chief reason for the enactment of the Stock and Bond law was that the issuance of railroad securities might be limited to approximately the physical value of the properties, which would serve, indirectly at least, as the basis for making freight rates. However, it is doubtful if up to this time the Commission has taken direct cognizance of its valuations of the railroads in the promulgation of its tariffs. That the law has had some effect, there can be no doubt, for it is readily seen that the railroad companies have been deprived of their most potent means of combatting rate reductions, as their earnings have increased, that is, by increasing their capitalization, for there can be no increase in the capitalization without fair compensation to the properties in the shape of permanent improvements and betterments. Ultimately there is no question but that the purpose of the law will be effected and the Commission will be controlled definitely in its rate-making by its valuations, as it will be only required to protect those securities outstanding by which the valuations will be represented.

The Stock and Bond law has had the effect of placing Texas railroad securities, in a large measure, beyond the influence of the gamblers and speculators of Wall Street and upon the high plane of legitimate investment. Their purchasers are protected to the extent that they have the assurance that additional indebtedness can not be created against the properties without a fair return to the same. The clever practice of "watering," which has been the favorite pastime of the manipulators and which has had the effect of defrauding innocent purchasers out of millions of dollars, is practically a memory of the past. The fixed charges, interest on bonds, etc., will be kept at the minimum, and the surplus earnings will be expended in improvements of all kinds to the mutual advantage and benefit of the railroads and the people.

The passage of the Stock and Bond law was at first looked upon as a blow aimed at foreign capital, and it was thought that it would be prejudicial to future railroad construction in the State. A great many people opposed its enactment on these grounds, but it has been proved that their fears were more or less unwarranted. While it is true that its effect has been to discourage railroad building from purely speculative motives, and perhaps a great many miles of railroad would otherwise have been constructed had the promoters had unlimited privileges in the matter of issuance of stocks and bonds, it has tended to promote legitimate construction in such territory as was undeveloped and where the prospective revenues appeared to warrant it. Only legitimate enterprises receive its encouragement. It has also had the commendable effect of discouraging paralleling and duplication of existing lines, which in some States has been carried to a degree injurious to the commerce of the country, from purely speculative motives. As was noted in a previous table, the railroad mileage of Texas has increased from 9154 miles in 1894 to 10,617 miles in 1902, a net increase of 1463 miles in eight years, and that under the direct influence of the Stock and Bond law. The increase during the past fiscal year was 463 miles, and the prospects are flattering for a greater increase during the next period.

In the early days of its enactment, the purposes of the Stock and Bond law were not appreciated nor its ultimate influence understood, and a great many persons, some from pure and others from selfish motives, busied themselves with misrepresentations of the attitude of the people towards, and the probable effect of the law on, foreign capital, and probably some harm was done to the State, but gradually this impression has dissipated and correct conditions comprehended, until today the law is considered by even its former enemies a most wholesome and beneficial legislation and one that is calculated to afford most valuable aid towards the successful solution of those most important and complicated questions of government regulation of railroads.

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The Poisonous Snakes of Texas, With Notes on Their Habits.

J. D. MITCHELL.

THE POISONOUS SNAKES OF TEXAS, WITH NOTES ON THEIR HABITS.*

BY J. D. MITCHELL.

The objects sought in the publication of these notes are:

First. To contribute to what is already known of the habits of the poisonous snakes of Texas.

Second. To register a plea for the protection of the useful and non-poisonous snakes.

Third. To provoke investigation into the habits of all snakes, that a true and correct knowledge of their usefulness, or danger, to mankind may be known.

The plates used in illustrating "The Poisonous Snakes of Texas" were obtained through the courtesy of the officers of the National Museum of Washington, D. C.

There are twelve species of poisonous snakes reported from Texas, as follows:

Elaps fulvius (Harlequin snake).
Ancistrodon piscivorus (Cotton-mouth).
Ancistrodon contortrix (Copperhead).
Sistrurus catenatus consors (Gulf Coast Massasauga).
Sistrurus catenatus edwardsii (Edward's Massasauga).
Sistrurus miliarius (Ground Rattlesnake).
Crotalus adamanteus (Diamond Rattlesnake).
Crotalus adamanteus atrox (Texas Rattlesnake).
Crotalus horridus (Banded Rattlesnake).
Crotalus molossus (Dog-faced Rattlesnake).
Crotalus confluentus (Prairie Rattlesnake).
Crotalus lepidus (Green Rattlesnake).

With the exception of *Elaps,* all of the above species are marked with a pit in the skin of the upper jaw, between and below the eye and nostril and forming a triangle with the nostril, the eye, and the pit for the three corners. They are known as pit vipers, and are thus distinguished from harmless snakes. The old theory that only those snakes that had a triangular head and projecting jaws were poisonous is not correct; but when

*Read before the Texas Academy of Science, November 28, 1902.

you find one with a pit in the upper jaw as described above, you can depend on it you have a poisonous snake to deal with, and the quicker you kill it the better.

Right here, I wish to enter a plea for the protection of the harmless or non-poisonous snakes. They are among the greatest of nature's benefactors to man and especially to the farmer. Observation has proved that their food consists largely of rats, mice, gophers, moles, and other destructive rodents; many species live largely on crickets, centipedes and other noxious insects; while again other species destroy the poisonous snakes. Outside of the natural-born prejudice of mankind to the snake family—a prejudice which should be modified by education—nothing has ever been charged against the harmless snakes but an occasional raid on a hen's nest by one or two of the larger species.

ELAPS FULVIUS, *Linnæus.*

(Harlequin Snake.)

PLATE I.

Prominent among the poisonous snakes of Texas is the *Elaps fulvius*, locally known under the various names of "Barber-pole Snake," "Thunder and Lightning Snake," "Candy-stick Snake," "King Snake," "Coral Snake" and "Harlequin Snake." It is a beautiful, highly colored snake, and its actions belie its dangerous qualities. It is related to the Indian cobra, and must be treated with the respect due a dangerous enemy.

DESCRIPTION.

"The red may be considered as the ground color of the body, though the black rings occupy nearly as much space above as the red, so as to give the general appearance of a succession of red and black rings. The yellow is intermediate. The anterior part of the head from the posterior point of the vertical plate (frontal), embracing the orbits, is black, as is also the tip of the lower jaw. A yellow ring passes across the occipital (parietal) region down to the inferior surface of the head, embracing the space between the posterior rim of the eye and the angle of the mouth. Then comes a black ring covering eight dorsal scales, margined posteriorly with yellow. From this region to the origin of the tail the black and red rings, from fourteen to nineteen in number each, alternate, being separated from each other by a narrow band of yellow. The black rings cover seven entire scales and two halves, the intermediate red space five entire scales and two halves, and the yellow either one and two half scales, or two halves only. Some red spaces may occasionally cover nine and ten scales. The tail is alternately black and yellow; the first caudal ring is

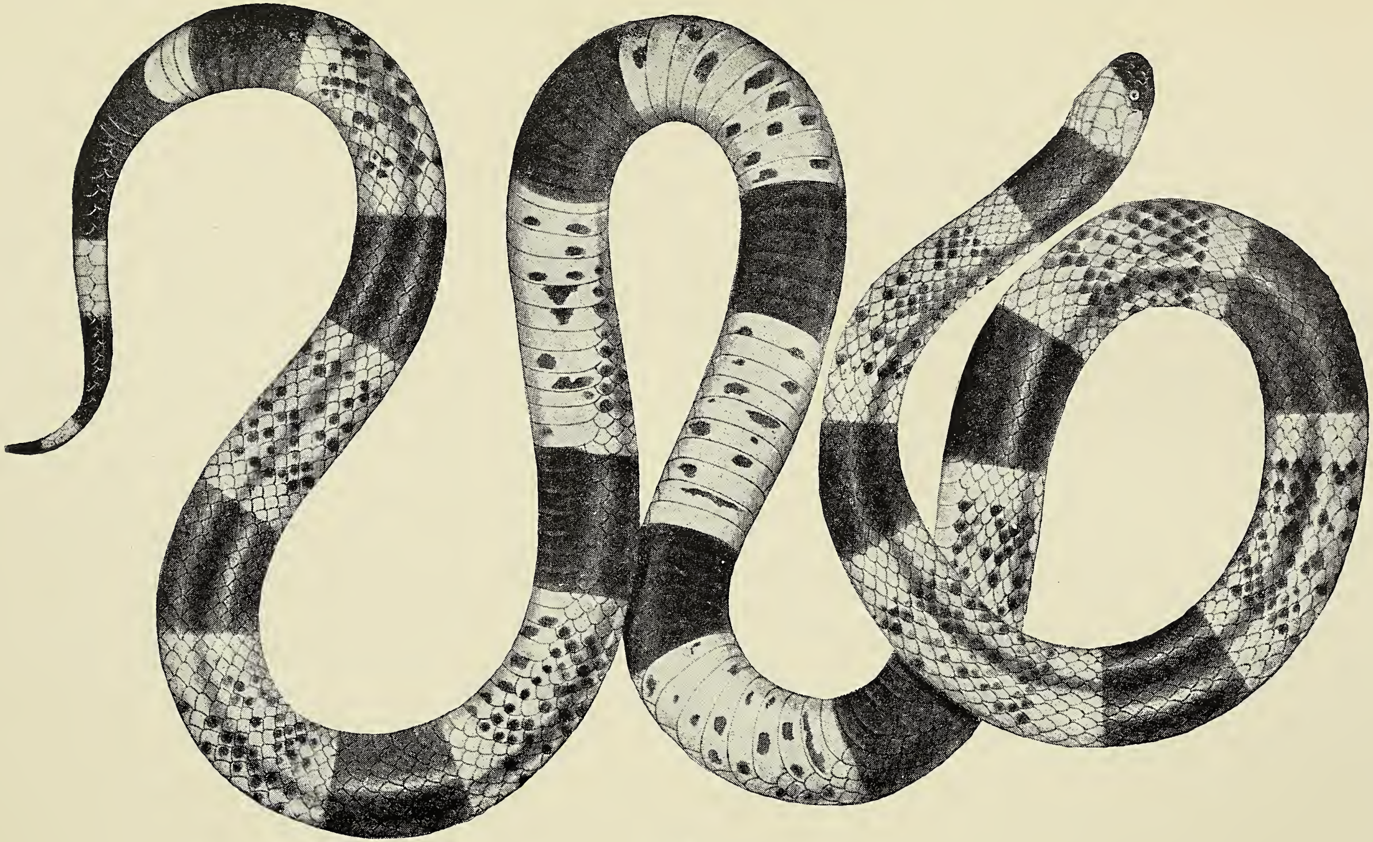

PLATE I.

Elaps Fulvius.

Harlequin Snake.

black, and embraces ten scales; the second is yellow and covers three scales. Two black and two yellow succeed and cover the same ground. The tip of the tail is black on five scales. The tip may be either black or yellow, for, according to the size, there are either three or four black rings. Underneath, the colors are the same, but dull; occasionally one or more black rings may not surround the body. The reddish spaces are irregularly blotched with deep black, as also sometimes on the upper surface." (Stejneger, "Poisonous Snakes of North America.")

The harmless and useful "Ring King Snake," *Lampropeltis annulatus,* is often, and I may say nearly always, mistaken for the poisonous *Elaps;* few people note the difference, which, briefly stated, is, first, *Elaps* has poison fangs in the upper jaw. *Lampropeltis* has no poison fangs, and is harmless. Second, in *Elaps,* the black rings are bordered on each side with yellow. In *Lampropeltis,* the yellow rings are bordered on each side with a black ring. The *Elaps* is very poisonous, and should be destroyed. The *Lampropeltis* is not only harmless, but useful to the farmer, by destroying rats, mice, centipedes and other snakes, and should be protected.

GEOGRAPHICAL DISTRIBUTION.

It is common all along the Texas coast region, from my own observation reaching inland as far as Houston, Columbus and San Antonio. Stejneger gives also the Rio Grande and Pecos rivers. Mr. John K. Strecker, Jr., says it is not uncommon in McLennan county ("Transactions of Texas Academy of Science," 1901, Vol. IV, Part II, No. 5). I am prepared to hear of its being found anywhere in Texas.

HABITS.

Elaps fulvius is so very quiet and retiring, and has such a dislike to sunlight, that little is known of its habits, and it is difficult to study in its natural conditions. It is nocturnal, and moves about after sundown and also on cloudy and rainy days. It prefers well-drained ground, and generally lives in a hole in the ground. I have sometimes found them under logs, and in Calhoun county I found one under the steps of a corn crib. Once located they will return to the same den every day. Their favorite food is the little brown lizard, *Liolepisma laterale,* which inhabits the same localities as *Elaps.* I have taken as many as three from the stomach of one *Elaps,* and I more frequently found this lizard in their stomach than any other food. They also eat other snakes. I found in one instance that an *Elaps* had swallowed a young "Coachwhip" snake, *Zamenis flagellum.* Another one, found by my brother and myself, was distended, helpless and unable to crawl, and had an inch or so of another snake's tail protruding from its mouth. We carried it home, and placed it in a vessel, and watched it disgorge a fair sized "Checked Pilot" snake, *Coluber obsoletus*, which was still alive, and was about three inches longer than the *Elaps* which had swallowed it. I have never found a female bearing eggs or young, and I know nothing of their breeding habits, and have found no literature throwing light on this subject.

ANCISTRODON PISCIVORUS, *Lacépède.*

("Cotton-mouth" or "Water Moccasin.")

PLATE II.

DESCRIPTION.

"No loreal. Inferior wall of orbit constituted by third labial; twenty dorsal rows. Dark chestnut-brown, with indistinct vertical dark bars. Line from superciliary along the edge of the head, through the middle of the second supralabial row. A second line, from the lowest point of the orbit, parallel to the first. Scales all large and well developed; those on side and back of head conspicuously so. Two nasal plates, with the nostrils between them. Anterior orbitals two, one above the other, the upper extending from the eye to the posterior nasal, the lower linear and forming the upper wall of the pit. Lower and posterior wall of pit constituted by a narrow plate resting along the third labial and terminating on the second. Third labial very large, constituting the inferior wall of the orbit, of which three scales form the posterior. Upper labials eight, very large and broad; lower ten. Occipitals (parietals) terminated each by a triangular plate. All the scales on the back of the head carinated. Dorsal scales all carinated.

"General color, dark chestnut-brown with darker markings. Head above, purplish black. An obsolete chestnut-brown streak passes from the posterior end of the superciliary along the upper edge of the head through the middle of the second row of supralabial scales. A narrow yellowish-white line passes from the third labial, or begins just below the lowest part of the orbit, and passing backward parallel with the first stripe, crosses the angle of the mouth at the seventh labial and meets the first stripe on the side of the throat. · On the lower labials are three short, nearly vertical light bars on fourth, sixth and seventh; the rest of the jaw itself, as well as the interval between the stripes on the sides of the head, dark purplish-brown, of which color is also the space in front and below the eyes. General color above, dull dark chestnut-brown. On each side a series of twenty or thirty narrow vertical pur-

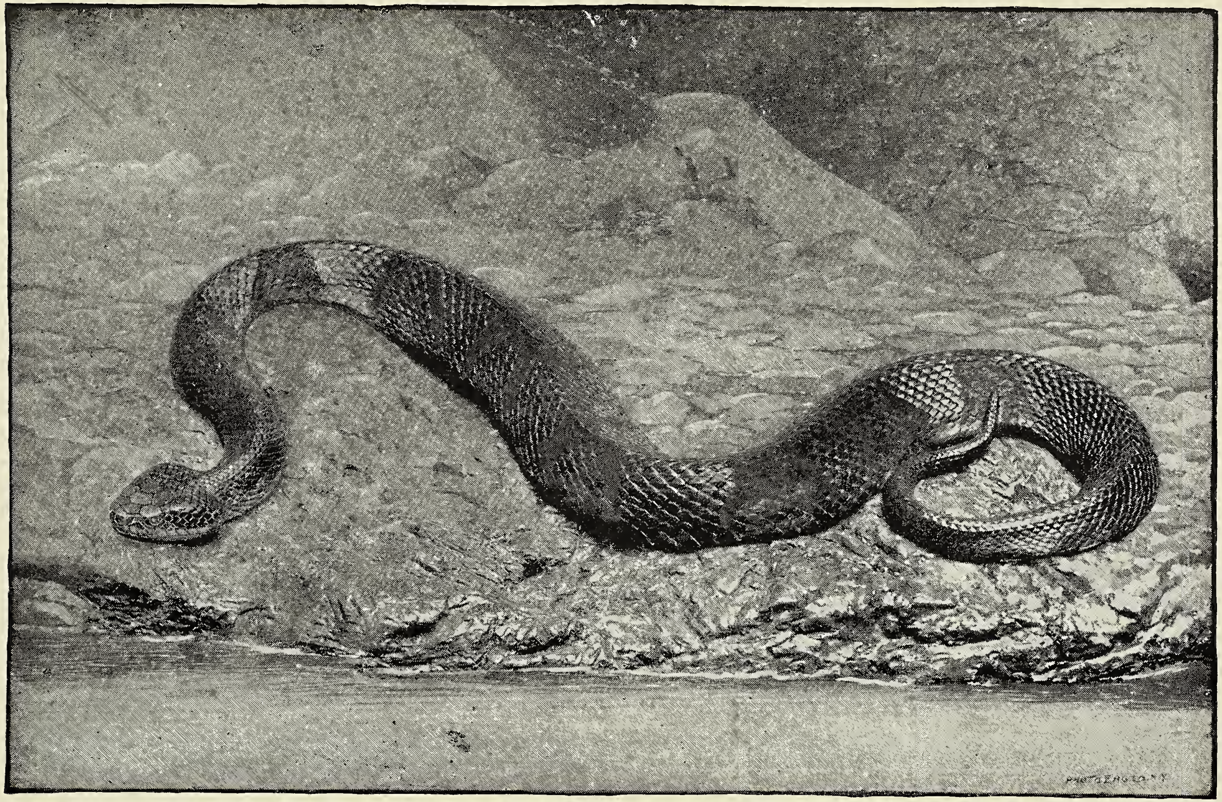

PLATE II.

Ancistrodon Piscivorus.

Cotton Mouth or Water Moccasin.

plish black bars one or two scales wide. Of these, sometimes two contiguous to each other on the same side are united above into an arch, inclosing a space, the center of which is rather duskier than the ground color; at others corresponding bars from the opposite side unite and form half-rings encircling the body. Sometimes there is a lighter shade bordering the dark bars. Beneath, black, blotched with yellow white. Number of ventrals (gastrosteges), one hundred and thirty to one hundred and forty-five; of subcaudals (urosteges), thirty-nine to forty-five, of which divided, 0 to 21." (Stejneger, "Poisonous Snakes of North America.")

The above description is all right for young snakes, but when they get aged, the colors fade, and the general appearance is dark, rough, and rusty; and I have seen specimens that were quite black.

GEOGRAPHICAL DISTRIBUTION.

All Texas, wherever moisture abounds.

HABITS.

The "Cotton-mouth" lives on the margins of streams, lakes, ponds, and in marshy and wet places; I have found them in places on the prairie where water stood only a few months of the year; digging post holes for a line of fence through such a place I found a fine specimen in a crawfish hole two feet below the surface; the ground was damp where it was, but the surface had been dry for a month. They are sluggish, and when alarmed generally make towards the water, but often towards brush or grass for protection. Their principal food is frogs, for which they lie in wait. Doctor Cope says (An. Rep. Smith. Inst., 1898, p. 1135), "They catch fish with ease." They have a habit of throwing their mouths open when danger threatens, and holding it open until the danger passes. The interior of the mouth is white, hence the name of "Cotton-mouth."

The Cotton-mouth gestates its young in the two horns of the uterus; in this species each young one being wrapped in a separate covering and separated from the others by a constriction of the uterus, the same as in animals that bear litters of young. The number of young produced at a birth is from two to twelve. The number is small, compared to the productiveness of their harmless cousin, *Natrix fasciatus,* which is often mistaken for *A. piscivorus,* and which brings forth from twenty-five to fifty young at a birth. *Tropidonotus Clarkii,* another harmless cousin of *A. piscivorus,* inhabiting the salt marshes along the Texas coast gestates in the same manner as *A. piscivorus.*

ANCISTRODON CONTORTRIX, *Linnæus.*

("Copperhead.")

PLATE III.

DESCRIPTION.

"Loreal present. Labials not entering into the orbit. Dorsal rows of scales, twenty-three. Color, light chestnut, with inverted Y shaped darker blotches on the side. Labials yellowish white. More slender than *A. piscivorus.* Plates on neck and sides smaller. Two anterior orbitals, one above the other, the lower narrower and forming the posterior wall of pit. A distinct loreal between these and the posterior nasal. Labial not forming part of the orbit, but separated by the four post and suborbitals. Labials not so largely developed; eight above, third and fourth largest; nine below. Above light hazel brown, rather brighter on the top of the head, and everywhere minutely mottled with very fine, dark points. On each side is a series of fifteen to twenty-six darker chestnut colored blotches resting on the abdominal scutellæ (ventrals, or gastrosteges), and suddenly contracting about the middle of the side, so as somewhat to resemble an inverted Y. These blotches extend to the vertebral line, where they may be truncated or end in a rounded apex. Generally, those of opposite sides alternate with each other, but frequently they are confluent above, forming continuous bands. They are so disposed that the intervals between the successive blotches are pretty much of the same shape and size, though inverted. The centers of the blotches are lighter; in some cases so much so as greatly to increase the Y shaped resemblance. Color beneath dull yellowish, with a series of distinct large blotches, thirty-five to forty-five in number, on each side. Chin and throat unspotted. Sides of head cream color; the line of demarcation very distinct; this passes along the upper edge of head, in front of the eye, and involving the lower three-fourths of the orbit, intersects the middle of the second post orbital plate (counting from above), and extends along the first row above the labials to the posterior edge of the last labial. The line then comes back through the middle of the lower labial range, where it is marked by a narrow black line. Rostral of the same color. A small areolated dark spot near the inner edge of each occipital (parietal) plate. Number of gastrosteges, 150 to 154; urosteges, undivided, 31 to 38; divided, 0 to 18 pairs. (Stejneger, "Poisonous Snakes of North America.")

GEOGRAPHICAL DISTRIBUTION.

In all the timbered lands of Texas.

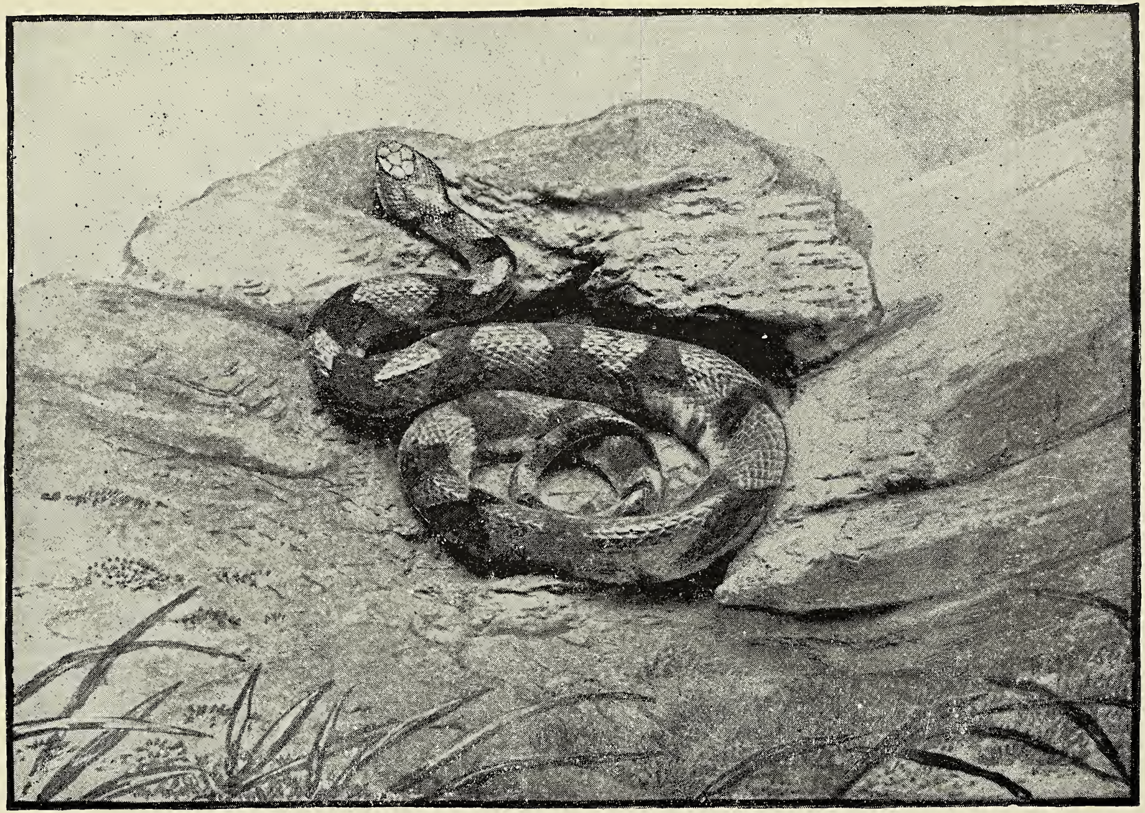

PLATE III.

Ancistrodon Contortrix

Copper head.

HABITS.

The Copperhead, sometimes known as the "Dry Land Moccasin," lives in the timber that boarders our rivers and creeks; always selecting land that seldom or never overflows. They hide under logs, in decayed stumps, in holes dug by small animals. They are rather lazy and sluggish, and cannot run fast, but will bear forced moving with very good grace unless roughly touched; this arouses their ire, and they strike back. They do not have to be coiled to strike; but can crawl and strike at the same time, having the body at rectangular curves. When thoroughly aroused they are very vicious and strike at anything presented. Their food consists of small rodents, lizards, frogs, etc.

They gestate their young, and they are born ready for the duties of life. The most I ever found in a female was eleven, seven in one horn of the uterus and four in the other horn. I have found as small a number as three, all in one horn of the uterus.

SISTRUROS CATENATUS CONSORS, *B. and G.*

(Gulf Coast Massasauga.)

DESCRIPTION.

"Twenty-five rows of dorsal scales, all carinated except the two first rows on each side. Seven series of blotches, one dorsal and three on each side, all very small. A yellowish white line passing from behind the nostril below and behind the eye. Resembles *C. miliarius* in its general appearance, but without the vertebral brownish red line. The ground color is olivaceus brown, the blotches of a deeper brown, and circled with a black fillet margined with a whitish yellow line. There are about fifty blotches in the dorsal series, emarginated anteriorly only, thirty of which are transversely elongated, very irregular; the twenty remaining ones nearly circular, with regular outlines. The blotches of the lateral rows are comparatively small and of nearly equal size, though sometimes one of either row may appear much the largest. The blotches of the first lateral series are opposite to those of the dorsal and affect the first, second, and third rows of scales, and the extremities of the abdominal scutellæ (ventrals or gastrosteges). The blotches of the second series alternate with these, extending on the third, fourth and fifth rows of scales. The blotches of the third series are obsolete, and alternate with those of the second series, and are generally opposite to those of the dorsal series situated in the fifth, sixth and seventh rows. The upper surface of the head is brown; there are two vittæ extending from the vertex along the neck to the first dorsal blotch. A broader and deep chestnut-brown band extends from the eye to the neck. The frontal region is deeper brown than the vertex. A yellowish white line starts from the nostrils near the upper surface of the head, extending backward, in passing between the eye and the pit, to the angle of the mouth. A vertical whitish bar extends from each side of the pit to the labial. The belly is yellowish white, mottled with black, transversely oblong patches. The vertical plate (frontal) is cordiform; the anterior frontal plates (internasals) proportionately small; the occipital (parietal) rather broad. The scales of the body are elongated, a little smaller than in *C. miliarius,* but not quite so acute posteriorly. The two lateral and smooth rows are much broader than the rest, and conspicuous. Most of the scales of these two rows are black, with the posterior edge straw-colored, giving the appearance of a succession of distinct crescents. The tail is conical and tapering; the rattle composed of one ring besides the terminal one. (Stejneger, "Poisonous Snakes of North America.")

GEOGRAPHICAL DISTRIBUTION.

"It was described by Baird and Girard from a single specimen collected at Indianola, Texas, which now appears to be lost." (Stejneger, Report Nat. Museum, 1893, p. 415.)

It is not mentioned by Dr. E. D. Cope in the report of the National Museum, 1898.

A fine specimen, collected at Victoria, Victoria County, Texas, by Dr. Crouse, has been identified by Dr. Stejneger, of the National Museum, as belonging to this species. The specimen is now in the Public School Museum at Victoria. Little is known of its range.

HABITS.

Nothing is known of its habits. They are possibly similar to those of *S. Catenatus.*

SISTRURUS CATENATUS EDWARDSII, *B. and G.*

(Edward's Massasauga.)

PLATE IV.

DESCRIPTION.

"Twenty-three rows of dorsal scales; first and second lateral rows smooth. Vertical plate (frontal) subpentagonal, tapering posteriorly. Lateral rows of blotches proportionately very small. The ground color is yellowish brown, with three lateral series of deep chestnut-brown

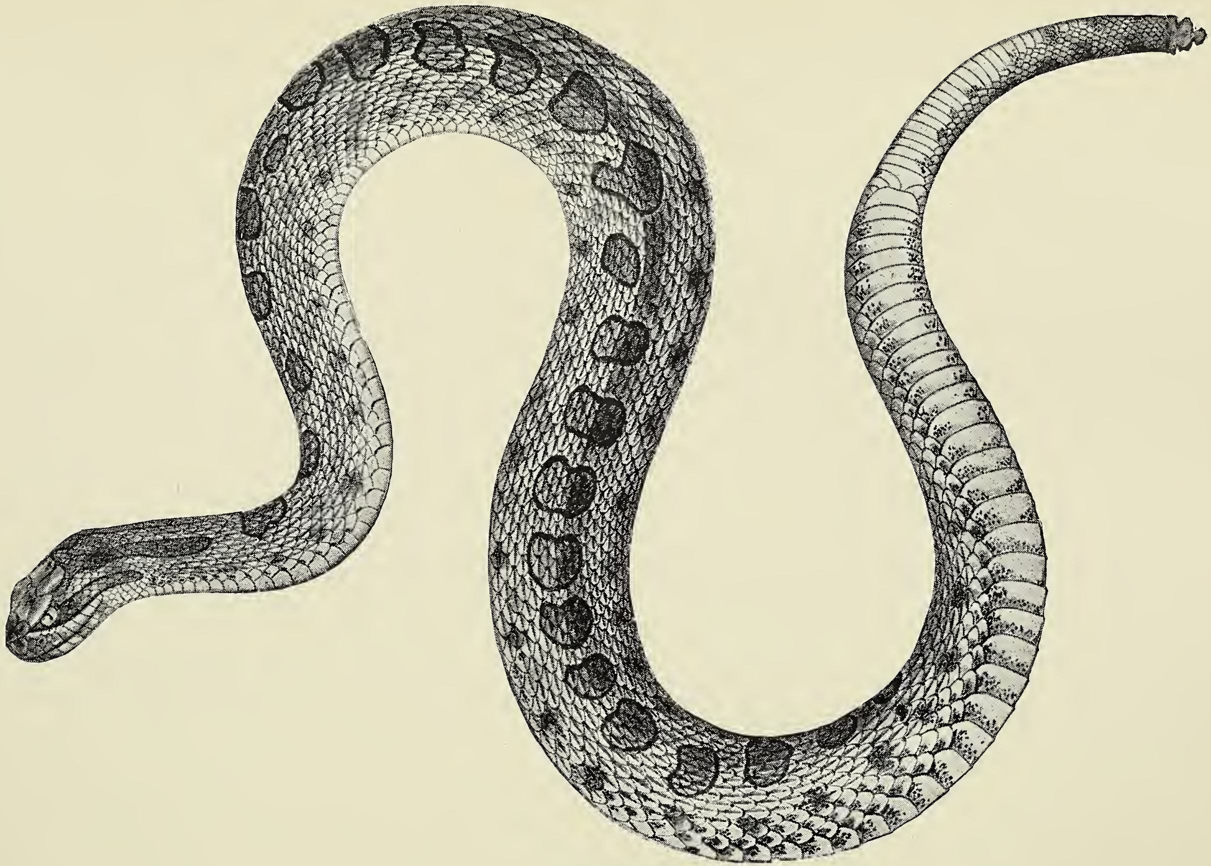

PLATE IV.

Sistrurus Catenatus Edwardsii.

Edward's Massasauga.

blotches. Two elongated brown blotches extend from the superciliaries (supraoculars) backward. A narrow band of chestnut-brown, from the posterior frontal plates (prefrontals), passes over the eyes to the neck, under which a yellowish stripe extends from the nostrils to the angle of the mouth. The snout and upper jaw are brown, with two yellow fillets diverging from the pit. The lower jaw and chin are mottled with brown and yellow. There are about 42 dorsal brown and irregular blotches, margined with deep black and encircled with a yellow fillet, from the head to the tip of the tail. The thirty-fourth opposite the anus, the last three passing to the sides of the tail, but do not meet below. Subcircular on the posterior half of the body, the blotches on the anterior half are longer transversely than longitudinally, emarginated anteriorly only. The blotches of the two lateral series are proportionately small. The blotches of the upper series are more or less obsolete, and alternate with the dorsal ones. Those of the second lateral series are the smallest, and alternate also, being of as deep a color as the dorsal ones, but do not extend beyond the anus, occupying the second, third, and fourth rows of scales. The first and lowest series affect the first and second rows and only one scale. The belly is of a light straw color, dotted and sprinkled irregularly with brown. Scales elliptical, subtruncated posteriorly, constituting twenty-three rows, strongly carinated, except the two lateral rows, which are smooth. Head, when seen from above, subelliptical; vertical plate (frontal) proportionately more elongated than in *C. tergeminus (S. catenatus)*. Number of ventrals (gastrosteges), 143 to 153; of caudals (urosteges), 24 to 31; scale rows across middle of body 23." (Stejneger, "Poisonous Snakes of North America.")

GEOGRAPHICAL DISTRIBUTION.

Dr. Stejneger says: "It is found from the Indian Territory, through Western Texas, to the Mexican border." ("Poisonous Snakes of North America," p. 418.)

Dr. Cope says: "This species ranges throughout Texas and part of Oklahoma, the Wichita specimen being the largest that I have seen. I took a specimen in the sandy region in the eastern part of Wheeler County, in the Panhandle of Texas." (Report of National Museum, 1898, p. 1146.)

I have never found this species myself.

HABITS.

Nothing is known of its habits.

SISTRURUS MILIARIUS, *Linnæus.*

("Ground Rattlesnake.")

PLATE V.

DESCRIPTION.

"Twenty-two or twenty-three dorsal rows of scales, all of which are carinated, the lateral and first row but slightly; a vertebral brownish red line; seven series of blotches, one dorsal and three lateral, on each side, the uppermost of which is obsolete, and the lowest subject to irregularities. Vertical plate (frontal) subcordiform, occipital (parietal) oblong and elongated. A narrow white line commences at the lowest point of the orbit and passes obliquely backward to the angle of the mouth. Ground color dark grayish ash, minutely mottled. A series of thirty-eight to forty-five subcircular dorsal blotches extending from head to tail, dark brown, each with a narrow distinct yellowish border. Interval rather narrower than the spots themselves. A broad band of purplish red passes from head to tail through the blotches. On each side may be distinguished three series of blotches, the first on the first and second lateral rows of scales and partly on the abdominal scutellæ (ventrals and gastrosteges); the second alternating with this on the second, third, fourth, and fifth rows of scales, and opposite the dorsal series; the third alternating with the second, and the dorsal series on the fifth, sixth, seventh and eighth rows of scales. The latter series is dusky and obsolete; the others are uniform and distinctly black. The shape of the blotches is subject to some variation, according to individuals. Generally subcircular or oblong, they become sometimes a transversely elongated quadrangle, three times as long as wide. Their shape varies according to the region of the body on which they are found. On the anterior third they are subquadrangular, anteriorly and posteriorly emarginated; on the middle region they elongate, and towards the posterior third, they become nearly circular. Backward of the anus the five or six blotches of that region extend on the sides, without, however, meeting on the lower surface. The blotches of the first lateral row are subquadrangular and a little smaller than those on the second and third rows; the blotches of the second row being transversely oblong and largest on the middle region of the body. Side of the head purplish brown, a narrow, distinct white line from the lowest part of the orbit passing obliquely backward to the angle of the mouth. Above and continuous with that white line a deep chestnut-brown vitta is observed, of the same length but broader, and lined above with a narrow, dull yellowish margin. Two undulated dark brown vittæ extend from the vertex to the first dorsal blotch and con-

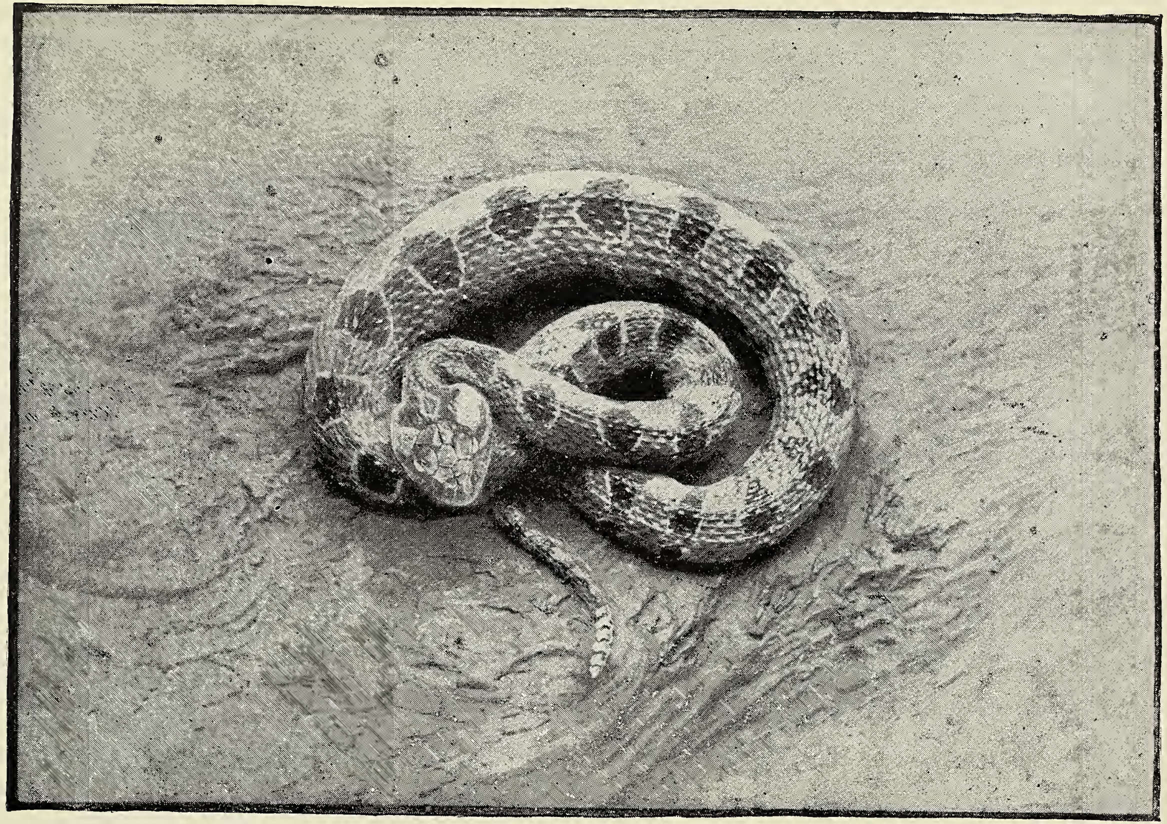

Plate V.

Sistrurus Miliarius.

Ground Rattlesnake.

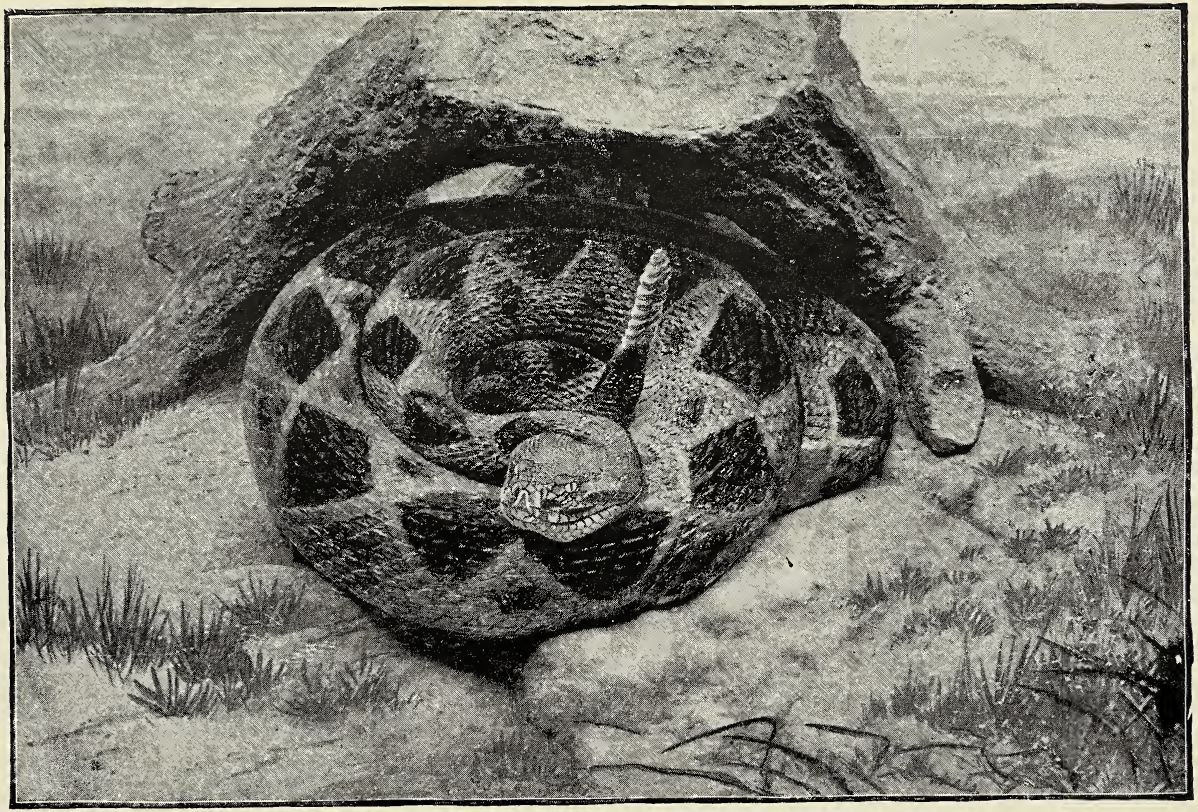

Plate VI.

Crotalus Adamanteus.

Diamond Rattlesnake.

fluent with it. A double crescentic blotch is observed on the frontal scuttellæ (internasals and prefrontals), leaving a transversal fulvus band across the head between the orbits. The color underneath is reddish yellow, marmorated with brownish black blotches and minute dots. The scales are elongated, carinated and acute posteriorly. Those of the lateral row are slightly carinated also, but narrower than in *C. consors,* and more acute posteriorly.

The number of ventrals (gastrosteges), 132 to 136; of caudals (urosteges), 27 to 36; scale rows, 21 to 23. The greatest number of joints to any rattle of this species in the U. S. National Museum is nine. (Stejneger, "Poisonous Snakes of North America.")

GEOGRAPHICAL DISTRIBUTION.

They are found everywhere in Texas.

HABITS.

Their general color is adapted to their surroundings, thus, those that live in open prairie in the grass, or that live on sandy land, are much lighter in appearance than those that live on black ground or in dense brush, or under houses. I have dissected a good many females, but have never found one that had either young or eggs.

Dr. Stejneger quotes Professor F. W. Putnam in the American Naturalist, (1868, Vol. II, p. 134), that he had once dissected a specimen having fourteen eggs, all with embryo two inches in length in the oviduct.

They are much dreaded by the country people, not so much on account of their poison (I never knew of any person bitten by a ground rattlesnake but what suffered more from the remedies administered than from the poison of the snake) as from their quietness, their habit of living around homes and outhouses, and their sudden attack. I have found in their stomachs mice and crickets. They are nocturnal, but move about on cloudy and rainy days.

CROTALUS ADAMANTEUS, *Beauvois.*

("Diamond Rattlesnake.")

PLATE VI.

DESCRIPTION.

"Head triangular. Two anterior frontals (internasals) connected with superciliaries (supraoculars) on each side by two large plates; inside of these a second row; included space filled by small scales. Scales margining superciliaries (supraoculars) small; scattered larger ones towards the center of the intermediate space. Three rows of scales between the suborbitals and labials. Suborbitals extending to the middle of the orbit. Labials fifteen or sixteen above; first, fifth and seventh largest and vertical; below, eighteen; first, fourth and fifth largest. Dorsal rows, twenty-seven, outer rows obsoletely carinated. Three or four dark rings on tail. Three series of well defined perfect rhombs, one dorsal, two lateral, separated by narrow lines. Light stripe from superciliary to the angle of the mouth.

Scales on the cheek smooth. Three rather large plates on the edge of the upper part of the head, between the superciliaries (supraoculars) and rostral, inside of which is a second row of three, also larger than the rest. The two lower rows of lateral scales smooth. Third and fourth very faintly carinated. Scales on the back and side not conspicuously different in size except the lower two or three rows. Posteriorly, near the tail, all the scales are carinated except the lowest. General color, yellowish gray, with rhomboidal black blotches, lighter in the center, and with the angles perfect. Or rather there is a series of dull yellowish lines crossing obliquely from one side of the abdomen to the other over the back, following the oblique series of scales, and occupying generally the posterior half of each scale, the basal portion being black. These lines of which there are about thirty-six, crossing from each side, from head to tail (nine on tail), decussate first on the fifth and sixth lateral row, and then on the back, where they are more or less confluent three or four rows. The rhomboids thus inclosed and crossing the back are generally black for one and a half or two scales within the yellowish lines, and the most central portion is dark yellowish brown, mottled with darker. The intervals on the sides between the lines are mostly dark, yellowish brown, minutely mottled with dark brown. These intervals constitute a lateral series of transverse rhomboids, sometimes with the lower angle truncated. Opposite to the dorsal rhomboids is a series of small triangles in the angle of the first decussation. The distance between two parallel transverse stripes generally consist of five rows of scales, occasionally of six.

On the sides and posteriorly these markings are more or less indistinct, though generally recognizable. The tail usually exhibits a good deal of black with under part of dull yellowish white, or greenish white clouded towards the side with brown; no regular spots visible. The black on the tail does not constitute complete rings but is interrupted in the middle of the lower surface, and in fact the black patches alternate with each other and are not opposite.

The top of the head is light brown, with occasional black scales. A dull yellowish streak starts at the posterior edge of the superciliary plate, and passing obliquely backward, through two rows of scales, extends to

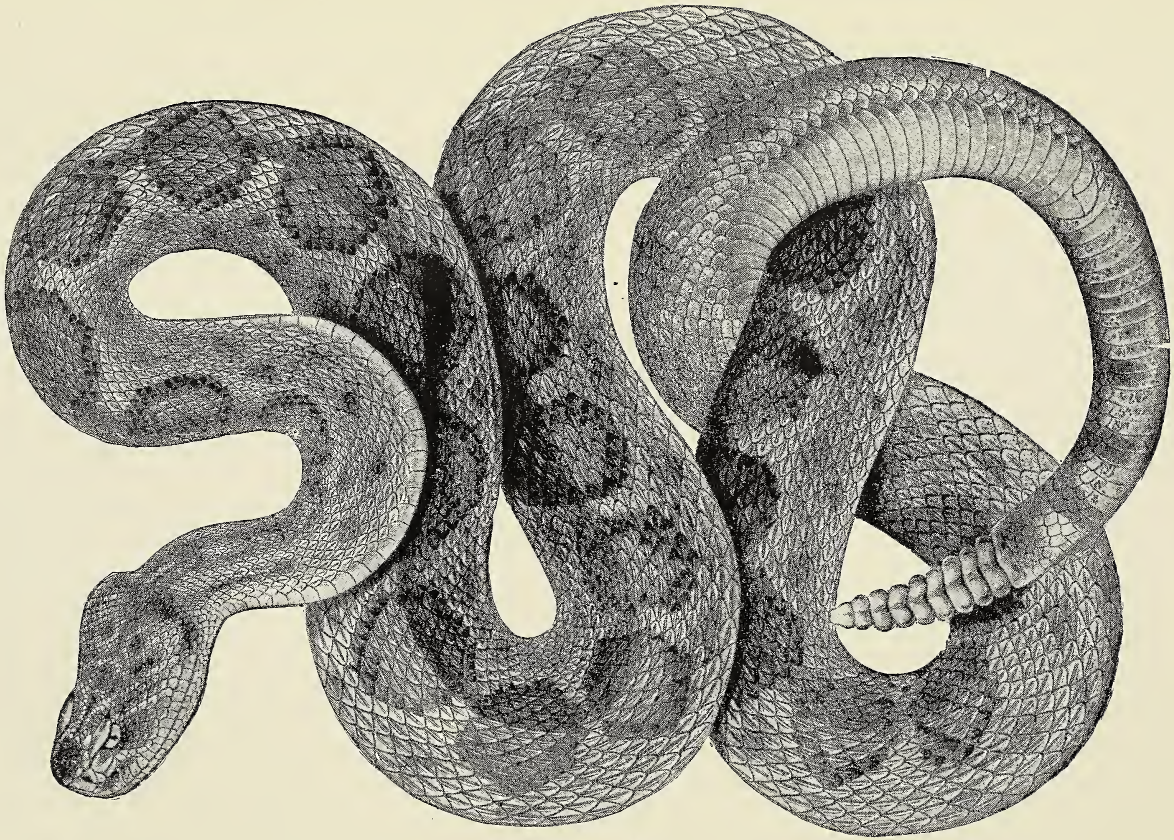

Plate VII.

Crotalus Adamanteus Atrox.

Texas Rattlesnake.

the angle of the mouth. A second band starts on the plate in advance of the superciliary, and crossing the anterior orbitals, expands till it involves the seventh, eighth and ninth upper labials. Interval between the first two stripes dark brown. There are also indications of a second vertical light bar in front of the nostril, and two below the pit. Rostral dark yellowish, lighter in the margin.

Number of ventrals (gastrosteges), 169; of subcaudals (urosteges), 32; scale rows across body, 27. (Stejneger, "Poisonous Snakes of North America.")

GEOGRAPHICAL DISTRIBUTION.

I have read nothing which records *Crotalus adamanteus* from Texas. My own observations (which cover fifty years), prove that this species was rather numerous thirty years ago in the timbered belts along the coast region. I have found it in the counties of Harris, Matagorda, Lavaca, Jackson, Victoria and Calhoun. It was known among ranchmen and cowboys as the timber rattlesnake, on account of its preference for river bottoms, to distinguish it from the variety, *Crotalus atrox,* which prefers the open country.

HABITS.

It prefers dense shade and moisture, hence is most frequently found in river bottoms. It associates with *Crotalus atrox.* I have found them hibernating in the same den in the winter, and I have found them together in the summer. Their general habits are the same as *Crotalus atrox,* under which head see remarks.

CROTALUS ADAMANTEUS ATROX, *B. and G.*

("The Texas Rattlesnake.")

PLATE VII.

DESCRIPTION.

"Head triangular; plates on head; two anterior frontals (internasals) in contact; between these and the superciliaries (supraoculars), on side of the crown, two imbricated plates; space inclosed occupied by smaller scales; superciliaries (supraoculars) bordered by a row of larger scales; the anterior much largest. Three rows of scales between labials and suborbitals; labials sixteen above, first, fifth and seventh largest; fifteen below, first and third largest; dorsal row twenty-five to twenty-seven; two exterior rows smooth; on the tail three to six half rings. Color yellowish brown, with a continuous succession of dorsal lozenges, sometimes truncate before and behind; intervals all narrow. A single transverse

—3—

light line; superciliary stripe from superciliary directly through the angle of the mouth.

General style of coloration somewhat as in *Crotalus adamanteus*. Ground color above, dull yellowish brown, with a series of subhexagonal patches from the head nearly to the tail, in an uninterrupted series, separated throughout by narrow lines. We may refer the marking to the intersection of two series of light yellowish lines, about forty in number, crossing obliquely from each side across to the other, along the anterior half of as many oblique series of scales. The lateral decussation is along the sixth row of dorsal scales; on the back, where they cross, the lines are confluent for a breadth of five or six scales, making a series of transverse lines across the back, truncating the obtuse angles of the rhomboids, which otherwise would be produced. Sometimes the acute lateral angles of the rhomboids are also truncated. Laterally the yellowish lines are more or less obsolete, leaving a more or less distinct chain pattern. The rhomboids or subrhomboids inclosed have a narrow margin of dark brown, lighter towards the center. In all cases the interval between the successive rhomboids is but one or two half scales in width. The lateral rhomboids and triangle referred to in *Crotalus adamanteus* are indicated by two alternating series of dark brown blotches, the first along the third and fourth lateral row, opposite the apices of the rhomboids; the second along the sixth and seventh, and alternating with the same; the spots occupy one scale, or part of four contiguous ones. Space between these rhomboids and the yellowish lines, dull yellowish brown. Beneath nearly uniform yellowish, slightly clouded on the sides of the scales. On the tail the blotches are confluent into three or six dark brown half rings, interrupted on the surface. General distribution of lines on the head much as in *Crotalus adamanteus;* a narrow line from the posterior end of superciliary backward directly to the angle of the mouth; a second from the anterior extremity, nearly parallel with the first, the two inclosing an indistinct patch and separated on the labial by four and one-half scales. There is also a single light line across the superciliary, perpendicular to its length, obsolete in old specimens.

It may be readily distinguished from *C. adamanteus* by its light color and the truncations of the rhomboids, as well as the general obsoleteness of the lateral markings. The rhomboids are longer in proportion and more rounded. The two lateral rows of scales are smooth, the next two more strongly carinated than in *Crotalus adamanteus.* The fifth upper labial is largest, and transverse, the rest nearly uniform. The stripes on the side of the head are less distinct.

From *Crotalus confluentus* it may be distinguished by the greater comparative size of the interval between the dorsal blotches, especially posteriorly. In *Crotalus confluentus* there are two light lines across the superciliary plate, dividing it into three sections, the central rather narrower. Here, too, the posterior facial stripe, instead of passing to the angle of the mouth, goes back of it on the second row above the labials, in *Crotalus atrox,* passing directly to the angle of the mouth. Other important distinctions are seen in the narrower scales of *Crotalus confluentus,* etc.

From *Crotalus lucifer,* the more narrow head, fewer and larger intersuperciliary scales, lighter color, arrangement of color along the head, will at once distinguish it.

Number of ventrals (gastrosteges), 177 to 187; number of subcaudals (urosteges), 23 to 28; number of scale rows across the body, 25 to 27." (Stejneger, "Poisonous Sankes of North America.")

GEOGRAPHICAL DISTRIBUTION.

Dr. Stejneger ("Poisonous Snakes of North America," p. 439), says: "*Crotalus atrox* covers a considerable area, embracing the arid portion of Texas, parts of southern New Mexico, Arizona, and parts of California, southward into Mexico. In Western and Southern Texas west of about the 97th meridian, this species appears to be the rattlesnake, being apparently common in all suitable localities."

I have found it in Matagorda, Calhoun, Jackson, Lavaca, Victoria, Aransas and Nueces counties. It was very common in those counties twenty or thirty years ago, and is still the principal rattler of the coast region. It was known among ranchmen and cowboys as the Prairie Rattler to distinguish it from *Crotalus adamanteus.* I have always regarded *Crotalus atrox* as a variety of *Crotalus adamanteus,* for the reasons that I have frequently found them together, both in winter quarters and in their summer wanderings, and I have found every variation of the color pattern from one type to the other. I have never found the two species in actual coitus, but I have found the male of one species and the female of the other species together under very compromising circumstances.

HABITS.

Crotalus atrox comes out of winter quarters in February or March, according as spring is late or early. I have found them mating as early as March 14th and as late as June 20th. The female lays eggs, generally twelve at a time. She lays two clutches several weeks or a month apart. The eggs of the first clutch are all contained in one oviduct. The second clutch of eggs are all from the other oviduct. Thus, a mating female cut open the latter part of March had twelve eggs, a little smaller than rice grains, in the right oviduct, and nothing in the left oviduct. Another mating female, cut open in May, had twelve eggs in the right oviduct mature and ready for depositing and twelve eggs about the size of rice grains in the left oviduct. Another, cut open the last of June had eight mature eggs in the left oviduct, and nothing in the right oviduct. The dissection of perhaps more than fifty females with eggs, bears out the above facts. I have found as many as sixteen eggs in one oviduct, and as small a number as four. The female deposits her eggs in some damp, cool place. I have found them in "cave in" holes in the bay bank made by water; in holes in the ground at root of bushes dug by box tortoise or some rodent; and under timber piled near the ground. I have always found the mother snake near the eggs; frequently she was coiled around the eggs and fought savagely to protect them.

During the mating season the males are very aggressive, and will promptly rattle a challenge to an intruder; I have received such a challenge when fifty feet away. Once on dismounting to fix my saddle, I heard a challenge rattle about twenty feet away, on looking that way I saw a large male about five feet long coming towards me in fighting attitude; when about eight feet off, I broke his back with a pistol bullet; this stopped him but did not change his mind, for he made frantic efforts to get at me before he died.

When first disturbed a rattlesnake will throw himself into a coil and sound his rattle; this is a warning to the intruder to keep away. Continued irritation will bring him to a fighting attitude, to assume which he raises the anterior one-third of his body, doubles it in rising folds across the balance of his body which is coiled and used as a base. This brings his head some inches from the ground; he can now face an enemy from any side, and just so far as his body is folded, just that far can he strike. Many times when attacking and tormenting a snake, and it was unable to strike back, I have had them to crawl away towards cover with the posterior part of their body, and keeping the anterior part elevated and directly over the posterior part and facing me; it is the most aggressive and protective action imaginable. This is the most dangerous attitude the snake can assume, for thus postured he can strike nearly his full length. As he thus moves, with his neck flattened, saliva dripping from his mouth, tongue darting back and forth, his rattle sounding, and his sickening odor filling the air, his expression is hellish, and the sight is well calculated to give one a creepy feeling along the spinal column.

About May 1, 1866, at Point Comfort, Calhoun County, I was moving some palings, which had been piled on two by four scantlings; grass had grown around the pile, forming an ideal place for snakes. A young negro man was assisting me; when near the bottom of the pile we were notified by the rattling that snakes were under the pile. We slipped a scantling under one edge of the pile, and turned it over at one stroke. In one corner a large female was coiled, with small ones, eight or ten inches long, crawling over her and coiled around her. In another corner was coiled another large female with young ones about half the size of the first batch crawling over her. The young negro exclaimed, "For God's sake look, she is eating them." A look showed the tail of one of the smaller brood disappear down its mother's throat. We began on them with sticks, and soon killed the whole lot. A dissection then followed. Snake number one was poor, but in normal condition, and had twelve young ones around her. Snake number two was poor also, and had three of her young ones in her stomach; one was dead, having been killed by a blow on the mother, the other two were alive; there were seven young ones besides the three taken from the mother's stomach; the dried egg cases were present, showing that they had not been hatched very long. The mother snake also had a bunch of wire worms in the abdominal cavity, near the anus.

After June the *Crotalus* becomes sluggish, and as fall approaches it becomes very fat, lazy and good natured. A favorite habit of this snake in midsummer is to crawl to the edge of the bay, towards sundown, and enjoy the cool breeze and spray, and incidentally to watch for prey. They hunt nearly altogether by lying in wait for their prey. Selecting a place beside a path, and coiling itself as near out of sight as possible, it waits; any number of animals may pass, and if not suitable for food, they can pass in safety; but a rabbit, rat, or bird, will fall a victim. Once in the Navidad River bottom in Jackson County, I was watching the antics of a fox squirrel; it was running up and down the trunk of a leaning live oak tree, barking furiously; each time it would descend a few feet lower than before; its entire attention was given to some object at the foot of the tree, in some moss and sticks; at length descending to some two feet from the ground, a very large rattlesnake suddenly struck it on the back of the neck; with a squeak the squirrel fell to the ground, and when I arrived on the spot, it was dead, and the snake had hold of it and was ready to swallow it. On two occasions I witnessed a mocking bird lose its life by a rattlesnake. In each case the bird had a nest nearby, and the snake was coiled in the weeds; the bird began darting at the snake, uttering its cry of anger; continuing to dart, it finally came within reach, when the snake by a quick spring struck it dead. Things of this kind, in my judgment, are what have given color to the fallacy that snakes can charm their prey.

Place a rattlesnake where it cannot escape, whip it into a frenzy with a switch, and it will bite itself, sinking the fangs deep into the flesh. I once thought that they intended to commit suicide, but later experiments proved that their bite was harmless to themselves, and that in their blind fury they would bite themselves by accident.

When a rattlesnake is getting ready to shed its outer skin, it retires to a hole in the ground, or other secret cool place, and remains quiet until the young skin is fully ripe, and the old skin loose, when it comes out, and literally goes it blind until it finds something like a stiff weed to rub its head against to start the old shed from around its mouth; as soon as it has pushed the old shed back from its head, it is all right, for it can then see its way. In crawling around, the old shed gets caught on vegetation, and the snake crawls out of it, leaving it inverted. I witnessed this performance several times in Calhoun County in July and August; one snake which I dug out of the ground, in August, and found the old shed loose, I assisted in changing its dress. Just before shedding, the colors of the skin almost disappear, and in a freshly shed specimen the colors are very bright and beautiful.

The rattler is not afraid of water, and when he wishes to emigrate, the bay is no drawback. In sailing across Keller's Bay I once met a fine specimen swimming from the north side of the bay to a point of land known as Sand Point on the south side of the bay, distant about four miles. When seen the snake was near the midle of the bay. At another time I found one in the middle of Espiritu Santo Bay, going from the mainland to Matagorda Island. In both cases, the snakes seemed to have a well defined purpose.

As cool weather approaches, rattlers drift to the bay bluff where there are fissures and holes made by water; or to some well drained ridge where holes are dug by small animals, and at first frost enter these holes and pass the winter in a torpid condition. They are neither selfish nor select in their company in winter quarters, as will be seen by the contents of some of the dens which I have dug out.

No. 1. Situated on the bank of Cox's Creek, Jackson County, contained seventeen rattlers and one coachwhip, each snake coiled separately. All these rattlers had wire worms in the abdominal cavity.

No. 2. On shore of Matagorda Bay, Calhoun County, contained eight rattlers and one dry land tortoise. These were all in a mass about the size of a half bushel measure. I took the mass out and laid it in the sun for a half hour or more, when they softened enough to loosen, and the tortoise was found in the middle of the mass.

No. 3. On bank of Carancahua Bay, Calhoun County, contained one cottontail rabbit, one skunk, two coachwhips and seven rattlers. The rabbit had just been run into the den by a hawk; the snakes were each coiled to itself, and quite stiff, and were lifted out like blocks of wood.

No. 4. Under a huisache bush on a sandy ridge, Calhoun County, contained four very large rattlers, and two large coachwhips; these were all tangled together like a mass of ropes.

No. 5. At root of catclaw bush on a sandy ridge, Jackson County, contained six large rattlers and one land tortoise. These were all coiled separately.

The four longest snakes that I ever killed and measured, were all killed in Calhoun County, and measured as follows: One male, six feet two inches; one female, six feet nine inches; one male, six feet ten inches; and one female six feet eleven inches.

The rattler has three natural enemies, that are much dreaded by it, and which assist in keeping it in bounds. The Mexican eagle (*Caracara*), the hog (wild and domestic), and the speckled kingsnake (*Ophibolus getulus*).

The Mexican eagle is the foe of all snakes, and kills them for food. I have twice witnessed them destroy a rattler. In each case the snake was less than three feet long; and in each case the mode of attack was the same; the eagle dropped to the ground near the snake, and when the snake straightened out to crawl away, the bird by a quick dart caught the snake by the neck with its claws, and with one stroke of its strong beak wrenched the head from the body.

Hogs catch and eat rattlers without ceremony. In one instance a three foot snake was coiled under a bush. A gentle sow was following me; I passed the snake without seeing it; when the sow came opposite the snake she made a rush into the bush, and came out holding the snake by the middle; the snake bit her several times on the jowls, and it must have been painful, for she squealed lustily, but did not falter; she put her forefeet on the snake, and tore it in pieces and devoured it. When she attempted to pick up the head, though it had but an inch of the neck to it, it opened its mouth and caught the sow by the lip, and she had to use her feet to get it loose. In another instance, I saw two shoats trotting along, when they came upon a snake stretched across the path; by mutual instinct they pounced on it, tore it to pieces, and devoured it in less time than it takes to write about it. No evil effects followed in either case. I could cite many more instances.

The king snake (*Ophibolus getulus*) seems to be able to rob the rattler of its power of resistance, as will be noted in the following account of a battle between them. It was in the spring of 1858, in Calhoun County; I heard the rattler's challenge, or warning rattle, and going to the place I found in a clear space surrounded by brush and cacti two very large rattlers nearly six feet long each, coiled, with heads up and rattles sounding; they were looking in the opposite direction from me, and seemed more alarmed than angry; presently a small kingsnake, not more than half the length of the rattlers, glided out of the brush into the clear space. He came with head and part of his body raised and curved and waving from side to side; he approached the nearest rattler, alternately swelling and flattening his neck, crawled half way round the rattler, and then back again, as if looking for an opening; the rattler remained on the defensive, and both he and his mate seemed paralyzed with fear. Finally the kingsnake made a dart; for awhile I could see nothing but a tangle of snakes and a cloud of dust; as the combatants quieted down, I saw that the kingsnake had the rattler by the jaw with his mouth, and had his body twisted several times around the rattler's neck; the rattler was striking the ground violently with his tail and the posterior part of his body, and the kingsnake was momentarily tightening his grip by convulsive muscular action. After a time the rattler ceased all motion and the kingsnake gradually loosened his folds, keeping his mouth hold on the jaw; feeling no motion in the rattler, he let go, and pushed the rattler's head with his nose, then he crawled over the rattler's body several times, going from head to tail and back again, nosing the head again. Convinced that his enemy was dead, he immediately assumed his offensive attitude and started for the second rattler, which had continued in the same position during the battle with the first. A second battle now followed, the counterpart of the first; when the kingsnake was satisfied that his second victim was dead, he glided into the bushes and left the dead snakes to me. The kingsnake was scarcely half the length of either rattlesnake, and showed neither fear nor hesitation at any time during the battle. The rattlesnakes showed great alarm from the start; and the second one seemed too much paralzyed by fear to crawl away during the first battle. Neither rattlesnake made a single stroke that I saw. Both rattlers had their heads dislocated from their bodies, and several inches of the vertebra crushed to a pulp.

The danger of death from the bite of a poisonous snake is, in my opinion, very much exaggerated. Of course, there is danger of death when a large snake plants a full dose of poison in a vein or artery; in such a case the most prompt and heroic treatment would hardly avail; but like Mount Pelee's eruptions, such bites are few and far between. For the benefit of anyone bitten by a poisonous snake, and who is beyond the reach of a physician, I would advise the following treatment: Tie a cord above the wound if possible. Scarify freely around the wound. Get as much blood from the wound as possible, either by suction or cupping. Empty the stomach with an emetic, and the bowels with a purgative.

In our boyhood, my brother and myself were made the owners of an imported bull terrier, crop-eared, bob-tailed and ugly of countenance, but he was gritty, and never hesitated whether it was a rat, rattlesnake, or catamount. I do not exaggerate when I say that this little dog killed more than one hundred large rattlesnakes, besides copperheads, cottonmouths, small rattlers and harmless snakes. He was bitten sixteen times by large rattlers, when my brother and myself were present, and we were

PLATE VIII.

Crotalus Horridus.

Banded Rattlesnake.

his sole medical advisers; melted lard internally, and cold water applications externally were the only remedies used. He was always bitten on the head; and on one occasion, I drew a curved fang from his nose three-fourths of an inch long. He died of old age. I have known a great many dogs to be bitten by rattlesnakes, and I have known only two to die; both of these were left several miles from home, in mid summer, and when found the next day were dead; the heat and exhaustion may have helped to cause death.

I know that I am flying in the face of all that I have read about the breeding habits of *Crotalus,* when I say that they deposit their eggs. I will not say that they do not sometimes retain their eggs until hatching time and then bring forth the young alive; (for I have opened females bearing eggs, in which incubation was well under way); but I have never witnessed this performance; whereas I have frequently found the eggs, guarded by the mother snake, which fought till death for their protection. It is true that I have never found perfectly fresh eggs in a nest, they were always ready or nearly ready to hatch, the thin shell or envelope having lost its roundness and crinkled in around the young snake. Another theory which may throw some light on this point, is, that the writers who speak of rattlesnakes bringing forth live young, made their observations upon snakes in captivity; which condition may have had some influence upon them, causing them to retain their eggs until hatched and the young snakes were brought forth alive. My observations were made with wild snakes in a state of nature. I will leave the reconciliation of these contradictory facts to future observers.

The flesh of the rattlesnake is white and palatable, very much resembling the breast of quail in look and flavor. The oil makes a fine foundation for a liniment, and is used by old ranchmen on sorebacked horses; and it is claimed to be a specific for rheumatism.

CROTALUS HORRIDUS, *Linnæus.*

("Banded Rattlesnake.")

PLATE VIII.

DESCRIPTION.

"Head angular. Scales between the superciliaries small, numerous, uniform. Plates above the snout, two anterior frontal (internasals) and five post frontal (prefrontals). Suborbital chain continuous, of large scales; two rows between this and labials. Labials 12 to 14 above, fifth largest; thirteen to fifteen below. Rows of scales on the back twenty-three to twenty-five, all carinated; carination on outer row obsolete. Tail black. Above sulphur brown, with two rows of confluent brown lozenges. Light line from superciliary to angle of the mouth; behind this a dark patch.

Head above covered with small subtuberculous scales. Superciliaries (supraoculars) large. Anterior frontals (internasals) large, triangular, emarginated behind to receive a series of three small plates. A single subhexagonal plate between the superciliary (supraocular) and anterior frontal (internasal). The exterior plate of the posterior frontal (prefrontal) row is much the largest, and is in contact with the superciliaries (supraoculars). A series of three or four large flat scales extend from the posterior extremity of the superciliary (supraocular). Scales on cheeks (temporals) very large, truncate. Anterior orbitals (preoculars) double, the upper one rectangular, elongated logitudinally, separate from the (posterior) nasal by two small plates (loreals).

General color above that of roll sulphur; beneath, whitish yellow. Along the back is a double series of subrhomboidal blotches, looking as if they had been in contact, and then the line of junction partially effaced, for the three or four central rows. The impression conveyed by the color of these blotches is that of coarse mottlings of soot or gunpowder grains, more crowded exteriorly. There are twenty-one of these blotches from the head to the anus, the tail being entirely black. The rhomboids are inclosed within about twelve dorsal series of scales. Directly opposite to these spots on each side is a series of subtriangular blotches similarly constituted as to color, and extending from the abdomen to about the fifth lateral row, and some six or seven scales long. Anteriorly these are distinct from the dorsal series, but posteriorly they are confluent with them, forming a series of zigzag blotches across the body. The scutellæ below show more or less of the grain-like mottlings. Posteriorly the yellow of the body is suffused with darker.

There are no markings of lines distinctly visible on the sides of the head. In the center of the spaces between the dorsal and lateral series of blotches are indications of small obsolete spots, and in some cases the yellow scales external to the blotches are of a lighter color than the rest.

Number of ventrals (gastrosteges), 166; of subcaudals (urosteges), 25; dorsal scale rows, 23.

Total length, 42 inches; tail, 5 inches."

(Stejneger, "Poisonous Snakes of North America.")

GEOGRAPHICAL DISTRIBUTION.

"The banded rattlesnake extends even into Texas, as Dr. Shumard sent to the Smithsonian Institution a specimen collected on the upper Brazos during Captain Marcy's exploration of that river." (Dr. Stejneger, "Poisonous Snakes of North America.")

In April, 1902, Dr. H. W. Crouse secured a fine specimen near the

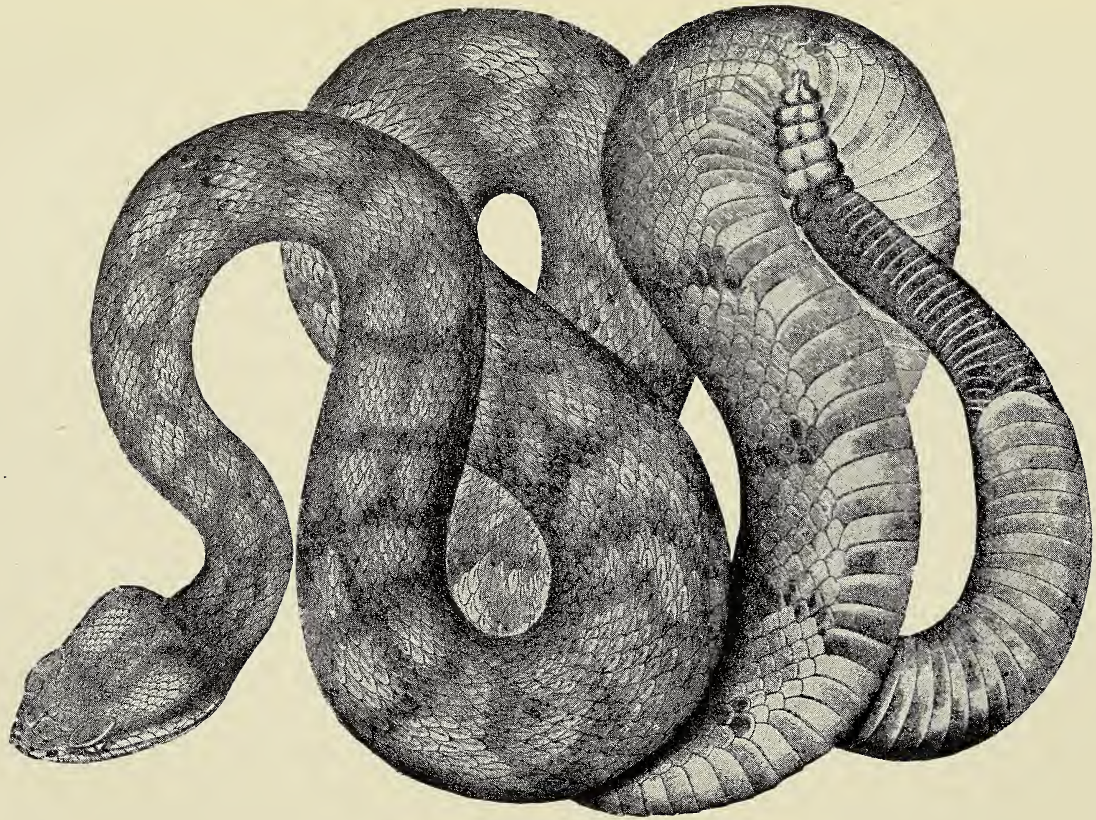

PLATE IX.
Crotalus Molossus.
Dog-faced Rattlesnake.

city of Victoria, Texas; which is now in the Public School museum there, as is also the stuffed skin of a fine specimen captured by Professor Gates Thomas in Fayette County, near the town of Winchester in June, 1902. John K. Streecker, Jr. (Transactions of Texas Academy of Science, Vol. IV, part II, No. 5, 1901), mentions one large specimen being killed four miles north of Waco, McLennan County. I expect it has been plentiful in the timber districts of Central Texas, and no doubt a search would find specimens there yet.

HABITS.

I have never observed this snake myself, and know nothing of its habits.

Quoting from Professor O. P. Hay on the habits of *Crotalus horridus* (Report of National Museum, 1898, page 1189): "The number of young appears to be about nine. I found this number of eggs in a female about thirty-seven inches long, brought from Pennsylvania. The eggs were 1.5 inches long by an inch in diameter. Of these there were four in the left oviduct. There were evidences that development had begun."

CROTALUS MOLOSSUS, *B. and G.*

(Dog-faced Rattlesnake.)

PLATE IX.

DESCRIPTION.

"Muzzle broad; rostral small. Scales between superciliaries (supra oculars) small, uniform, except the two anterior. Two frontal plates (internasals), four post frontals (prefrontals), two intersuperciliary (interorbitals), all in contact. Five rows scales between the labials and and suborbital row; middle row not extending beyond the middle of the orbit; labials, eighteen above, fifth and sixth largest; seventeen below. Dorsal rows of scales, twenty-nine; two external rows, small. Tail uniform black. Color roll sulphur; a series of chestnut brown transverse lozenges with exterior corners produced to the abdomen; centers of lozenges with one or two spots; each scale but one color; a brown patch below and behind the eye.

One of the most strongly marked of all species. Head very broad in front; outline nearly rectangular. Rostral small. Two anterior frontals (internasals); behind these, four plates, the exterior resting on the superciliary; behind these two other plates between and in contact with the superciliaries (supraorbitals). Anterior nasal subtriangular. Top of head with numerous smooth subtubercular scales. Suborbitals large, extending to the anterior canthus. General aspect smoother than in

Crotali generally; scales rounded at the posterior apex, carinated but slightly.

General color above, that of roll sulphur; beneath, pale yellowish. Posteriorily, very faintly clouded with brownish. Tail black. Anteriorily the scutellæ (ventrals or gastrosteges) are entirely immaculate. Along the back is a series of transverse reddish or chestnut brown lozenges embraced in a width of twelve or fourteen scales and four or five scales long, and with the exterior angles produced to the abdomen. These lozenges are frames with the outlines generally one scale in width, and with the centers of the ground color; sometimes divided by a median line of brown so as to show two yellowish spots inside of the lozenges. The scales exterior to the lozenges are rather lighter. Sometimes the brown rings and the lozenges widen at the abdomen and indicate lateral spots of four scales; at others, and especially anteriorly, the rings are obsolete and the brown is in a dorsal series. In fact, for the anterior fourth of the body we have a dorsal patch of brown showing alternately, at successive intervals, one large yellowish spot and then a pair of smaller ones, owing to the confluence of the successive lozenges. The superciliaries and scales anterior to them, as well as a broad patch below and behind the eye, light greenish brown. Tail uniform dark-brown above, paler beneath.

A remarkable character of this species is that each individual scale is of the same uniform tint to its base, and not showing two colors as in other species."

(Stejneger, "Poisonous Snakes of North America").

GEOGRAPHICAL DISTRIBUTION.

Quoting from Report Nat. Museum, 1893, page 426: "The Texas specimen upon which Hallowell based the *Crotalus Ornatus,* was collected by Dr. Heerman at the Pecos River, en route between El Paso and San Antonio, and is so far the only specimen obtained in Texas." (*C. ornatus* is now considered a synonym of *C. molossus.*)

HABITS.

Nothing is known of its habits.

CROTALUS CONFLUENTUS, *Say.*

("Prairie Rattlesnake.")

PLATE X.

DESCRIPTION.

"Head subtriangular. Plates on top of head squamiform, irregular, angulated, and imbricated; scales between superciliaries (supraoculars),

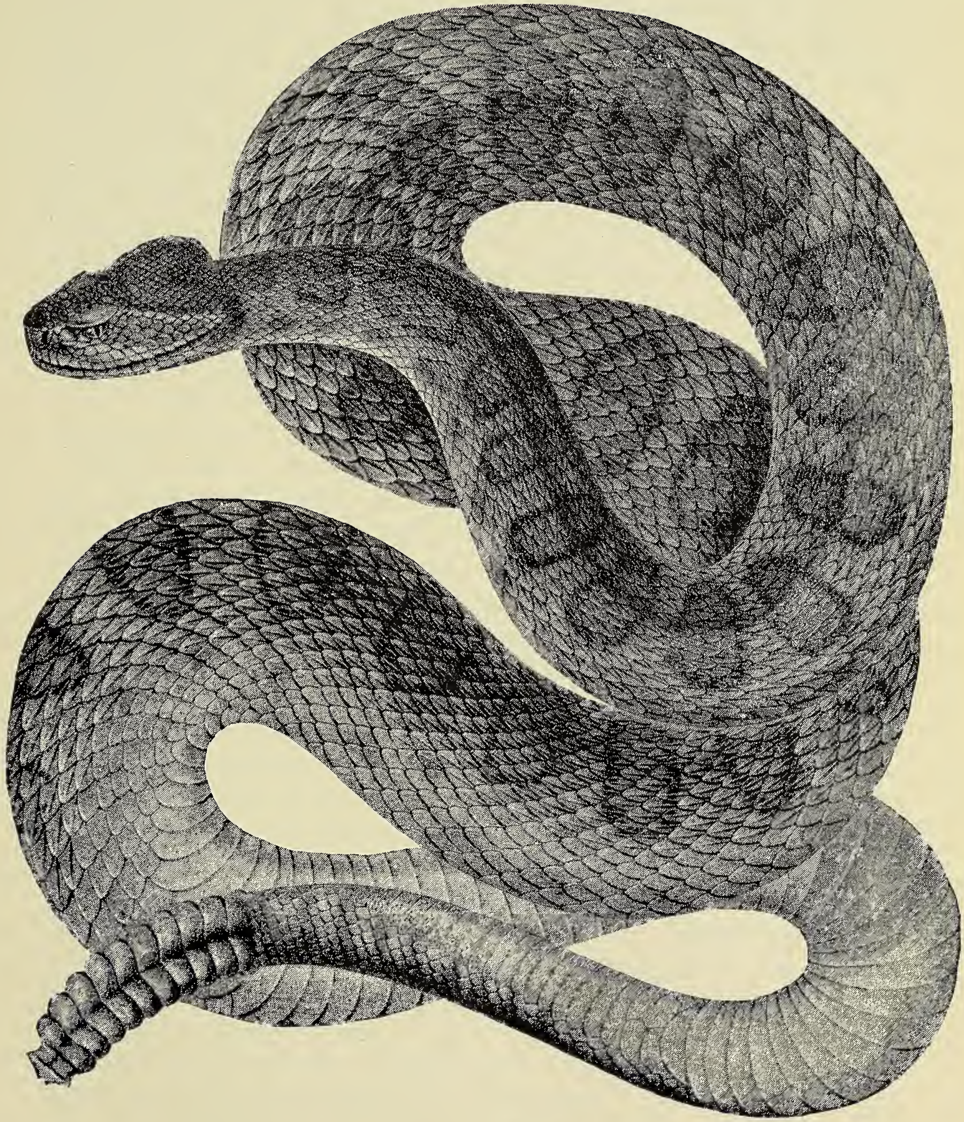

Plate X.

Crotalus Confluentus.

Prairie Rattlesnake.

small, numerous, uniform. Four rows of scales between the suborbital series (which only extends to the center of the orbit) and the labials. Labials fifteen or eighteen, nearly uniform. Dorsal series twenty-seven to twenty-nine. Dorsal blotches quadrate, concave before and behind; intervals greater behind. Spots transversely quadrate posteriorily, ultimately becoming ten or twelve half rings. Two transverse lines on superciliaries, inclosing about one-third. Stripe from superciliary to angle of jaw crosses angle of the mouth on the second row above labial. Rostral margined with lighter.

This species bears a considerable resemblance to *Crotalus atrox*, but the body is more slender and compact. Scales on top of the head anterior to the superciliaries nearly uniform in size. Line of scales across from one nostril to the other consists of six, and not four, as in *Crotalus atrox*. Superciliaries more prominent. Labial series much smaller. Upper anterior orbitals (preoculars) much smaller, as also is the anterior nasal. Scales on the top of the head less carinated. Scales between superciliaries smaller and more numerous, five or six in number instead of four. Two lateral rows of scales smooth, first, second and third gradually increasing in size. Scales more linear than in *Crotalus atrox*.

General color yellowish brown with a series of subquadrate dark blotches, with the corners rounded and the anterior and posterior sides frequently concave, the exterior convex. These blotches are ten or eleven scales wide, and four or five long, lighter in the center, and margined for one-third of a scale with light yellowish. The intervals along the back light brown, darker than the margin of the blotches. Anteriorly the interval between the dark spots is but a single scale; posteriorly it is more, becoming sometimes two scales, where also the spots are more rhomboidal or lozenge shaped; nearer the tail, however, they become transversely quadrate. The fundamental theory of coloration might be likened to that of *Crotalus adamanteus*, viz.: of forty or fifty light lines decussating each other from opposite sides; but the angles of decussation, instead of being acute, are obtuse, and truncated or rounded off throughout. Along the third, fourth, and fifth lateral rows of scales is a series of indistinct brown blotches covering a space of about four scales, and falling opposite to the dorsal blotches; between the blotches and opposite to the intervals of the dorsal blotches are others less distinct. Along the fifth, sixth, seventh and eighth rows is a second series of obsolete blotches, each covering a space of about four scales, and just opposite the intervals between the dorsal spots. The dorsal and lower series are separate by an interval of three scales, this interval light brown. Beneath the color a dull yellowish, and ten or twelve darker half rings are visible on the tail.

In point of coloration the principal features as compared with *Cro-*

talus atrox lie in the dorsal blotches, being disposed in subquadrate spots instead of subrhomboids; the intervals thus forming bands across the back perpendicular to the longitudinal axis. This tendency to assume a subquadrangular pattern has broken up the chain work into isolated portions, as in *Coluber eximus* or *Crotalophorus tergiminus* (*Sistrurus catenatus*). The intervals of the dorsal blotches are wide and darker in the middle, while in *Crotalus atrox* they are narrow, not linear, and unicolor. The sides of the head present the usual light stripe from the posterior extremity of the superciliary; and passes, however, to the angle of the jaw on the neck, along the second row of scales, above the labials. A second stripe passes in front of the eye to the labials, widening there. A small light vertical bar is seen below the pit and another on the outer edge of the rostral. On the superciliaries are seen two light transverse lines inclosing a space nearly one-third of the whole surface. In *Crotalus atrox* there is a single median line. Sometimes, as in *Crotalus atrox,* the single blotches on the nape are replaced by two elongated ones parallel to each other."

(Stejeneger, "Poisonous Snakes of North America").

GEOGRAPHICAL DISTRIBUTION.

Quoting from "Poisonous Snakes of North America" (Dr. Stejeneger), pages 443 and 444: "While in northwestern Texas it is recorded from between the main forks of the Brazos River and on the Llano Estacado as far south as Cañon Blanco."

"Further west Captain Pope collected specimens at the Pecos River near the thirty-second parallel." (Cope, Zool. Pos. Texas, p. 24; Proc. Phila. Acad., 1892, p. 336.)

HABITS.

Again quoting Stejneger, "Poisonous Snakes of North America," p. 444: "The prairie rattlesnake being one of the smaller species, as it seldom reaches a length of over four feet with a proportionately slender body, does not seem to be a very dangerous snake. Dr. Allen, as referred to above (Union Pacific Railroad Expedition), found it so common in the region visited by the expedition that several hundred were killed by the different members, yet the only casualty resulting from it was one horse bitten. On the expedition of 1872, not less than two thousand were killed, and not a man nor an animal was bitten. Allen also comments upon the fact that they were found abroad quite late in the season, as they were met with quite frequently after several severe frosts had occurred. During July two pairs were found in coitu, indicating the season at which they pair. Dr. O. P. Hay (Proc. U. S. Nat. Museum,

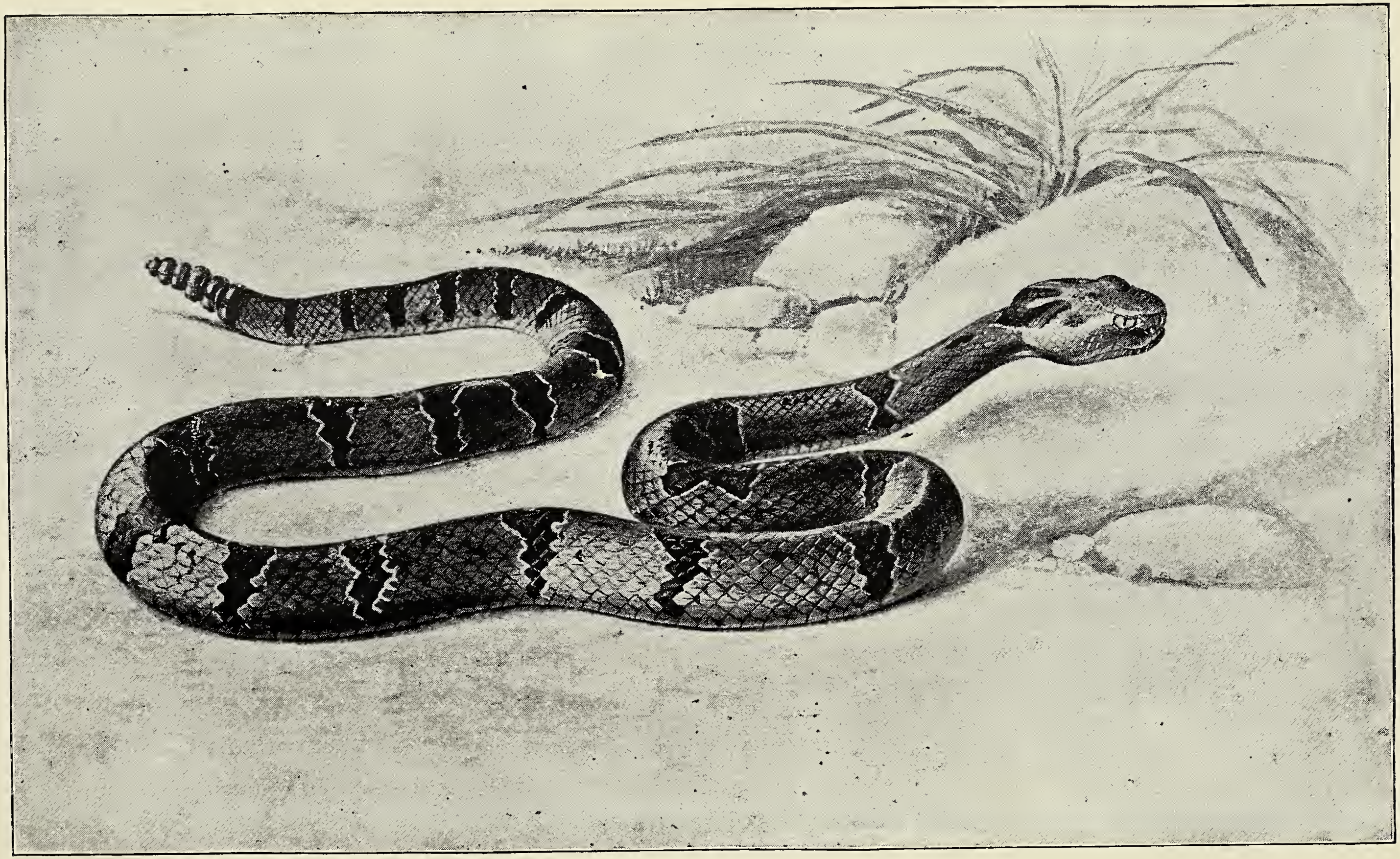

Plate XI.
Crotalus Lepidus.
Green Rattlesnake.

XV, 1892, p. 387), on the other hand, quotes Professor S. W. Williston as stating that the sexes pair in May."

"Taylor (l. c.) found its food habits similar to those of the Massasauga. It is the species often found in or around the homes of the prairie dogs, where they are most abundantly found during the breeding season of the dogs.

"Professor Cope records a similar observation (Proc. Phila. Acad., 1892, p. 336), and remarks that the snake protects itself by retreating quickly into the holes of the prairie dogs. The popular belief that these rodents and the rattlesnakes live together because of a special friendship is erroneous, as there can be no doubt that the latter to a great extent feed upon the offspring of the former.

"In addition to the hibernation, which, according to Dr. Coues, lasts about six months, terminating with the loosening of the ground from frost, Dr. Suckley (Pac. R. R. Rep., XII, pt. III, p. 296) observed these snakes in a more or less sluggish and stupid condition during the drouth of summer, a condition which he calls 'æstivation.'"

CROTALUS LEPIDUS, *Kennicott.*

("Green Rattlesnake.")

PLATE XI.

DESCRIPTION.

"The top of the muzzle is covered by eight smooth scutæ; the rostral plate is rather low, and is in contact with the prenasal; there are two preoculars and two loreals; and but two scales separate the orbit from the superior labial scuta. Of the latter there are twelve occipital scales smooth. Scales of body in twenty-three rows, the two external on each side smooth. Gastrosteges (ventrals), 153; urosteges (subcaudals), 27. The rattle consists of seven segments and a button, and narrows gradually towards the extremity.

The color above is greenish gray, which is crossed by nineteen jet black rings on the body, which do not extend on the abdomen. These rings are two and a half scales wide on the middle line, and narrow downwards on each side so as to cover but one scale in width. The scales which border the annuli are half black and half green, the effect of which is to give the edge of the ring a turreted outline. The edges of the ground color are paler than any other part of the scales, thus throwing the black into greater relief. A large black spot, shaped like two hearts side by side with the apices posterior, marks the nape, and there is an irregular small black spot on each side of the occiput. No other marks on the head. Near the middle of the gray spaces of the body some of the scales of many of the rows have black tips. The tail is light brown above and has a basal broad black, and two other narrow brown annuli. Below, dirty white with closely placed shades of brown. (Stejneger, "Poisonous Snakes of North America").

GEOGRAPHICAL DISTRIBUTION.

This species has been reported from Eagle Pass and Presidio Del Norte, Texas.

HABITS.

Nothing is known of its habits.

Contribution to a Knowledge of the Coleopterous Fauna of the Lower Rio Grande Valley in Texas and Tamaulipas, with Biological Notes and Special Reference to Geographical Distribution.

C. H. T. TOWNSEND.

Contribution to a Knowledge of the Coleopterous Fauna of the Lower Rio Grande Valley in Texas and Tamaulipas, with Biological Notes and Special Reference to Geographical Distribution.

BY C. H. T. TOWNSEND.

In recording the distribution of the 522 species mentioned in this paper, I have had access to the following lists:

Horn.—Coleoptera of Baja California, 1894.

Riley.—Coleoptera of Death Valley Expedition, 1893.

Wickham.—Coleoptera of Northern New Mexico and Arizona, 1896; Coleoptera of Southern Shore of Lake Superior, 1896; Coleoptera of Bahama Expedition, 1895; Coleoptera of the Lower Rio Grande, 1897.

Cockerell.—Coleoptera of Custer County, Colorado, 1893; Notes on Coleoptera of Jamaica in Journal Institute of Jamaica.

Leconte.—Coleoptera of Kansas and Eastern New Mexico; Coleoptera of Alpine Regions of the Rocky Mountains, 1878-1880.

Champion.—Heteromerous Coleoptera of St. Vincent and Grenada.

Gahan.—Longicorn Coleoptera of the West Indies.

Blaisdell and Dunn.—Lists of California Coleoptera in Zoe.

Smith.—Lachnosternas of North America; Catalogue of Insects of New Jersey.

Schwarz.—Semitropical Texas.

Schaupp.—Synopsis of the Cicindelidae.

Linell.—Descriptions of New Species of North American Coleoptera of Families Cerambycidae, Scarabaeidae and Chrysomelidae. Several papers in Proc. U. S. N. Mus.

Fall.—Revision of the Species of Apion; Synopsis of the Species of Acmaeodera.

Hamilton.—The Lamiinae of North America.

Casey.—Coleopterological Notices.

Leconte and Horn.—Rhynchophora of North America.

Townsend.—Published Lists of Coleoptera of Southern Louisiana, Southern Michigan, New Mexico and Arizona, and Jamaica.

I have also had the benefit of my own personal observations and manuscript notes on collecting in Mexico, in the State of Tamaulipas, Vera Cruz and Tabasco, where I have made extensive collections of coleoptera. Of these the Vera Cruz material is in the collection of Mr. F. C. Bowditch, and the Tabasco material is in that of Capt. Thomas L. Casey.

In addition to the above, Mr. E. A. Schwarz, of the Department of

Agriculture and one of the leading authorities on American coleoptera. at the direction of Dr. L. O. Howard, Chief of the Entomological Division, kindly went over my entire manuscript and filled in all gaps in the known distribution of the various species so far as he could supply the information from his extended knowledge of the subject. My thanks are therefore due to Dr. Howard and Mr. Schwarz; also to Prof. H. F. Wickham, of the University of Iowa, for information and assistance.

The material herein listed, except where otherwise specifically stated, was all collected by myself during the season of 1895, while acting as Temporary Field Agent of the Entomological Division of the United States Department of Agriculture, under the direction of Dr. L. O. Howard, to whom I am again indebted for the opportunity of publishing these results. While my own work in the Lower Rio Grande Valley was the first entomological work ever undertaken in that region, it was materially supplemented the same season by that of Mr. Schwarz and Professor Wickham, who arrived in June and July, after I had been in the field for four or five months, and who secured a large amount of material in the limited time at their disposal. Both gentlemen have already published some preliminary results of their work, the titles of which will be found in the bibliography at the end of this list.

CICINDELIDAE.

1. *Tetracha carolina,* Linn.—Taken by Wickham under pieces of wood along bank of resaca near Fort Brown, in July. *Distr.* Southern United States from Atlantic to Pacific, both coasts of Mexico, West Indies, and South America.

2. *Cicindela rectilatera,* Chaud.—Taken at La Puerta, Tamaulipas, on banks of Rio Grande, May 6th; also on mud banks of Rio Grande back of Fort Brown, July 3rd. Numerous through June all along river banks on both sides. Det. Wick. and Schw. *Distr.* Gulf coast of Texas and Mexico.

3. *Cicindela tenuisignata,* Lec.—At light at Fort Ringgold (Rio Grande City), numerous specimens, May 11th. At light at Refugio, Texas, May 13th. Det. Schw. *Distr.* Southern California, Arizona, New Mexico, through Texas and Mexico.

4. *Cicindela tortuosa,* Dej.—Taken at mouth of the Rio Grande, on Texas side, on sand at edge of river, April 24th. Det. Schw. *Distr.* Occurs on seashore of Florida, Louisiana, Texas, and California; also inland on mud banks of rivers and fields. Taken by the writer on mud flats at mouth of Red River in Louisiana. Wickham has taken it on seashore at Key West, Florida; on the Bahama beaches; and on the Cuban coast at Bahia Honda. Wright has taken it on the west Mexican coast at

Mazatlan. Southern coasts of the United States, Arizona, Southern California, Mexico, West Indies.

5. *Cicindela saulcyi*, Guer.—Taken on south end of Padre Island, on sea beach, June 8th to 29th. In cop., June 29th. Det. Wick. and Schw. *Distr.* Occurs on the seashore of the Gulf of Mexico, in Texas, Louisiana, and Florida, and doubtless extends down the Mexican coast. It belongs to the Antillean fauna, and is strictly maritime.

6. *Cicindela marginata*, Fab.—Taken numerously at mouth of Rio Grande, on Texas side, on sand at water's edge, April 24th; also taken in July by Wickham on beach at Pt. Isabel, Texas. *Distr.* Coasts of Mexico, Texas, West Indies, Florida, Georgia, North and South Carolina, and on salt marshes near New York City and in Massachusetts. It is a seashore species.

7. *Cicindela circumpicta*, Laf.—Taken by Wickham on beach at Point Isabel in July; rare. *Distr.* Texas, Arizona, New Mexico, and salt marshes in Kansas.

8. *Cicindela togata*, Laf.—Taken on sea beach just south of Point Isabel April 25th and June 29th. Taken in July in depressed areas or small basins amongst the Yucca Ridges, half way between Brownsville and the coast. Also taken on salt flats back from beach at Point Isabel. *Distr.* Occurs on salt marshes in Nebraska and Kansas, extending to Texas and Tamaulipas.

9. *Cicindela pamphila*, Lec.—Numerous on sea beach just south of Point Isabel, April 25th and June 29th. Det. Wick. *Distr.* Occurs in Louisiana, Texas, and Tamaulipas.

10. *Cicindela severa*, Lap.—Taken by Wickham on beach at Point Isabel in July. Rare. *Distr.* Occurs in Louisiana, Texas, and New Mexico.

CARABIDAE.

11. *Omophron americanum*, Dej.—Taken by Wickham on banks of resaca in July. *Distr.* Canada to Mexico.

12. *Calosoma aurocinctum*, Chaud.—Three taken under logs near resaca in damp place September 15th. *Distr.* A tropical Mexican species, now first recorded for the United States.

13. *Calosoma macrum*, Lec.—Taken by Armstrong in September. Det. Wick. *Distr.* Known only from Texas.

14. *Calosoma sayi*, Dej.—One taken on open ground at San Tomas, June 9th. Det. Schw. *Distr.* Alabama to Missouri, Texas, and Lower California.

15. *Scarites subterraneus*, Fab.—One found in Brownsville June 22nd. Det. Wick. *Distr.* Occurs in Kansas, Nebraska, Louisiana, Texas, New Mexico, Arizona, Southern California, and Lower California. It

probably occurs also in the Bahamas, as Wickham took a *Scarites* on Harbor Island, which seems like a small specimen of this species.

16. *Dyschirius terminatus*, Lec.—Taken commonly on resaca banks at Brownsville in June and July. Det. Wick. *Distr.* Southwest Texas to New Mexico, Arizona, and California.

17. *Dyschirius erythrocerus*, Lec.—Taken in numbers by Wickham on river bank at Laredo July 24th. *Distr.* New York and Ohio to Texas.

18. *Dyschirius sublaevis*, Putz.—Taken by Schwarz and Wickham on beach at Padre Island in June. *Distr.* Known only from Texas.

19. *Clivina dentipes*, Dej.—Taken by Wickham on shores of mud sloughs in July. *Distr.* Atlantic States to Iowa, Georgia, Louisiana, Texas, Arizona, and California.

20. *Clivina ferrea*, Lec.—Taken at light June 11th. *Distr.* Occurs from Illinois, Iowa, Missouri, Kansas, and Texas to Arizona and Lower California.

21. *Aspidoglossa subangulata*, Chaud.—Taken by Wickham on shores of mud sloughs in July. *Distr.* Louisiana, and Texas from Dallas south to Tamaulipas.

22. *Schizogenius sallei*, Putz.—Taken by Wickham on river bank July 24th. *Distr.* Known only from Texas.

23. *Bembidium coxendix*, Say.—Taken by Wickham on river bank at Laredo July 24th. Det. Hayward. *Distr.* Extends up Rio Grande Valley to El Paso and Albuquerque, New Mexico.

24. *Bembidium intermedium*, Kirby.—Taken by Wickham at Laredo in July. Det. Hayward. *Distr.* Canada to Texas, New Mexico, and Arizona.

25. *Bembidium constrictum*, Lec.—Taken by Wickham on banks of resaca in July. Det. Hayward. *Distr.* New York and New Jersey to Florida and Texas.

26. *Bembidium fraternum*, Lec.—At light, March 29th. In numbers running over muddy sand on beach of river back of Fort Brown, July 3rd. *Distr.* Southern States and Mexico.

27. *Bembidium nubiculosum*, Chaud.—Taken by Wickham in July. Det. Hayward. *Distr.* Texas to El Paso, Albuquerque, Little Colorado Valley, Tuscon, Yuma, and Lower California.

28. *Bembidium versicolor*, Lec.—Taken by Wickham on wet banks in July. Det. Hayward. *Distr.* Iowa, Arkansas, Texas, and Arizona, to Oregon and Alaska.

29. *Bembidium laevigatum*, Say.—Taken by Wickham on river bank in July. Det. Hayward. *Distr.* Ohio, Iowa, and Missouri to Texas.

30. *Tachys pallidus*, Chaud.—Taken running over beach south of Point Isabel June 29th. Taken by Wickham under debris on beach at Point Isabel in June and July. Det. Horn. *Distr.* A Mexican species

extending into Texas (distribution imperfectly understood according to Schwarz).

31. *Tachys xanthopus,* Dej.—Taken by Wickham in June. Det. Horn. *Distr.* New York, New Jersey, Pennsylvania, and west to Texas.

32. *Tachys vorax,* Lec.—Taken by Wickham at Brownsville and Point Isabel in June and July. Det. Horn. *Distr.* Texas, New Mexico. to Southern California and Lower California.

33. *Tachys andax,* Lec.—Taken by Wickham on river bank at Laredo, July 24th. Det. Horn. *Distr.* Texas to Southern California and Lower California.

34. *Tachys corruscus,* Lec.—Taken by Wickham in June. Det. Horn. *Distr.* Pennsylvania and Illinois to Texas.

35. *Tachys vivax,* Lec.—Taken by Wickham in July. Det. Horn. *Distr.* Texas and Mexico (distribution imperfectly understood according to Schwarzz).

36. *Pogonus texanus,* Chaud.—A large colony found by Wickham under palmetto log on mud flat at Point Isabel in July. *Distr.* This hitherto very rare species is known only from Texas, and is probably maritime. It belongs to the Antillean fauna, and doubtless extends down the coast of Tamaulipas.

37. *Pogonus lecontei,* Horn.—On sand near beach at Point Isabel April 25th, and on beach at south end of Padre Island June 8th. Specimens were taken on beach south of Point Isabel June 29th, which are either this species or texanus. *Distr.* Belongs to maritime Antillean fauna, but has been taken near Great Salt Lake, Utah.

38. *Pterostichus texanus,* Lec.—Large numbers taken by Armstrong in September. Det. Wick. *Distr.* Known only from Texas.

39. *Badister micans,* Lec.—Taken by Schwarz in June. Distr. Massachusetts to Georgia, Florida and Texas.

40. *Platynus texanus,* Lec.—At light, March 19th. At light at Fort Ringgold, May 11th. *Distr.* Texas, Southern Arizona, and Mexico. Specimens from Arizona are known as *P. californicus* according to Schwarz.

41. *Casnonia pennsylvanica,* Linn.—Taken in cotton square at Carmen, near Brownsville, May 24th. *Distr.* Canada and Massachusetts to Iowa, Kansas, Texas, and Lower California.

42. *Zuphium longicolle,* Lec.—At light, June 19th. *Distr.* Texas and California. A mainly Southern and Mexican genus.

43. *Galerita atripes,* Lec.—Many taken by Armstrong in September. *Distr.* Iowa (rare) to Kansas and Texas.

44. *Agra oblongopunctata,* Chevr.—Beaten from masses of clematis vines in palmetto thickets at San Tomas, June 16th and 27th. Beaten from clematis in woods back of Fort Brown, July 3rd. *Distr.* This is a

distinctively tropical Mexican genus, now first known to reach the Lower Rio Grande. It occurs in the thickest vine tangles of the palmetto thickets or semi-tropical jungles. The writer has taken this species in the States of Vera Cruz and Tabasco. It is the first member of the *Agrini* reported from within the boundaries of the United States.

45. *Ega sallei,* Chevr.—Taken by Wickham swarming on wet banks of sloughs in June and July. *Distr.* From San Antonio, Texas, southward into Mexico.

46. *Tetragonoderus latipennis,* Lec.—Taken by Wickham at Laredo, July 24th. *Distr.* Southern Texas.

47. *Tetragonoderus fasciatus,* Hald.—Taken by Wickham at Laredo, under vines near river, July 24th. *Distr.* Atlantic States to Indiana, Texas, Arizona, and Lower California.

48. *Lebia grandis,* Hentz.—In cotton field at San Tomas, April 5th. *Distr.* Canada and Massachusetts to Michigan, Iowa, Colorado, Texas, Arizona, and Lower California.

49. *Lebia bitaeniata,* Chevr.—Santa Maria, Texas, May 7th. La Blanca, Texas, May 8th. *Distr.* Texas and Tamaulipas. A southern and Mexican species.

50. *Lebia viridis,* Say.—Taken by Wickham in July. *Distr.* Maine and Canada to Oregon, Arizona, New Mexico, Texas, Mexico, and Guatemala.

51. *Lebia rhodopus,* Schw.—Taken by Wickham on vines in July. *Distr.* Florida, Texas, and Mexico.

52. *Lebia viridipennis,* Dej.—Taken by Wickham in July. *Distr.* Canada to Texas and Mexico.

53. *Lebia ornata,* Say.—Beaten in palmetto thickets at Santo Tomas in June. *Distr.* United States to Texas and Mexico.

54. *Lebia analis,* Dej.—Beaten in palmetto thickets at Santo Tomas, June 27th. *Distr.* Middle Atlantic States to New Mexico, Texas, Lower California and Mexico.

55. *Lebia abdominalis,* Chaud.—Taken by Schwarz in June. *Distr.* Georgia to Missouri and Texas.

56. *Lebia furcata,* Lec.—Beaten in palmetto thickets at Santo Tomas, June 9th and 16th. *Distr.* Canada to Kansas, New Mexico, Texas, California, and Mexico. Reaches the high transition in Colorado, and on White Mountains, New Hampshire.

57. *Lebia bivittata,* Fabr.—Beaten by Wickham in June and July. Rare. *Distr.* New England States to Colorado, New Mexico, and Texas.

58. *Micragra aenea,* Putz.—Beaten from vine tangles by Wickham in woods back of Fort Brown in July. Det. Horn. *Distr.* A tropical species, not before recorded from the United States. It ranges from Brazil north through Central America to tropical Mexico.

59. *Apristus subsulcatus*, Dej.—Taken by Wickham at Laredo, July 24th. *Distr.* Canada to Texas and New Mexico.

60. *Blechrus pusio*, Lec.—Taken by Wickham in July. Rare. *Distr.* Ohio to Texas.

61. *Axinopalpus biplagiatus*, Dej.—Taken by Wickham in sifting dead leaves in July. *Distr.* Maine and Canada to Texas, New Mexico, and California.

62. *Technophilus croceicollis*, Men.—Beaten from dead plants of *Yucca treculeana* at Yucca Ridges, half way between Brownsville and the coast, July 9th. This is the variety *pilatei*, Chaud. *Distr.* The species in its varieties extends from California and Oregon to Montana, Utah, Arizona, New Mexico, and Texas. The variety *pilatei* is confined to Texas.

63. *Euproctus texanus*, Wick.—Beaten by Schwarz and Wickham in palmetto jungles in June and July. *Distr.* Not yet known elsewhere. This species doubtless belongs to the semi-tropical fauna.

64. *Callida punctulata*, Chaud.—Beaten by Wickham in July. Det. Schwarz, by comparison with Mexican specimens. *Distr.* Tropical Mexico, extending up the coast to the Lower Rio Grande.

65. *Callida planulata*, Lec.—Beaten in palmetto thickets at Santo Tomas, and from dead *Yucca treculeana* at Yucca Ridges, June 9th and 27th. *Distr.* Mexico, reaching southern Texas. Belongs to the semi-tropical fauna.

66. *Callida viridipennis*, Say.—Taken at Granjeno, Texas, May 9th. On plants, June 5th and 18th. *Distr.* Eastern and Gulf States, from Florida to Texas and Mexico. Taken by writer in Vera Cruz and Tabasco.

67. *Callida decora*, Fabr.—Beaten commonly in the palmetto thickets in June and July. Det. Wickham. *Distr.* Florida, through Gulf States to Texas and into Mexico.

68. *Philophuga viridicollis*, Lec.—Taken by Wickham between Brownsville and San Ignatius in July. *Distr.* Kansas to Texas, according to Schwarz.

69. *Pinacodera punctigera*, Lec.—Beaten by Wickham from tangles of herbage in July. *Distr.* Southern Texas to Southwestern New Mexico, Southern Arizona, and Southern California. Characteristic of Middle Sonoran.

70. *Apenes sinuata*, Say.—Beaten by Wickham in July. *Distr.* New York to Iowa and Texas.

71. *Helluomorpha ferruginea*, Lec.—At light, June 11th. Also taken by Armstrong in September. *Distr.* Texas to Southern Arizona, according to Schwarz.

72. *Brachynus lateralis*, Dej.—Under logs in moist places near Rock's

Resaca, June 26th. *Distr.* Missouri to Texas, Arizona, Southern California and Lower California. Determined with query in specimens from Southern Michigan taken by writer.

73. *Brachynus fumans,* Fab.—Under logs in moist places at edge of Rock's Resaca, June 26th. Many taken by Armstrong in September. *Distr.* Louisiana to Texas and Mexico. Widely distributed according to Schwarz.

74. *Chlaenius orbus,* Horn.—Taken by Armstrong in September. Det. Wick. *Distr.* Texas, from Luling south.

75. *Chlaenius chaudoiri,* Horn.—Taken by Armstrong in September. A rare species. *Distr.* Texas and Tamaulipas.

76. *Anatrichis oblonga,* Horn.—Taken by Wickham on bank of Rio Grande in July. *Distr.* Known only from Rio Grande region of Texas.

77. *Oodes 14-striatus,* Chaud.—Under log in damp place near Rock's Resaca, June 26th. Also taken on river bank by Wickham in July. *Distr.* Louisiana and Texas.

78. *Oodes cupraeus,* Chaud.—Taken by Wickham on margin of resaca in June. *Distr.* Extends up Rio Grande to Albuquerque, where Wickham states that is is common.

79. *Pogonodaptus piceus,* Horn.—Taken abundantly by Wickham on low wet resaca banks in July. *Distr.* Known only from Texas, and hitherto very rare in collections.

80. *Agonoderus lineola,* Fabr.—Taken by Wickham in July. *Distr.* Widely distributed.

81. *Agonoderus pallipes,* Fabr.—Taken by Wickham in July. *Distr.* Widely distributed.

82. *Agonoderus pauperculus,* Dej.—Taken by Wickham in July. *Distr.* Widely distributed in Middle and Southern States according to Schwarz.

83. *Harpalus nitidulus,* Chaud.—Taken by Wickham in July. *Distr.* Southern and Western States to Kansas and Texas.

84. *Selenophorus palliatus,* Fabr.—At light, June 20th. Distr. Florida and Southern Louisiana to Texas, Arizona, Southern California and Lower California.

85. *Selenophorus fatuus,* Lec.—At light, June 10th. *Distr.* Widely distributed in Middle and Southern States, according to Schwarz.

86. *Selenophorus perpolitus,* Casey.—Taken under old *Yucca treculeana* trunks by Wickham at Yucca Ridges in July. *Distr.* Known only from this region.

87. *Stenolophus spretus,* Dej.—One taken by Wickham in July. *Distr.* Widely distributed in Southern States, according to Schwarz.

88. *Bradycellus rupestris,* Say.—Taken in June. *Distr.* In its varieties, from British America to Lower California, Arizona, and Mexico.

HALIPLIDAE.

89. *Haliplus,* sp.—Attracted to light, June 10th. Two specimens of this genus taken by Wickham in July are doubtfully referred by him to *H. ruficollis,* DeG.

90. *Cnemidotus 12-punctatus,* Say.—Taken by Wickham in July. *Distr.* Canada to Texas and Mexico.

DYTISCIDAE.

91. *Laccophilus maculosus,* Germ.—Taken by Wickham in sloughs in July. *Distr.* Eastern United States to Texas.

92. *Laccophilus americanus,* Aube.—One specimen, from cistern, April 7th. Det. Wick. *Distr.* Alabama to Louisiana, Texas, Mexico, and West Indies.

93. *Bidessus pullus,* Lec.—Taken by Wickham in resacas in June and July. *Distr.* Mississippi and Louisiana to Texas and Mexico.

94. *Coptotomus interrogatus,* Fabr.—Taken by Wickham in sloughs in July. *Distr.* Canada and Atlantic States to Texas and California.

95. *Copelatus chevrolatii,* Aube.—Taken by Wickham in resacas in June and July. *Distr.* Lake Superior to Kansas, New Mexico, Texas, Arizona, California, and Lower California.

96. *Eretes sticticus,* Linn.—One taken by Armstrong in September. *Distr.* Pennsylvania to Illinois, Kansas, New Mexico, Arizona, Texas, and Mexico.

GYRINIDAE.

98. *Gyretes sinuatus,* Lec.—In swarms on surface of Rio Grande, near edge in quiet places, at Fort Ringgold, May 13th. *Distr.* Illinois to Texas and Arizona.

HYDROPHILIDAE.

99. *Hydrochus variolatus,* Lec.—At light, June 20th. Wickham took this species commonly in resacas in June and July. *Distr.* Southern Texas and Mexico to Southern California.

100. *Ochthebius nitidus,* Lec.—Taken commonly in resacas by Wickham in June and July. *Distr.* Lake Superior to Texas, Mexico, Arizona, and Oregon.

101. *Hydrophilus triangularis,* Say.—Taken by Armstrong in September. Det. Wick. *Distr.* Atlantic to Pacific and Canada to Texas and Mexico.

102. *Tropisternus nimbatus,* Say.—Taken by Wickham in sloughs in July. *Distr.* Canada to Georgia, Colorado, New Mexico, and Texas.

103. *Tropisternus ellipticus*, Lec.—Taken by Wickham in sloughs in July. *Distr.* Southern Texas up Rio Grande valley to New Mexico, Utah, Arizona, California, and Lower California.

104. *Berosus miles*, Lec.—Taken by Wickham in sloughs in July. *Distr.* Southern Texas to Arizona and Lower California.

105. *Berosus infuscatus*, Lec.—Taken by Wickham and myself in July. *Distr.* Southern United States through Gulf States to California.

106. *Berosus striatus*, Say.—At light, June 20th, one specimen. *Distr.* Eastern United States, Canada, and Wisconsin to high Transition of Colorado (8000 feet), New Mexico, Texas, and Mexico.

107. *Philhydrus nebulosus*, Say.—Taken by Wickham in June and July. *Distr.* Canada to Texas, New Mexico, Arizona, California, Lower California and Mexico.

108. *Creniphilus subcupreus*, Say.—Taken abundantly by Wickham in July. *Distr.* Widely distributed.

109. *Cercyon variegatus*, Sharp.—Taken by Wickham, in dung, in July. *Distr.* Southern Louisiana and Southern Texas through Mexico to Nicaragua.

110. *Cercyon pygmaeus*, Ill.—Taken by Wickham, in dung, in June and July. *Distr.* Widely distributed, if not cosmopolitan.

111. *Cercyon nigriceps*, Marsh.—Taken by Wickham, in dung, in June and July. *Distr.* Widely distributed, if not cosmopolitan.

SCYDMAENIDAE.

112. *Scydmaenus longicornis*, Casey.—Taken by Wickham in July. *Distr.* Known only from Lower Rio Grande region of Texas.

113. *Connophron longicorne*, Casey.—Taken by Wickham in July. *Distr.* Known only from Lower Rio Grande region of Texas.

PSELAPHIDAE.

114. *Ctenistes consobrinus*, Lec.—Taken by Wickham near river bank in July. Det. Casey. *Distr.* Southern States.

115. *Pilopius cinderella*, Casey.—One taken by Wickham in July. *Distr.* Known only from subtropical Texas (Lower Rio Grande).

STAPHYLINIDAE.

116. *Hoplandria pulchra*, Kraatz.—Taken by Wickham in July. *Distr.* Florida, Georgia, and Louisiana to Southern Texas.

117. *Philonthus flavolimbatus*, Er.—Taken by Wickham in July. *Distr.* Gulf States to Texas, Arizona, New Mexico, and Lower California.

118. *Philonthus alumnus*, Er.—At light, June 20th. *Distr.* Atlantic

and Gulf States to Texas, Arizona, Lower California, Mexico, and West Indies.

119. *Actobius pacderoides*, Lec.—Taken by Wickham in July. *Distr.* New Jersey to Texas, New Mexico, Arizona, Utah, California, and Lower California.

120. *Leptacinus nigripennis*, Lec.—Taken by Wickham in July. *Distr.* Florida, Georgia, and Louisiana to Southern Texas.

121. *Cryptobium bicolor*, Grav (?).—One specimen under log in woods near resaca, June 26th. *Distr.* New Jersey, Michigan, and Indiana to Texas and Mexico.

122. *Lithocharis obsoleta*, Nord.—Taken by Wickham in July. *Distr.* Nearly cosmopolitan; North, Central and South America, Africa, Australia, and Europe.

123. *Sunius longiusculus*, Mann.—Taken by Schwarz in June. *Distr.* Canada and North Atlantic States to Michigan, Iowa, Kansas, Texas, California, and Oregon.

124. *Palaminus normalis*, Lec.—Taken by Schwarz in June. *Distr.* New Jersey to Michigan and Texas.

125. *Bledius opaculus*, Lec.—Taken by Wickham at Point Isabel in July. A maritime species. *Distr.* Coasts of Maine and New York to Florida, Texas, and California.

126. *Trogophloeus spectatus*, Casey.—Taken by Wickham in July. *Distr.* Known only from Lower Rio Grande region.

127. *Apocellus sphaericollis*, Say var.—Taken by Wickham in July. *Distr.* Typical form New Jersey to Indiana, New Mexico, and Arizona.

PHALACRIDAE.

128. *Olibrus*, sp.—One specimen, June.

129. *Acylomus ergoti*, Casey.—Taken from dead and dried last year's cotton bolls, standing in field, March 24th. Also beaten from cane brakes, April 30th. *Distr.* Widely distributed.

CORYLOPHIDAE.

130. *Sacium*, n. sp.—Taken by Schwarz in June. *Distr.* Known only from the Lower Rio Grande region.

131. *Sericoderus flavidus*, Lec.—Taken by Schwarz in June. *Distr.* Widely distributed.

132. *Orthoperus*, sp.—Taken by Schwarz in June.

COCCINELLIDAE.

133. *Anisosticta seriata*, Melsh.—Beaten from sea-oats on Padre

Island by Wickham, June 29th. Det. Wick. *Distr.* New Jersey and Lake Superior to Texas.

134. *Megilla maculata,* DeG.—Beaten March 11th. *Distr.* Canada to Florida, Texas, and Mexico.

135. *Hippodamia convergens,* Guer.—Beaten from volunteer cotton, March 20th. *Distr.* Canada to California and Mexico, reaching the high Transition in Colorado.

136. *Cycloneda sanguinea,* Linn.—In corn fields, at Santa Maria, May 7th. *Distr.* Europe and Canada to California, Mexico, and the West Indies. Reaches the high Transition in Colorado.

137. *Cycloneda oculata,* Fabr.—Beaten from mesquite, April 9th, and from cotton, June 17th. Also beaten from mesquite at Reynosa, Tamaulipas, May 16th. *Distr.* Kansas, Texas, and New Mexico to Oregon, California, and Mexico.

138. *Chilocorus cacti,* Linn.—Beaten from vine-tangles of *Clematis drummondii* in palmetto thickets, at Santo Tomas. *Distr.* Florida to Texas and Mexico.

139. *Exochomus marginipennis,* Lec.—Beaten from *Abutilon holosericeum,* June 18th, and from cotton, April 27th. *Distr.* Ontario to New Jersey, Colorado (high Transition), New Mexico, Texas, Arizona, and California.

140. *Exochomus marginipennis,* Lec. var.—A black variety beaten with the typical form from *A. holosericeum,* June 18th.

141. *Smilia misella,* Lec.—Two specimens found preying on *Mytilaspis gloveri* on orange leaf, February 23rd. Also beaten June 30th. *Distr.* Nw Jersey to New Mexico and Texas.

142. *Brachyacantha dentipes,* Fabr.—In corn fields at Santa Maria, May 7th; and beaten in palmetto thickets at Santo Tomas, June 27th. *Distr.* New Jersey to Texas and Mexico.

143. *Hyperaspis undulata,* Say.—Taken by Schwarz in June. *Distr.* Eastern United States to Montana, Kansas, Texas, California, and Mexico.

144. *Hyperaspis lagubris,* Rand.—Taken by Wickham in July. *Distr.* Maine to Illinois, Colorado, and Texas.

145. *Hyperaspis annexa,* Lec.—Bred numerously from masses of *Coccus cacti* var. collected at Point Isabel, Texas, April 25th, and La Puerta, Tamaulipas, May 6th, issuing May 19th to 31st. Adults found in the coccids collected April 25th. *Distr.* Texas to Southern New Mexico and Colorado.

146. *Hyperaspis moerens,* Lec.—Taken by Wickham at Point Isabel, in July. *Distr.* Lake Superior to Southern Texas.

147. *Hyperaspis centralis,* Muls.—Beaten from *Abutilon holoseri-*

ceum, June 17th and 18th; also taken by Wickham in July. *Distr.* Texas and Mexico.

148. *Hyperaspis sexverrucata*, Muls.—Beaten from foliage in palmetto thicket at Santo Tomas, June 9th and 16th. *Distr.* Texas and Mexico.

149. *Hyperaspis medialis*, Casey.—Taken by Wickham in July. *Distr.* Known only from the Lower Rio Grande region.

150. *Hyperaspis wickhami*, Casey.—Taken by Wickham in July. *Distr.* Known only from the Lower Rio Grande region.

151. *Hilesius nubilans*, Casey.—Taken by Wickham in July. *Distr.* Known only from the Lower Rio Grande region.

152. *Scymnus bioculatus*, Muls.—Taken by Schwarz in June, and by Wickham in July. This is considered a variety of *S. flavifrons*, Melsh. *Distr.* Canada to Florida, Missouri, Louisiana, Texas, and Mexico.

153. *Scymnus debilis*, Lec.—Taken by Schwarz in June. *Distr.* Lake Superior to Florida, Texas, and California.

154. *Scymnus collaris*, Melsh.—Beaten from cotton foliage March 20th and April 19th, at Santo Tomas. At light, June 11th. Also taken by Wickham in June and July. *Distr.* Widely distributed.

155. *Scymnus loewii*, Muls.—One specimen taken in a square of cotton, July 1st. Black, with elytra nearly all reddish except inner basal edge. *Distr.* This is a tropical Mexican species which reaches the Lower Rio Grande region of Texas.

156. *Scymnus intrusus*, Horn.—Taken by Wickham at Brownsville and Point Isabel in July. *Distr.* Maryland to North Carolina, Missouri, Arkansas, and Texas.

EROTYLIDAE.

157. *Languria*, n. sp.—A dozen or more specimens beaten from dead, half dead, and live stalks of thistles, *Cnicus virginianus*, in edge of palmetto thicket at Santo Tomas, June 7th. Also beaten from other plants in palmetto jungle, June 23rd. Length, 7 to 8 mm. Elytra deep green. Head, thorax and underside orange-red, anal segment blackish. Antennae blackish. One specimen has a trace of two blackish spots on thorax, but the others have no such trace. Legs, except bases, same green as elytra. *Distr.* Known only from the Lower Rio Grande region.

158. *Dasydactylus*, n. sp.—A half dozen or more specimens beaten in company with preceding from same thistle stalks, *Cnicus virginianus*, June 7th. Also beaten from foliage in palmetto jungle, June 9th, and from *Xanthoxylum pterota*, August 20th. Length, $6\frac{1}{3}$ to $7\frac{2}{3}$ mm. In form, very slender and elegant. Color wholly shining dark metallic green, the underside showing a brownish tinge, and the clubbed

joints of antennae being purplish-black. *Distr.* The genus is a Neotropical one. This species, like the preceding, is known only from this region and belongs to the semitropical fauna.

COLYDIIDAE.

159. *Ditoma,* n. sp.—Taken by Schwarz in June. *Distr.* Known only from the Lower Rio Grande region.

160. *Phloeonemus catenulatus,* Horn.—Taken by Schwarz in June. Also taken by Wickham in July under mesquite bark. According to Schwarz this species is common, with its larva, beneath the bark of freshly cut mesquite. *Distr.* Arizona to Texas.

161. *Bothrideres geminatus,* Say.—One specimen taken under the bark of a large dead ash tree, at Granjeno, Texas, May 9th. Also one taken by Wickham in July. *Distr.* New Jersey and Pennsylvania to Kansas and Texas.

CUCUJIDAE.

162. *Silvanus surinamensis,* Linn. Taken in June. *Distr.* Cosmopolitan.

163. *Laemophloeus modestus,* Say.—Taken by Schwarz in June. *Distr.* Widely distributed.

CRYPTOPHAGIDAE.

164. *Loberus,* n. sp.—Beaten from foliage in palmetto thicket at Santo Tomas, June 9th and 16th. Also taken by Wickham. Det. Wick. *Distr.* Known only from the Lower Rio Grande region. Belongs to the semi-tropical fauna.

165. *Tomarus acutus,* Reit.—Taken by Schwarz in June. *Distr.* Florida to Louisiana, Texas, and West Indies.

MYCETOPHAGIDAE.

166. *Litargus balteatus,* Lec.—Taken by Schwarz in June. *Distr.* Colorado, New Mexico, and Texas to Arizona, Southern California, and Lower California.

167. *Berginus,* n. sp.—One specimen taken from dead and dried cotton boll on standing last year's stalk, in field at Santo Tomas, March 24th. Length, $1\frac{1}{2}$ mm. Color wholly dark, clothed with a fine, short whitish pubesence, giving it a frosted, grayish appearance under moderate power lens. *Distr.* Known only from the Lower Rio Grande region.

DERMESTIDAE.

168. *Dermestes caninus,* Germ.—Taken by Schwarz in June. *Distr.* Cosmopolitan.

169. *Dermestes vulpinus,* Fabr.—On sacks of old bones, in May. *Distr.* Cosmopolitan.

170. *Acolpus primus,* Jayne.—Beaten from foliage in woods near Rock's Resaca, June 26th. *Distr.* Southern Texas to Arizona.

171. *Anthrenus varius,* Fabr.—Flying, March 16th to 23rd. *Distr.* Cosmopolitan.

172. *Cryptorhopalum balteatum,* Lec.—On *Abutilon holosericeum,* June 18th. *Distr.* Arizona and New Mexico to Texas, and Mexico.

173. *Cryptorhopalum triste,* Lec.—Taken in flowers of cacti in March. *Distr.* New Jersey to Southern Arizona, Texas, and Tamaulipas.

HISTERIDAE.

174. *Hololepta yucateca,* Mars.—Two specimens of this gigantic histerid (18 to 19 mm.) were taken in an offensively rotten and recently decayed head of *Yucca treculeana* at the Yucca Ridges, July 9th. They were found in the pulp between the bark of head and the central cylindrical head mass of the plant. *Distr.* Yucatan and north through Mexico to Texas, Southern Arizona, Southern California, and Lower California.

175. *Hololepta vicina,* Lec.—Three taken in decaying heads of *Yucca treculeana* at Yucca Ridges, July 9th. *Distr.* Texas, Mexico, Arizona, and Southern California.

176. *Hister,* sp.—Several of a small species found in same Yucca trunks with preceding, July 9th.

177. *Teretrius,* n. sp.—Two specimens taken from burrow or tunnel of dead *Amphicerus* in cotton stalk, March 20th, and ten or more issued up to June 14th from dead last year's cotton stalks gathered in March. They occurred particularly if not uniformly in the deserted transverse tunnels of the *Amphicerus.* Length, $2\frac{1}{2}$ mm. Like *T. conigerum,* but wholly polished black, somewhat stouter and a little more elongate. *Distr.* Known only from the Lower Rio Grande region.

178. *Teretriosoma conigerum,* Lewis.—Numerous specimens taken from tunnels of *Amphicerus* in dead last year's cotton stalks, February 13th to June 14th, gathered in field at Santo Tomas. They occur, like the preceding, in the deserted transverse tunnels of the *Amphicerus,* upon which they are parasitic. *Distr.* Mexico, reaching Southern Texas on the north.

NITIDULIDAE.

179. *Carpophilus pallipennis,* Say.—Taken numerously in flowers of cacti, March 24th. Larvæ found making longitudinal tunnels in flowers, March 31st, and pupæ found April 10th, which changed to adults April 13th. Life cycle, from egg to adult, is about 21 days. The larvæ bore among the mass of stamens inside the flower, also apparently in the fleshy portions of base of flower between the ovary and the sepals. The adults aid in cross-fertilization of the cacti flowers, going from one flower to another to deposit their eggs, or at least going from the flower in which they were bred to another flower in which to deposit, and meantime feeding on the pollen as they burrow among the mass of stamens and anthers. *Distr.* Nebraska, Kansas and Colorado to Texas, New Mexico, Arizona, Utah, California and Lower California. Reaches high Transition in Colorado.

180. *Carpophilus mutilatus,* Fabr.—Taken flying, July 13th. *Distr.* Cosmopolitan.

181. *Colastus maculatus,* Er.—One taken by Wickham in June. *Distr.* Originally tropical, but widely distributed through commerce.

182. *Conotelus stenoides,* Murr.—Flying March 24th. *Distr.* Mexico and Texas.

183. *Soronia undulata,* Say.—Taken by Schwarz in June. *Distr.* New Jersey to New Mexico, Arizona, and Texas.

184. *Smicrips hypocoproides,* Reit.—Flying July 13th. *Distr.* West Indies and Mexico to Florida, Southern Texas, and the Yuma region of Arizona.

LATRIDIIDAE.

185. *Corticaria pumila,* Lec.—Several taken in dead bolls on standing last year's stalks of cotton, February 13th. *Distr.* Cosmopolitan.

TROGOSITIDAE.

186. *Nemosoma cylindricum,* Lec.—Taken by Schwarz in June. Also a specimen of a variety of this species taken by Wickham in July. *Distr.* Atlantic States to Michigan, Florida, and Texas.

187. *Trogosita virescens,* Fabr.—One at light, March 14th. Distr. New Jersey to Oregon, Idaho (Transition, 7800 ft.), Utah (high Transition, 9000 ft.), California, Arizona, New Mexico, Texas, and Mexico, including Lower California.

188. *Tenebrioides semicylindrica,* Horn.—Beaten in woods at Rock's Resaca, June 26th. Also one taken by Wickham in June. *Distr.* Florida, Southern Texas, and adjacent Mexico.

PARNIDAE.

189. *Throscinus*, n. sp.—Two specimens taken running on muddy beach south of Point Isabel, June 29th. A very small black elongate beetle. *Distr.* Known only from the Lower Rio Grande region.

HETEROCERIDAE.

190. *Heterocerus pallidus*, Say.—One at light, June 22nd. *Distr.* Arizona, New Mexico and Kansas to Texas.

191. *Heterocerus schwarzii*, Horn.—One at light, June 19th. *Distr.* Known only from a few widely separated localities.

DASCYLLIDAE.

192. *Scirtes*, n. sp.—One beaten in palmetto thicket at Santo Tomas, June 23rd. Like a large halticid, pale tawny yellowish with finely black-lined elytra, lines interrupted on hind third. *Distr.* Known only from the Lower Rio Grande region.

ELATERIDAE.

193. *Alaus gorgops*, Lec.—Three taken on trunks of live and dead ash trees, at La Blanca and Granjeno, Texas, May 8th and 9th. *Distr.* Kansas to Texas and Mexico.

194. *Hemirhipus fascicularis*, Fabr.—One at light, June 19th. *Distr.* District of Columbia to Missouri, Florida, and Texas.

195. *Horistonotus curiatus*, Say.—Beaten from tangles of *Clematis drummondii* in openings of woods near Rock's Resaca, June 25th. *Distr.* Virginia, North Carolina and Florida to Alabama, Louisiana, and Texas.

196. *Horistonotus*, n. sp.—Several beaten from *Clematis drummondii* tangles in palmetto jungle at Santo Tomas, June 23rd. A small, brown species. *Distr.* Known only from the Lower Rio Grande region.

197. *Esthesopus*, n. sp.—One beaten from foliage in palmetto thicket at Santo Tomas, June 9th. *Distr.* Known only from the Lower Rio Grande region.

198. *Anchastus bicarinatus*, Lec.—One at light, June 10th. *Distr.* Florida to Louisiana, and Texas.

199. *Monocrepidius vespertinus*, Fabr.—One beaten in palmetto thicket at Santo Tomas, June 9th, and one at light, June 22nd. *Distr.* New Jersey to Nebraska, Kansas, and Texas.

200. *Ischiodontus ferreus*, Lec.—One female at light, June 10th, and

two beaten from vine tangles in palmetto jungle at Santo Tomas, June 16th and 23rd. *Distr.* Southern Texas and Tamaulipas to Southern Arizona, and Lower California.

201. *Drasterius cribratus,* Lec.—Found in soil around cotton roots, at Santo Tomas, March 2nd. Beaten from weeds and foliage in fields, palmetto jungles and woods, June 7th to 26th. At light, June 11th. *Distr.* Known only from Texas.

202. *Ludius texanus,* Lec.—Beaten by Schwarz and myself in edge of palmettos, June 9th, and taken by Wickham in July. *Distr.* Texas and Mexico to Southern Arizona, and Lower California.

203. *Physorhinus,* n. sp.—Four beaten from dead heads of *Yucca treculeana* at Yucca Ridges, July 9th. Length, 11½ to 12 mm. Color wholly soft brown, with a conspicuous circular light yellow patch on head taking up whole front or upper surface except narrow margin. Thorax ending in spine at hind angle on each side. *Distr.* Known only from the Lower Rio Grande region.

204. *Pyrophorus physoderus,* Germ.—Numerous specimens taken flying at night amongst mesquite growth, May 13th, at Refugio, Texas, six miles by land below Fort Ringgold, on Rio Grande. Beaten in June in palmetto jungles, and taken in evening in Brownsville and Matamoros, in July. Taken in large numbers in evening in palmetto jungle at Santo Tomas, August 27th. *Distr.* The genus is Neotropical. This species occurs in Southern Texas and Tamaulipas, and is known also from Florida and Sonora.

BUPRESTIDAE.

205. *Chrysobothris octocola,* Lec.—One on mesquite log in sun at Ramirez, Tamaulipas, May 10th. Three on live mesquite bushes at Reynosa, Tamaulipas, May 16th. This species is peculiar to *Prosopis juliflora,* according to Schwarz. *Distr.* Southern California and Southern Arizona to Southern Texas, and Tamaulipas.

206. *Chrysobothris debilis,* Lec.—One taken on boat at Agua Negra, Texas, May 8th. Also peculiar to *Prosopis juliflora,* according to Schwarz. *Distr.* Southern California through Southern Arizona, Southern New Mexico, and Western and Southern Texas to Mexico.

207. *Chrysobothris,* n. sp.—Four specimens issued from dead fig twigs, April 17th. Length, 8 mm. Elytra dark metallic greenish, head and thorax metallic bronzed greenish. Underside purplish bronzed, including underside of legs, the upper edge of legs being greenish. *Distr.* Known only from Lower Rio Grande region.

208. *Actenodes,* n. sp.—One taken at Reynosa, Tamaulipas, on *Prosopis juliflora,* May 16th. Length, 14 mm. Face brilliant reddish

bronze, rest dull bronze brown with a greenish lustre. Underside more bronze and less greenish. *Distr.* Known only from Lower Rio Grande region.

209. *Acmaeodera flavomarginata,* Gray.—Fall, in his recent revision of the genus, gives a range for this species which would indicate its presence in the Lower Rio Grande region. *Distr.* It occurs from Southwest Texas to Southeast California, and the Cape region of Lower California.

210. *Acmaeodera rubronotata,* Laf. and Gory.—Fall gives habitat as Texas along the Mexican border. It may reach the Lower Rio Grande.

211. *Acmaeodera pulchella* var. *mixta,* Lec.—One specimen (7 mm.) taken by Wickham in June. A larger specimen (10 mm.), thought to be this variety, was beaten by Wickham in palmetto jungle, June 27th. It is much broader and stouter, with the lateral posterior yellow of prothorax very distinct and conspicuous. *Distr.* The typical *pulchella* ranges from Pennsylvania to Florida and west to Eastern California. The variety *mixta* occurs from Nebraska and Kansas to New Mexico, Texas, and Mexico.

212. *Mastogenius,* n. sp.—One taken on corn at Santa Maria, Texas, May 7th. Length, 3½ mm. Bluish-black, oval-elliptical, of elegant form, evenly rounded in outline anteriorly, slightly tapering posteriorly. Entirely black, with a bluish tinge especially above. Shields of prothorax delicately reticulate, elytra delicately punctured. *Distr.* Known only from Lower Rio Grande region.

213. *Agrilus lecontei,* Saund.—One beaten from foliage in palmetto thicket at Santo Tomas, June 27th. This species is peculiar to *Celtis,* according to Schwarz. *Distr.* New Jersey to Texas.

214. *Agrilus macer,* Lec.—One specimen of this large and beautiful species was beaten by Wickham from vines in woods near Rock's Resaca, June 26th. Det. Wick. *Distr.* Known only from Texas, and peculiar to *Celtis,* according to Schwarz.

215. *Agrilus addendus,* Crotch.—Taken on leaves and stems of *Prosopis juliflora* at Reynosa, Tamaulipas, May 16th. *Distr.* Texas to Arizona, Lower California, and Mexico.

216. *Agrilus palmacollis,* Horn.—Three specimens bred from dead fig twigs broken from trees in February, issuing March 12th, March 19th, and April 7th. *Distr.* Southern Texas and Southern Arizona, according to Schwarz. Doubtless occurs in Mexico on the fig.

217. *Taphrocerus,* n. sp.—One taken on leaves of *Lantana camara* June 5th, and one on cotton at Santo Tomas, June 7th. Length, 4 to 4½ mm. Color cupreous brown or metallic brownish-greenish above, merging into purplish posteriorly and greenish anteriorly. Underside

dark, obscure greenish or greenish brown. *Distr.* Known only from Lower Rio Grande region.

218. *Pyropya minuta*, Lec.—One taken by Schwarz in June. *Distr.* Widely distributed.

219. *Photinus lineellus*, Lec.—One beaten from foliage at Rock's Resaca, June 26th. *Distr.* Florida (Lake Worth) to Texas.

220. *Photinus pyralis*, Linn.—Taken flying from last week in March through June. Also beaten from foliage in palmetto jungle at Santo Tomas, June 16th. *Distr.* New Jersey to Kansas, Nebraska, and Texas.

221. *Photuris pennsylvanica*, D. and G.—Beaten in palmetto thickets at Santo Tomas, June 9th. *Distr.* Canada and New Jersey to Florida, Southern Louisiana, Nebraska, Kansas, and Texas.

222. *Mastinocerus texanus*, Lec.—The luminous larviform females of this species were frequently found after dark on brick pavements and sidewalks in town, from February 26th to April 20th. None were noticed through May and June, nor till third week in July, which seems to mark a new brood. During last week of July they were seen every night, also during August and until September 14th. The specimens taken vary from 7 to 10 mm. The head is especially luminous, all the abdominal segments but little less so, and the thoraic segments not at all. *Distr.* Texas and Southern New Mexico.

223. *Tytthonyx*, n. sp.—Taken by Schwarz in June. *Distr.* Known only from Lower Rio Grande region.

224. *Chauliognathus marginatus*, Fabr.—Beaten in gardens March 18th to 20th. Numerous and in coitu on flowers of *Prosopis juliflora*, April 9th. *Distr.* New Jersey to Kansas, Nebraska, Southern Louisiana, and Texas.

225. *Belotus abdominalis*, Lec.—Beaten at Brownsville, May 5th; at Granjeno, Texas, May 9th; common on cotton plants, June 6th, near Matamoros, in cop. *Distr.* Throughout the Southeastern United States from District of Columbia to Texas and Tamaulipas.

MALACHIDAE.

226. *Collops balteatus*, Lec.—Beaten May 7th to June 9th. *Distr.* Southern Texas and Tamaulipas, north to San Antonio.

227. *Collops vittatus*, Say.—Beaten March 11th to June 26th. Both sexes numerous March 11th. Common on mesquite in April. *Distr.* Michigan and Lake Superior to Texas, New Mexico, Colorado, Arizona, California, Lower California, and Mexico. It reaches the high Transition in Colorado and New Mexico.

228. *Collops*, sp.—Beaten from sea-oats on Padre Island, June 29th. Elytra deep purplish green, head and underside of mesothorax and meta-

thorax bluish-black. All the rest of insect reddish-yellow, except terminal portion of antennae tawny-brownish. Length, 4 mm.

229. *Anthocomus pusillus,* Gorham. — Beaten from foliage near Rock's Resaca, June 25th. *Distr.* Widely distributed.

230. *Pseudebaeus,* n. sp.—Taken by Schwarz in June. *Distr.* Known only from Lower Rio Grande region of Texas.

231. *Attalus rufiventris,* Horn var.—Taken by Schwarz in June. *Distr.* The typical form of *A. rufiventris* occurs in Texas, New Mexico, and Arizona.

CLERIDAE.

232. *Elasmocerus terminatus,* Say.—One specimen in house, June 4th, and one beaten in woods near Rock's Resaca, June 26th. *Distr.* Pennsylvania, Indiana, and Missouri River to Texas and Mexico.

233. *Tillus occidentalis,* Gorh.—One specimen taken at Point Isabel, Texas, August 21st. *Distr.* This is a Neotropical species ranging from Southern Texas, Southwestern Arizona and Lower California through Mexico to Nicaragua.

234. *Cymatodera brunnea,* Melsh.—At light, June 19th. *Distr.* New Jersey to Southern Michigan (Constantine, St. Joseph county), Arizona, Texas, and Mexico.

235. *Cymatodera undulata,* Say.—One beaten from *Clematis drummondii* near Rock's Resaca, June 25th, and one beaten in palmetto jungle at Santo Tomas, June 27th. *Distr.* Widely distributed.

236. *Clerus quadrisignatus,* Say.—One specimen flying, June 18th, in mesquite thicket. *Distr.* New Jersey to North Carolina, Texas, Arizona, Lower California, and Mexico.

237. *Clerus abruptus,* Lec.—One specimen beaten by Wickham in woods near Rock's Resaca, June 26th. Identified by Wickham as probably this species. *Distr.* Texas and Tamaulipas to New Mexico and Arizona.

238. *Hydnocera discoidea,* Lec.—Several beaten from foliage in palmetto thicket at Santo Tomas, June 9th and 27th, one of which, taken on former date, may be considered a variety of this species. Also beaten from foliage in woods near Rock's Resaca, June 26th. Determined as doubtfully this species. *Distr.* The typical form of *H. discoidea* occurs from Texas through Southern New Mexico (Mesilla Valley, Silver City) and Southern Arizona (Yuma) to Southern California (Death and Panamint Valleys).

239. *Hydnocera,* n. sp.—Taken by Schwarz in June. *Distr.* Known only from the Lower Rio Grande region.

240. *Chariessa vestita,* Spin.—One specimen taken on fence post,

June 26th. Det. Wick. *Distr.* South Atlantic coast of United States to Texas and Mexico.

241. *Cregya mixta,* Lec.—Two specimens bred from dead branches of fig, issuing March 30th and April 21st. *Distr.* Florida to Louisiana, Texas, and Mexico.

242. *Cregya bilineicollis,* Chev.—One specimen beaten in palmetto thicket at Santo Tomas, June 27th. This species has been referred to the genus Pelonium. *Distr.* Tropical Mexico to Panama.

243. *Orthopleura texana,* Bland.—One beaten from foliage in palmetto thicket at Santo Tomas, June 9th. *Distr.* Known only from Texas.

244. *Necrobia rufipes,* Fabr.—One attracted to light, March 14th. Also taken at Fort Ringgold, May 13th, and on bags of bones at Refugio, May 14th. *Distr.* Cosmopolitan.

PTINIDAE.

245. *Mezium americanum,* Lap.—One specimen of this interesting species was taken on a window in doors, May 19th. The species looks exactly like a small spider at first sight, being a little over 2 mm. long. The bases of the elytra are armed with spinose hairs, a very remarkable character. *Distr.* West Indies and Southern States to Texas and Mexico.

246. *Ptinus bimaculatus,* Melsh.—Beaten in palmetto thicket at Santo Tomas, June 16th. *Distr.* Throughout the Southern States, reaching north to New York, Ohio, etc.

247. *Ptinus,* n. sp.—Two new species of the genus were taken by Schwarz in June. *Distr.* Known only from this region.

248. *Trichodesma,* n. sp.—One specimen taken in cotton field three miles south of Matamoros, in Tamaulipas, June 1st. It was on the outside of a cotton square, and was taken in the act of eating into a division of the square on the edge. Length, 5⅕ mm. Color soft, velvety cream-gray; nearly the hinder one-third of elytra warted brick-tawny and dark velvet-brown, mostly the former, the velvet-brown in spots on anterior border of this area. Thorax remarkably produced back of middle into a sub-angular prominence; color brown, tawny and gray interspersed. Legs, underside, and head brownish, clothed with short tawny pubescence. Upper side thickly short pubescent, giving the various colors, and with a sparse longer grayish pubescence rising out of the whole and showing above it. The prothorax is bent downward, the dorsal prominence pointing straight upward. *Distr.* Known only from the Lower Rio Grande region.

249. *Eupactus nitidus*, Lec.—One at night, June 11th. *Distr.* New Jersey to Texas.

250. *Catorama minuta*, Lec.—Taken by Schwarz and Wickham in June. *Distr.* Florida to Louisiana, Texas and Mexico.

251. *Hemiptychus punctatus*, Lec.—Taken by Wickham in July. *Distr.* District of Columbia to Florida, Louisiana, and Texas.

252. *Hemiptychus*, sp.—One specimen in bunch of green seeds of *Fraxinus viridis* var., on tree, June 10th. Another attracted by light, June 19th. Length, 2⅗ mm. Color above brownish, with a short, soft brassy pubescence; below lighter, the legs, abdomen and head showing more or less reddish. *Distr.* Known only from this region.

253. *Sinoxylon simplex*, Horn.—Taken very numerously from dead woody last-year's cotton stalks, February 13th to June 14th. The species works transversely of the stalk, usually two together side by side, which causes the breaking of the stalks. Almost any stalk when bent would snap off and reveal them. *Distr.* District of Columbia to Texas, Arizona, and Lower California.

254. *Sinoxylon texanum*, Horn.—Flying, February 27th. Numerously attracted to light, March 14th to June 11th. One found at Reynosa, Tamaulipas, May 16th, boring into live green wood of broken girdled end of *Prosopis juliflora* branch. It had bored in a distance of 5 mm. lengthwise with the grain. *Distr.* Arizona, New Mexico, Texas, and Mexico.

255. *Bostrychus bicornis*, Web.—One beaten from *Xanthoxylon pterota* in palmetto thicket near Santo Tomas, August 20th. *Distr.* Atlantic Coast to Lower Mississippi Valley, Texas, and Mexico.

256. *Amphicerus punctipennis*, Lec.—Taken from dead woody cotton stalks, February 13th to June 14th. Also one taken shortly before dark in burrow in dead guava branch on tree, it having eaten into branch its length, 13 mm. Three larvæ, apparently this species, were found in this dead guava branch on splitting it up with a knife. The larvæ have the anterior end, being the thoracic segments, much swollen or humped, thus approaching the humped thorax of the adult. *Distr.* California, Lower California, Utah, Arizona to Texas and through Mexico to Panama and Venezuela. Also occurs in the Sandwich and Galapagos Islands.

257. *Dinoderus brevis*, Horn.—Bred from dead woody cotton stalks, June 14th. Casey has erected the genus *Patea* for this species. *Distr.* Southern States to Louisiana, Texas, and Northeastern Mexico.

258. *Polycaon plicatus*, Lec.—Taken from dead woody cotton stalks, February 13th to June 14th. At light, March 19th. One beaten from dead branches of fallen tree in palmetto thicket near Santo Tomas, June 27th. *Distr.* Known only from Texas and Tamaulipas.

259. *Polycaon obliquus,* Lec.—Three specimens at light, June 11th. Also taken from dead woody cotton stalks, June 14th. *Distr.* Known only from Texas and Tamaulipas.

260. *Trogoxylon californicum,* Casey.—Issued from dead woody cotton stalk, March 30th. Thirteen specimens taken from same stalk, June 14th. *Distr.* Southern California and Southern Arizona to Southern Texas and Tamaulipas.

LUCANIDAE.

261. *Lucanus,* sp.—One specimen, doubtfully this genus, was taken under bark of large dead ash tree at Granjeno, Texas, May 9th. Length 33 mm. Color brown. Face between jaws, underside of metathorax, and less so at anus, with brownish-yellow hair. Antennae slender and hardly two-thirds length of body. Shield of prothorax finely punctulate, leaving three smooth surfaces in the form of an U with the limbs cut from the base.

SCARABAEIDAE.

262. *Canthon ebenus,* Say.—Common, rolling pellets of dung, at La Blanca and Granjeno, Texas, May 8th and 9th. *Distr.* Atlantic Coast to Kansas, Texas, New Mexico and Northern Mexico.

263. *Canthon laevis,* Drury.—Common, rolling pellets of dung, La Blanca, May 8th. *Distr.* Same as preceding.

264. *Canthon perplexus,* Lec.—One specimen at light, March 19th. *Distr.* Southern States to Texas and Tamaulipas.

265. *Choeridium histeroides,* Web.—One under a log at Rock's Resaca, June 26th. *Distr.* Atlantic Coast to Texas.

266. *Pinotus colonicus,* Say.—One specimen at light, September 5th. Det. Linell. *Distr.* This is a Mexican species, new to the United States lists. It is widely distributed in Mexico.

267. *Ataenius inquisitus,* Horn.—At light, May 24th. *Distr.* Southwestern Texas and Northeastern Mexico.

268. *Ataenius cognatus,* Lec.—Nine specimens at light, May 24th to June 22nd. Also beaten in woods at Rock's Resaca, June 26th. *Distr.* Atlantic Coast and Northern United States to Texas and Mexico.

269. *Ataenius strigatus,* Say.—One at light, March 19th. *Distr.* Canada, Eastern and Middle United States to Texas, New Mexico, Lower California, and Mexico.

270. *Ochodaeus biarmatus*, Lec.—One at light, June 10th. *Distr.* Texas, New Mexico, and Arizona.

271. *Bradycinetus minor,* Linell.—One taken by Schwarz at San Diego, Texas, May 26th. *Distr.* Known only from Southern Texas.

272. *Podolasia ferruginea,* Lec.—One specimen at light at Fort Ringgold, Texas, May 11th. *Distr.* Known only from Fort Ringgold, which is the type locality.

273. *Diplotaxis truncatula,* Lec.—One at light, June 10th. *Distr.* Kansas to Texas. A specimen from Southern New Mexico (Rincon) has been doubtfully referred by Liebeck to this species.

274. *Diplotaxis texana,* Lec.—One at light, March 14th. *Distr.* Texas. Probably occurs in Northern Mexico and elsewhere, but distribution is not known according to Schwarz.

275. *Lachnosterna submucida,* Lec.—Four specimens at light, May 18th to June 11th. *Distr.* Occurs in Texas and Mexico. I have taken what is evidently this species in Tabasco, attracted to light abundantly during the latter part of April. It agrees perfectly with *submucida* in all superficial respects.

276. *Lachnosterna crinita,* Burm.—One taken in doors, May 26th. *Distr.* Texas, Northern Mexico, New Mexico, and up to high Transition in Colorado.

277. *Phytalus cavifrons,* Linell.—Two males, May 20th, and one female, June 11th, all at light. *Distr.* Known only from the Lower Rio Grande region.

278. *Anomala binotata,* Gyll.—One at light, Fort Ringgold, May 11th. *Distr.* Middle States to Texas, Arizona, and Northern Mexico.

279. *Strategus julianus,* Burm.—Four females, June 10th; one male, June 11th; one female, June 21st; and one female, September 15th, all at light. This species has a most fragrant odor, partaking of a woody flavor. *Distr.* Louisiana, Texas, Mexico, Southern and Eastern New Mexico, and Arizona.

280. *Phileurus valgus,* Fabr.—Two at light, June 20th and July 3rd. *Distr.* Kansas and Nebraska to New Mexico, Texas, and Mexico.

281. *Euphoria melancholica,* Gory.—One specimen in cotton bloom, May 24th. Also one indoors, August 30th. *Distr.* Florida (Lake Worth), Southern Louisiana, Kansas, and Nebraska to New Mexico, Texas, and Mexico.

CERAMBYCIDAE.

282. *Mallodon dasystomus,* Say.—One taken at Granjeno, Texas, May 9th. *Distr.* Kansas and Nebraska to Texas and Mexico.

283. *Achryson surinamum,* Linn.—Two specimens at light, June 18th and July 2nd. *Distr.* The genus is Neotropical. This species extends from the Atlantic and Southern States through Mexico and Central America to Guiana, and over nearly all the West Indies. Horn gives its range as Middle Atlantic States to Paraguay. I have taken it at Frontera, Tabasco.

284. *Gnaphalodes trachyderoides*, Thorn.—Two specimens taken at twilight, running rapidly up and down dead guava branches, June 10th. *Distr.* This genus is also Neotropical. The species occurs in Texas and Mexico, including Lower California.

285. *Chion cinctus*, Drury.—Taken at San Juan de Allende, Coahuila, November 25th. *Distr.* Atlantic States to Texas and Mexico. Occurs on the Lower Rio Grande.

286. *Eburia stigmatica*, Chev.—One specimen at light, July 12th. *Distr.* Texas and Mexico.

287. *Eburia ovicollis*, Lec.—Three attracted to light, June 10th to 16th. One taken at twilight running rapidly up and down dead guava trunk and branches, June 10th. One beaten from foliage in palmetto jungle at Santo Tomas, June 23rd. *Distr.* Texas and Tamaulipas.

288. *Eburia tumida*, Lec.—One taken indoors, June 14th. *Distr.* Known only from Texas.

289. *Eburia mutica*, Lec.—One taken indoors, March 29th. *Distr.* Known only from Texas.

290. *Romaleum atomarium*, Drury.—One taken in mail sack from Alice, Texas, June 27th. *Distr.* Atlantic coast to Southern Michigan (Constantine) and Texas.

291. *Elaphidion irroratum*, Linn.—One dead specimen taken from spider-web, July 10th. A live specimen was taken by Wickham. *Distr.* United States, through Mexico and Central America, and in Cuba, Jamaica, Hayti, and other islands of the West Indies.

292. *Elaphidion mucronatum*, Fab.—One at light, near Monterey, Texas, May 14th. *Distr.* New Jersey and Pennsylvania to Southern Michigan (Constantine), Western and Southern States, Texas, and Mexico.

293. *Elaphidion inerme*, Newm.—One at light, April 13th. *Distr.* Widely distributed in the Southern States, extending to Southern Texas and Mexico.

294. *Elaphidion spurcum*, Lec.—One at light, February 24th. *Distr.* Western and Southern Texas.

295. *Elaphidion unicolor*, Rand.—One taken by Wickham in July. *Distr.* Atlantic coast to Texas.

296. *Elaphidion moestum*, Lec.—One specimen beaten from lower dead leaves of *Yucca treculeana*, at Yucca Ridges, July 9th. One taken on fence in town about dark, August 19th. One at light, August 22nd. Also taken by Wickham. *Distr.* Widely distributed in Southern States, reaching Texas and Mexico. The genus *Elaphidion*, as remarked by Gahan, is practically restricted in range between the United States and Panama, including the West Indies.

297. *Piezocera serraticollis*, Linell.—One specimen beaten in pal-

metto jungle at Santo Tomas, June 16th. Also taken by Schwarz. *Distr.* This is a distinctively Neotropical genus, now just recorded for the United States lists. The species is known only from the Lower Rio Grande region, and belongs to the tropical fauna.

298. *Ibidion exclamationis,* Thoms.—Two specimens beaten from shrubs in woods near Rock's Resaca, June 25th. The species was also taken by Wickham in July. *Distr.* This species has been previously recorded only from Almalonga, Mexico, and is thus new to the United States lists. It belongs to the tropical fauna.

299. *Ibidion townsendi,* Linell.—Two male specimens beaten from vine tangles in palmetto jungle at Santo Tomas, June 9th and 23rd. *Distr.* Known only from the Lower Rio Grande region. The genus *Ibidion* is distinctively Neoptropical, and is now just recorded as occurring within the limits of the United States.

300. *Phyton pallidum,* Say.—Bred numerously from dead twigs and branches of fig, issuing from March 12th to April 21st, as follows: March 12th, 1; March 25th, 2; March 30th, 4; April 7th, 5; April 21st, 4. Numbers beaten from foliage in palmetto thicket at Santo Tomas, June 9th; and further specimens at light, June 11th. *Distr.* Atlantic to Central States, Texas, and Mexico.

301. *Obrium mozinnae,* Linell.—Beaten from bushes of *Mozinna spatulata,* and taken in flowers of same, June 5th. Also taken by Schwarz on same bush, June 5th. *Distr.* Known only from the Lower Rio Grande region.

302. *Rhopalophora laevicollis,* Lec.—One specimen taken at Fort Ringgold, on *Prosopis juliflora,* May 12th. One beaten from *Celtis.* at Rock's Resaca, June 26th. Also taken by Wickham in July. *Distr.* Southern New Mexico to Southern Texas and Mexico.

303. *Dendrobias mandibularis,* Serv.—An elytron of this species was found in May, in town. *Distr.* Lower California and Southern Arizona to Southern Texas and Mexico. This species was taken by me near Chocoy, Tamaulipas, October 15, 1894.

304. *Sphaenothecus suturalis,* Lec.—One specimen taken on *Prosopis juliflora* branch, near fresh exit to burrow, from which it had evidently just emerged, at Yucca Ridges, July 9th. *Distr.* Southern Arizona (Tucson) and Southern New Mexico (Mesilla Valley, Deming) to Texas and Tamaulipas. It is found on mesquite in New Mexico; a pair was taken by me in copula on that plant, in the Mesilla Valley, July 8th.

305. *Ischnocnemis bivittatus,* Dup.—Two males issued from dead fig twigs, April 2nd and 7th. Five males and two females on mesquite flowers, April 9th, two pairs being in coitu. One female issued from fig twigs, April 12th. *Distr.* Southern Arizona to Southern Texas and Mexico.

306. *Stenosphenus dolosus*, Horn.—One specimen, April 7th. *Distr.* Known only from Southwestern Texas, according to Schwarz.

307. *Cyllene crinicornis*, Chev.—One, at light, March 14th. One, on flowers of mesquite, April 9th. On same flowers, May 6th, at Tahuachal, Tamaulipas. Flying, May 9th and June 8th, Hidalgo and Point Isabel, Texas. *Distr.* Southern Arizona to Texas and Mexico.

308. *Neoclytus luscus*, Fab.—One specimen beaten by Wickham in palmetto jungle, at Santo Tomas, June 23rd. Det. Wick. *Distr.* Atlantic States to Texas and Mexico.

309. *Euderces exilis*, Casey.—Two, May 6th, La Puerta, Tamaulipas. One, May 9th, Reynosa, Tamaulipas, on Mimosa. Found through June in palmetto jungles at Santo Tomas, and thickets near Brownsville. Beaten from tangles of *Clematis drummondii*. *Distr.* Known only from Southern Texas.

310. *Tetranodus niveicollis*, Linell.—One specimen, taken June 26th, is the type of this new genus and species. Beaten in palmetto jungle. *Distr.* Known only from the Lower Rio Grande region. The genus is allied to *Euderces*, and belongs to the tropical fauna.

311. *Leptostylus parvus*, Lec.—Two bred from fig twigs, May 4th. *Distr.* Canada, Pennsylvania, and District of Columbia to Ohio, Kansas, and Texas.

312. *Leptostylus biustus*, Lec.—One specimen issued from fig twigs, March 19th. One in dead cotton stalk, March 20th, at Santo Tomas. *Distr.* Canada, New York, New Jersey, Illinois, Virginia, Florida, Louisiana, and Texas to Mexico, Cuba, and Hayti.

313. *Liopus crassulus*, Lec.—One beaten in palmetto thicket at Santo Tomas, June 9th. One beaten from foliage at Rock's Resaca, June 26th. *Distr.* New Jersey and District of Columbia to Texas, Lower California, and Mexico. Said by Schwarz to breed in dead twigs of *Celtis texana*.

314. *Liopus alpha*, Say var.—Six beaten in palmetto thicket at Santo Tomas, June 9th and 16th. *Distr.* Canada and Eastern States to Michigan, Illinois, Kansas, Texas, Florida, and Mexico. I have taken the typical form of this species in the Carolinian of Southern Michigan (Constantine) on red oak, in which it there breeds.

315. *Dectes spinosus*, Say.—One beaten from *Abutilon holosericeum* at Santo Tomas. *Distr.* New England States to Ohio, Iowa, Colorado, Louisiana, Texas, New Mexico, and Mexico.

316. *Lepturges symmetricus*, Hald.—Numerous specimens of both sexes bred from dead fig branches and twigs, issuing from March 19th to June 14th. The majority issued before the last of April. A female was found on recently weather-killed guava branches, April 12th, where she was doubtless ovipositing. The female of this species, when at rest, stretches herself out flat on the bark of dead twigs, with legs spread out

more or less straight from body and nearly or quite full length, and antennae trained straight backward longitudinally over the body. In this position the insect much resembles a small dusky spider, the whitish parts of the legs looking like similarly colored parts of a spider. Besides this, the insect looks so nearly the color of the twig that it is almost invisible, as it keeps perfectly motionless. *Distr.* Canada, Michigan, Wisconsin, Iowa, New York to Florida, Louisiana, Kansas, Texas, and Mexico.

317. *Ecyrus fasciatus,* Hamilton.—Three specimens beaten from *Celtis,* at Rock's Resaca, June 26th, a pair being in coitu. This species resembles bird-dung with its gray-wood color and whitish creamy patches across body at junction of elytra and thorax and on ends of elytra. *Distr.* Known only from the Lower Rio Grande region. Belongs to the tropical fauna.

318. *Desmiphora mexicana,* Thom.—One taken by Wickham in July. Det. Wick. *Distr.* Gahan gives *D. mexicana,* Thom., as a synonym of *D. hirticollis,* Oliv., which species extends from Brazil to Venezuela, Colombia, Central America, St. Vincent, Grenada and Cuba. *D. mexicana* is, however, considered a valid species, its range being Southern Texas and Mexico.

319. *Oncideres pustulatus,* Lec.—One taken by Wickham in palmetto jungle, at Santo Tomas, June 30th, where many branches of *Leucaena pulverulenta* were found girdled, one such branch being nearly one and one-half inches in diameter. Det. Wick. *Distr.* Arizona to Southern Texas, Mexico, and Jamaica.

320. *Oncideres cingulatus,* Say.—Girdling branches of mesquite at Reynosa, Tamaulipas, May 16th. Green branches from ten to fifteen mm. in diameter had been girdled. The girdler was found resting above the girdled portion on a branch that still held, its anterior two pairs of legs being grasped around the branch. Determined by Schwarz as *O. putator,* Thom., which is given by Hamilton as a synonym of *O. cingulatus.* *Distr.* Middle States, New York, New Jersey, and Pennsylvania to Louisiana, Texas, Arizona, and Mexico.

321. *Oncideres texana,* Horn.—Chocoy, Tamaulipas, October 15th. Girdling branches of *Acacia.* This is mentioned as *O. putator* in Bull. Techn. Ser. No. 4, Div. Ent. U. S. Dept. Agric., p. 16. *Distr.* Kansas to Texas and Tamaulipas.

322. *Aporataxia lineata,* Hamilton.—Four beaten from tangles of *Clematis drummondii* in palmetto jungle at Santo Tomas, at Rock's Resaca and near Brownsville Ferry, June 16th to 28th. *Distr.* The genus and species are known only from the Lower Rio Grande region, and belong to the tropical fauna.

323. *Ataxia crypta,* Say.—One, at light, June 11th. One beaten from

foliage in woods, near Rock's Resaca, June 25th. One taken on *Mozinna spatulata,* August 10th. *Distr.* Pennsylvania to Alabama, Louisiana, New Mexico, Texas, and Mexico.

324. *Dorcasta cinerea,* Horn.—One on *Verbesina encelioides* at Granjeno, Texas, May 9th. One on cotton three miles south of Matamoros, June 1st. One on cotton at Santo Tomas, June 6th, and one on *Solanum eleaginifolium,* June 7th. One at light, June 11th. Said by Schwarz to breed in dead stalks of cotton and other plants. *Distr.* Known only from Southern Texas and Mexico.

325. *Mecas inornata,* Say.—One beaten by Wickham in palmetto thicket at Santo Tomas, June 27th. Det. Wick. *Distr.* Wisconsin, Iowa, Dakota, Nebraska, Colorado, and Nevada to Missouri, Kansas, Louisiana, Texas, and Mexico.

326. *Mecas pergrata,* Say.—One beaten by Wickham in palmetto jungle, at Santo Tomas, June 23rd. Det. Wick. *Distr.* Dakota, Nebraska, Missouri, Kansas, Colorado, and New Mexico to Louisiana, Texas, and Mexico.

327. *Amphionycha amoena,* Hamilton.—One beaten in palmetto jungle, at Santo Tomas, June 9th. *Distr.* Known only from the Lower Rio Grande, and belongs to the tropical fauna. Hamilton suggests that this species may be set in a separate genus, for which he proposes the name *Cathetopteron.*

328. *Amphionycha suturalis,* Linell.—Four beaten in palmetto jungle at Santo Tomas, from tangles of *Clematis drummondii, Ehretia elliptica,* and other foliage, June 9th to 23rd. Also taken by Schwarz at Santo Tomas in June. *Distr.* Known only from the Lower Rio Grande, and belongs to the tropical fauna. According to Linell, this species is doubtless to be referred to the Neotropical genus *Erana* of Bates.

CHRYSOMELIDAE.

329. *Megascelis texana,* Linell.—Beaten in May and June in palmetto jungle at Santo Tomas, being common during the latter month on low shrubbery in that locality. Also taken by Schwarz. *Distr.* The genus is a Neotropical one, not before known to occur within the United States. The species is known only from the Lower Rio Grande.

330. *Lema trilineata,* Oliv.—One specimen, May 27th. *Distr.* Atlantic coast to Colorado, Texas, and Mexico. Reaches high Transition in Colorado.

331. *Lema jacobina,* Linell.—One taken by Schwarz at San Diego, Texas, May 26th. *Distr.* Known only from Southern Texas. Allied to *L. sexguttata,* Oliv.

332. *Lema lebiodies,* Linell.—One beaten in palmetto jungle, at Santo

Tomas, June 9th. Also one taken by Schwarz. *Distr.* Known only from Lower Rio Grande. Belongs to the tropical fauna.

333. *Anomoea mutabilis*, Lec.—La Puerta, Tamaulipas, May 6th, and Brownsville, June 5th, on Mimosa. Common through June on various plants in palmetto jungle at Santo Tomas, and elsewhere. *Distr.* Texas and Mexico, according to Schwarz.

334. *Coscinoptera aeneipennis*, Lec.—One taken by Wickham in palmetto thicket, at Santo Tomas, June 27th. Also taken by Schwarz in June. Det. Wick. *Distr.* Southern Arizona and Lower California to Texas and Mexico.

335. *Babia quadriguttata*, Oliv.—Taken in June. *Distr.* New Jersey to Kansas, New Mexico (near Las Vegas), Colorado(West Cliff), Arizona, and Texas.

336. *Chlamys maculipes*, Chev.—One specimen taken on *Malvaviscus drummondii* in palmetto thicket at Santo Tomas, June 7th. Taken also by Schwarz at Santo Tomas in June. *Distr.* This is a tropical species, new to the United States fauna. It ranges from Tropical Mexico to Nicaragua, extending to the Lower Rio Grande.

337. *Chlamys memnonio*, Lec.—Three specimens, including a pair in coitu, taken on mesquite foliage, April 9th. Also taken by Schwarz at San Diego, Texas. *Distr.* Southern Arizona to Southwestern Texas and Mexico.

338. *Exema conspersa*, Mann.—One on *Parthenium hysterophorus*, June 22nd. *Distr.* Colorado and Utah to Southern California, Lower California, Arizona, and Texas.

339. *Cryptocephalus defectus*, Lec.—One taken by Wickham third week in June. Det. Wick. *Distr.* Known only from Texas, according to Schwarz.

340. *Cryptocephalus mutabilis*, Melsh. var.—One specimen taken by Wickham third week in June. Det. Wick. *Distr.* Atlantic coast to Texas is given as the range of the typical form.

341. *Cryptocephalus fulguratus*, Lec.—Beaten in palmetto thicket, at Santo Tomas, June 5th to 9th. Also taken by Wickham in June and July. *Distr.* Texas and Tamaulipas.

342. *Cryptocephalus trizonatus*, Suff.—Beaten from *Ehretia elliptica* and "retamal" in palmetto thicket near Santo Tomas, June 27th and August 20th, a pair being in coitu the former date. Also beaten from *Cassia* by Wickham in tangled thickets back of post, July 3rd. *Distr.* Texas and Mexico. A tropical species.

343. *Cryptocephalus*, sp.—One specimen beaten by Wickham in palmetto thicket near Santo Tomas, June 27th. Length, three mm. Color, wholly yellow, the elytra reticulate-veined with pale reddish-brown so as

to mark off seven or eight yellow cells on each elytron. *Distr.* Lower Rio Grande.

344. *Cryptocephalus*, sp.—Three specimens beaten from mesquite, April 9th, a pair being in coitu. Length of male, three mm.; of female, four and one-third mm. Color, shining black, elytra each with a bright red spot on outer base and smaller one at tip. Underside and legs delicately white pubescent. *Distr.* Lower Rio Grande.

345. *Griburius larvatus*, Newm.—One beaten from *Leucaena pulverulenta* in palmetto jungle at Santo Tomas, June 9th. One on cotton, June 24th. *Distr.* Southern Florida, Southern Texas, and Tropical Mexico. I took this species at San Rafael (near Jicaltepec), State of Vera Cruz. It goes as far north in Texas as Cuero and Bastrop. It is a Neotropical species.

346. *Pachybrachys*, sp.—One specimen on *Mimosa*, June 5th. *Distr.* Lower Rio Grande.

347. *Diachus auratus*, Fab.—One taken by Schwarz in June. *Distr.* Atlantic coast and Canada to Vancouver Island, Oregon, California, Lower California, Arizona, Utah, Colorado, New Mexico, Texas, Florida, and Mexico.

348. *Fidia cana*, Horn.—Beaten in palmetto thicket near Santo Tomas, June 27th. *Distr.* Known only from Texas, according to Schwarz.

349. *Glyptoscelis albidus*, Lec.—One on cotton, July 1st. *Distr.* Washington State and California to Texas and Mexico.

350. *Myochrous denticollis*, Say.—One beaten in palmetto thicket at Santo Tomas, June 7th. Two at light, June 19th. One in field, June 21st. *Distr.* Kansas, Nebraska, and New Mexico to Southern Louisiana and Mexico.

351. *Typophorus canellus*, Fabr.—Beaten in palmetto thicket at Santo Tomas, June 7th. *Distr.* Widely spread, according to Schwarz.

352. *Typophorus canellus*, var. *sexnotatus*, Say.—Two specimens on cotton, May 24th, eating leaves at edges, Carmen, near Brownsville. *Distr.* Widely spread.

353. *Typophorus viridicyaneus*, Cr.—A pair, in coitu, beaten in palmetto thicket near Santo Tomas, June 27th. *Distr.* Throughout the Southern States to Texas and Mexico.

354. *Chrysodina globosa*, Say.—Common on mesquite, in coitu and eating the leaves, April 9th. Beaten from *Ehretia elliptica* in palmetto thicket near Santo Tomas, June 7th. *Distr.* New Jersey to Texas.

355. *Rhabdopterus picipes*, Oliv.—Taken by Schwarz in June. *Distr.* Widely spread.

356. *Leptinotarsa 11-lineata*, Stal.—Nine specimens, April 19th, feeding on *Solanum eleaginifolium*, near Matamoros, Tamaulipas, to-

gether with larvæ. Not unusually abundant; and elytral markings not constant, varying more or less in detail. As illustrating a general rule, which I announced some fifteen years ago (*Entomologica Americana*, about 1885), I give below a detailed description of the variations in the elytral markings of these nine specimens. This rule is that, in *Chrysomela, Leptinotarsa, Doryphora* and allied genera, the elytral markings vary very considerably when a species is only ordinarily abundant, but are very constant during seasons of great abundance or unusual increase of a species.

Color of living adult very pale straw-color; elytra each with four longitudinal black lines. Thorax with a varying number of black dots, usually five on each side, but sometimes six and again only four; when five, arranged in square with fifth in center. Thorax in middle with two parallel short longitudinal lines, these lines sometimes broken up into four spots and sometimes united posteriorly into a V-shaped marking. Head with three constant spots. Scutellum narrowly or broadly margined with black, or wholly so with only faint lighter area in middle. Two outer elytral stripes generally joined behind in acute angle, especially in the more robust specimens; sometimes the inner of the two abbreviated behind and not joining outer one. Inner stripe of inner pair always shorter than outer one of same pair; the inner one much more shortened behind in some specimens than in others. Narrow inner edges of elytra posteriorly black for a greater or less extent. When inner line of outer pair is abbreviated behind, its extreme end is left in conjunction with end of outer line, forming a hook, or is sometimes represented by only a dot separated from end of outer line, the latter being the case when the outer line shows a tendency to become faint posteriorly. Prothorax with a longitudinally elongate black dot below on each side; mesothorax below with a longitudinally narrow straight distinct thread-like black line on each side, pointing outward a little behind, and a spot more or less triangular outside its anterior end. Venter with two spots on last segment, and two in middle and one on each side of other segments.

Although the larva has been described and figured by Dugés (Ann. Soc. Ent. Belg., XXVIII, 1884), I, nevertheless, append the following description, made from two living larvæ taken with the above nine adults, which will form a contribution to a knowledge of the variation of the markings in the larval stage.

Larva.—Length, seven to nine or ten mm., according to whether they are crawling undisturbed or contracted in length on being disturbed; width, six to seven mm., according to same conditions. Color, pale, dilute yellowish, or pale straw color. Head pronounced brownish-yellow. Prothorax evenly and narrowly margined with shining black, only widened in a slight cloud in middle of hind margin in one specimen. Mesothorax and metathorax each with the lateral outer angles black, and the next segment behind similarly black on its outer angle, thus making three small shining black spots in a longitudinal row below and behind the black border of prothorax. A row of seven shining black spots on each side of rest of body in a uniform line, and uniform in size except last one or two, which are gradually lessened in size, especially last. These spots all mark position of true spiraclear openings or stigmata. There is what appears like a stigmatal orifice immediately below posterior spot of anterior row of three on one side in one specimen, and marked with black, but it is a false opening or possibly adventitious and abnormal. Front spot of anterior row of three bears a true stigmatal orifice, but other two spots none. In one specimen (not the one with above false stigma) there is on one side of abdomen, below fourth black spot of lateral row, a circular black-bordered spot, resembling a stigma, but apparently without opening. Next to last segment shining black above, with a stigma on each side in black area; last segment dilute fuscous in one, and bearing a terminal pair of fleshy prolegs. Disk of prothorax more yellowish than rest of body. Last three joints of legs more or less blackish, nearly wholly in hind legs, and on joints in middle and front pair. Antennae black, except bulbous basal joint, which is pale yellowish. Palpi blackish terminally. Mandibles blackish-brown on terminal portion. Eyes represented by four black dots in a square behind each antenna, and two below each antenna and laterad to same. Described from two living specimens, fully grown. *Distr.* Southern Texas, through Tropical Mexico to Central America and Western South America.

357. *Leptinotarsa defecta,* Stal.—One specimen taken on *Solanum eleaginifolium,* June 6th. *Distr.* Southern Texas to Mexico. Mr. Schwarz has taken this species as far north as Columbus, Texas. A tropical species.

358. *Leptinotarsa multitaeniata,* Stal.—One specimen taken at Agua Negra, Texas, May 8th. *Distr.* A Neotropical species not before recorded for the United States. It ranges through Tropical Mexico, reaching Southern Texas.

359. *Chrysomela disrupta,* Rog.—Several taken by Wickham in July. *Distr.* Kansas to Arizona, Southern Texas, and Mexico.

360. *Lina thymaloides,* Stal.—Many beaten from foliage in palmetto jungle at Santo Tomas, June 9th and 23rd, where it was common on low shrubbery through that month. Also taken by Schwarz and Wickham. *Distr.* Previously known only from Tropical Mexico and Central America.

361. *Lina scripta,* Fab. var.—One at La Blanca, Texas, May 8th. Many on *Salix,* eating the foliage, June 21st. *Distr.* Atlantic coast to

Southern Louisiana and Texas. Reaches high Transition and Boreal in Colorado (Veta Pass, 9400 feet).

362. *Cerotoma furcata*, Oliv.—Five specimens beaten from plants in palmetto thicket at Santo Tomas, June 7th and 27th. Also taken by Schwarz. *Distr.* This species was described from "North America," and the present locality is the only one known for it, according to Schwarz.

363. *Diabrotica 12-punctata*, Oliv.—Taken on cotton near Matamoros, Tamaulipas, June 19th. *Distr.* Atlantic coast to Texas and Mexico.

364. *Diabrotica balteata*, Lec.—La Puerta, Tamaulipas, on *Mimosa*, May 6th. On corn, Santa Maria, Texas, May 7th. Fort Ringgold, Texas, May 11th. Reynosa, Tamaulipas, on mesquite, May 16th. Numerous in cotton field near Matamoros, eating squares of cotton, June 6th. Also taken by Schwarz at Brownsville and San Diego, Texas, who states that at latter place its food plant is *Parkinsonia aculeata*. *Distr.* Arizona, Lower California (to Cape region), and Sonora to Southern Texas and Mexico.

365. *Diabrotica longicornis*, Say.—Numbers beaten from *Cnicus virginianus* and other plants in palmetto thicket at Santo Tomas, June 7th and 9th. *Distr.* Mississippi Valley (Illinois, Missouri) to Rocky Mountains, Arizona, Texas, and Mexico.

366. *Diabrotica nitida*, Linell.—Taken by Schwarz at San Diego, Texas, in May. *Distr.* New Mexico to Southwestern Texas.

367. *Galerucella marmorata*, Jac.—Two specimens beaten from palmetto leaves in palmetto jungle at Santo Tomas, February 26th, and numbers beaten from same leaves at same place, June 7th. Also one each found on elm and *Erythrina* in garden, May 31st and June 1st. *Distr.* Previously known only from Tropical Mexico and Guatemala.

368. *Monoxia debilis*, Lec.—One taken on wild bamboo in garden, May 2nd. *Distr.* Widely distributed throughout the *Sonoran* regions, according to Schwarz. Reaches to high Transition and Boreal in Colorado (Veta Pass, 9000 feet) and Idaho (Atlanta, 7800 feet).

369. *Oedionychis interjectionis*, Cr.—One taken on *Lippia lanceolata*, June 22nd. *Distr.* Texas and Mexico.

370. *Oedionychis petaurista*, Fabr.—One beaten in palmetto thicket near Santo Tomas, June 7th. *Distr.* Atlantic coast to Texas.

371. *Oedionychis texana*, Cr.—One taken by Wickham in July. *Distr.* Kansas, Colorado, and New Mexico to Southern Texas.

372. *Disonycha glabrata*, Fab.—One on corn at Santa Maria, Texas, May 7th. *Distr.* Georgia to Texas, Northern Mexico and Arizona.

373. *Disonycha abbreviata*, Melsh.—One specimen found hibernating in earth around cotton roots at Santo Tomas, March 2nd. *Distr.* Widely spread, according to Schwarz.

374. *Disonycha 5-vittata*, Say.—Flying in large numbers in sunlight,

March 12th. *Distr.* Canada to Colorado, New Mexico, Texas, and Mexico, including Lower California. Reaches to the high Transition of Colorado.

375. *Disonycha varicornis,* Horn.—Taken on *Opuntia leptocaulis,* June 5th, on which plant the yellow larvæ feed externally. Also numbers found on cotton, July 1st. Taken by Schwarz at San Diego, Texas, on *Opuntia leptocaulis. Distr.* Known only from Texas, according to Schwarz.

376. *Disonycha mellicollis,* Say.—Taken by Schwarz in June. *Distr.* Atlantic coast to Texas.

377. *Haltica burgessi,* Cr.—Beaten in palmetto jungle at Santo Tomas, June 16th. *Distr.* Known only from Florida Keys and Southern Texas, according to Schwarz. Doubtless a tropical American species extending through Mexico.

378. *Haltica nigritula,* Linell.—Beaten in palmetto jungle at Santo Tomas, June 9th and 16th. Also taken by Schwarz at San Diego and Corpus Christi, Texas, April to June. *Distr.* Known only from Southern Texas. Belongs to the tropical fauna.

379. *Epitrix parvula,* Fab.—Taken by Schwarz in June. *Distr.* New Mexico to Texas, Southern States, Mexico, West Indies, and South America.

380. *Plectroteta,* n. sp.—One specimen taken indoors, March 1st. Length, five and one-third mm. Whole underside and legs reddish-yellow, except tibiae, tarsi, and distal tips of hind femora, which are brown. Antennae brown, yellowish basally. Head and thorax entirely yellowish, eyes brown. Elytra very dark green. *Distr.* Known only from this region.

381. *Longitarsus,* sp.—Taken by Schwarz in June. *Distr.* Known only from this region.

382. *Glyptina spuria,* Lec.—One, at light, June 11th. *Distr.* Atlantic coast to Kansas, Nebraska, New Mexico, and Texas.

383. *Glyptina atriventris,* Horn.—At light, June 22nd. *Distr.* Southern New Mexico, Texas, and Mexico. Widely distributed, according to Schwarz.

384. *Chaetocnema decipiens,* Lec.—Taken by Schwarz in June. *Distr.* Kansas to Southern Texas.

385. *Microrhopala dimidiata,* Horn.—One beaten from tangles of *Clematis drummondii* in palmetto thicket at Santo Tomas, June 16th. Two beaten in woods near Rock's Resaca, June 25th. *Distr.* Known only from Southwest Texas, according to Schwarz.

386. *Microrhopala,* sp., probably *melsheimeri,* Cr.—Five specimens taken on *Abutilon holosericeum* at Santo Tomas, June 6th and 18th. Length, three to four mm. Color, tawny or creamy yellowish. Male

larger, with very little brownish on elytra behind; head yellowish posteriorly, and prothorax with three horns on anterior margin, the middle horn pronounced. Female smaller, without thoracic horns; head entirely dark brown, considerable brown on posterior one-third of elytra, the front border of this brown being usually darker than the rest and forming an irregular zig-zagged line extending transversely across. Antennae dark brown in both sexes. Underside dark brown. Legs whitish. *Distr.* *M. melsheimeri* occurs in California, Lower California, and Arizona.

387. *Microrhopala gracilis,* Horn.—Taken by Schwarz in June. *Distr.* Known only from Texas, according to Schwarz, other localities being Columbus and San Diego.

388. *Brachycoryna pumila,* Guer.—Taken on a malvaceous plant, probably *Abutilon holosericeum.* Also taken by Schwarz at Brownsville and San Diego, Texas. *Distr.* This is a Neotropical genus. The species has hitherto been known only from Tropical Mexico, Central America, and Colombia.

389. *Stenopodius flavidus,* Horn.—Taken at Brownsville in June. Also taken by Schwarz at San Diego, Texas. *Distr.* Arizona (Winslow) to Southern Texas.

390. *Cassida texana,* Cr.—Larvæ found eating leaves of *Solanum eleaginifolium,* April 19th to May 24th, near Matamoros, Tamaulipas, and at Carmen, Texas. The larva is prickly, of a rich green color, being a Paris-green shade. It is interesting to note that the larva is wholly green, except the anal brown polished horns, and the adult is also of a prevailing green color. A larva taken April 19th was transformed to an adult April 27th. Those taken May 24th were full-grown. *Distr.* California and Arizona to Texas.

391. *Coptocycla aurichalcea,* Fab. (teste Horn).—One specimen beaten by Wickham in palmetto jungle at Santo Tomas, June 30th. *Distr.* Atlantic and Middle States to Florida, Louisiana, Colorado, New Mexico, Arizona, California, and Lower California. Reaches the high Transition of Colorado and New Mexico.

392. *Coptocycla signifer,* Hbst.—One taken on *Verbesina encelioides* at Granjeno, Texas, May 9th. *Distr.* Atlantic region to Kansas, Texas, Lower California, and Mexico.

393. *Coptocycla bonvouloiri,* Boh.—Two specimens beaten from vine tangles in palmetto jungle at Santo Tomas, June 16th and 27th. *Distr.* Hitherto known only from Mexico, including Lower California.

394. *Coptocycla leprosa,* Boh.—Several taken by Wickham in June and July. *Distr.* Mexico, extending to Southern Texas.

395. *Coptocycla marmorata,* Champ.—One specimen, doubtfully determined as this species, beaten in woods near Rock's Resaca. *Distr.* *C. marmorata* is known only from Mexico.

BRUCHIDAE.

396. *Bruchus ramicornis*, Boh.—One specimen beaten from fig, May 29th. *Distr.* Cosmopolitan in warmer climates, according to Schwarz.

397. *Bruchus discolor*, Horn.—One specimen beaten in garden, April 30th. *Distr.* Southern New Mexico, Arizona, and Sonora to Texas and Mexico, according to Schwarz, who adds that it breeds in seeds of *Prosopis* and *Parkinsonia.*

398. *Bruchus pruninus*, Horn.—Taken at Alice, Texas, December 12th. *Distr.* Texas, Southern New Mexico, and Arizona.

399. *Bruchus prosopis*, Lec.—One on *Abutilon holosericeum*, June 18th. One beaten in tangled woods, back of Fort Brown, July 3rd. Also one beaten from mesquite, July 8th, in pods of which it doubtless breeds. *Distr.* Texas, Southern New Mexico, Southern Arizona, and Southern California to Lower California and Mexico.

400. *Bruchus amicus*, Horn.—Hibernating in dead cotton bolls at Santo Tomas, February 13th. Camote, Tamaulipas, May 16th. On buds of *Abutilon holosericeum*, June 18th. In squares of cotton, July 5th. Numerous specimens bred from pods of *Prosopis juliflora glandulosa*, collected July 8th, issuing July 12th to 21st. *Distr.* Colorado, New Mexico, Arizona, and Lower California to Texas and Tamaulipas. Reaches the high Transition and Boreal in Colorado (Veta Pass, 9400 feet).

401. *Bruchus flavicornis*, Sharp.—One on buds of *Abutilon*, sp., two miles south of Matamoros, Tamaulipas, June 1st. Two in buds of same plant, near Brownsville, June 5th. One on buds and two in interior of hollowed-out seed-vessel of *Abutilon holosericeum*, at Santo Tomas, June 6th. Also taken by Schwarz at San Diego, Texas. *Distr.* Mexico, reaching Southern Texas.

402. *Bruchus*, n. sp.—Bred from mesquite pods collected July 8th, issuing July 12th. *Distr.* Known only from this region.

403. *Bruchus*, sp.—Beaten from vines and foliage in palmetto thicket, at Santo Tomas, June 9th and 16th. *Distr.* Known only from this region.

TENEBRIONIDAE.

404. *Emmenastus texanus*, Lec.—One March 2nd, and one, at light, June 19th. *Distr.* Southern New Mexico to Southern Texas.

405. *Eleodes seriata*, Lec.—One under log at Rock's Resaca, June 26th. *Distr.* Known only from Texas.

406. *Glyptotus cribratus*, Lec.—Taken by Schwarz in June. *Distr.* Florida to Louisiana and Southern Texas.

407. *Adelina lecontei*, Horn.—Taken by Schwarz in June. *Distr.* Southern Arizona to Southern Texas and Mexico.

408. *Opatrinus notus,* Say.—Under log at Rock's Resaca, June 26th. *Distr.* Atlantic coast to Southern Louisiana, Texas, and Mexico.

409. *Blapstinus pratensis,* Lec.—Flying, March 26th. La Puerta, Tamaulipas, May 6th. At light, June 10th. *Distr.* Kansas, Nebraska, Idaho, Colorado, and New Mexico to Southern Texas. Reaches high Transition in New Mexico, Colorado, and Idaho.

410. *Blapstinus fuscus,* Casey.—Three at light, June 11th and 19th. *Distr.* Southern New Mexico to Southern Texas and Tamaulipas.

411. *Blapstinus,* n. sp.—Two sifted from dead leaves in palmetto jungle at Santo Tomas, June 16th. *Distr.* Known only from this region.

412. *Ulus elongatulus,* Casey.—One at light, June 19th. *Distr.* Known only from Texas.

413. *Tribolium ferrugineum,* Fab.—This widely distributed species was taken in this region.

414. *Anaedus texanus,* Linell.—One taken by Wickham under leaves in July. Also taken by Schwarz in June. *Distr.* Known only from this region.

415. *Phaleria gracilipes,* Casey.—One taken June 8th, and a colony of ten taken June 29th, in cracks of logs and under debris on south end of Padre Island, in moist places on beach. The specimens vary in color from pale yellowish to nearly black. *Distr.* This is a strictly maritime species, and is known only from the Texas coast, according to Schwarz. It doubtless extends down the Mexican coast also. The genus is peculiarly Antillean, being found on the beach line under seaweed and debris throughout the West Indies and the coasts of Florida and Mexico, both Atlantic and Pacific. It also extends up the Atlantic coast to New Jersey.

416. *Talanus langurinus,* Lec.—Taken in palmetto jungle and wooded tangles in June and July. Also taken by Schwarz and Wickham. Det. Horn and Wick. *Distr.* Florida, Southern Texas and Mexico. The genus is West Indian and Tropical Mexican.

417. *Helops,* n. sp.—Taken by Schwarz in June. *Distr.* Known only from this region.

418. *Pyanisia tristis,* Cast.—A pair taken under log at Rock's Resaca, June 26th. *Distr.* Southern Texas and Mexico.

CISTELIDAE.

419. *Lobopoda punctulata,* Melsh.—Several specimens beaten from dead *Yucca treculeana* leaves at Yucca Ridges, July 9th. *Distr.* Middle and Southern States to Southern Texas and Tamaulipas.

420. *Lobopoda mexicana,* Champ.—Two beaten from vine tangles of *Clematis drummondii* in palmetto jungle at Santo Tomas, June 16th.

Distr. Tropical Mexico and Central America, extending up to the Lower Rio Grande. Belongs to the tropical fauna. The genus is distinctively Neotropical.

421. *Hymenorus,* sp.—One specimen at light, June 19th. Length 6 mm. Color wholly soft light brown, legs brownish yellow, antennae brownish red, head dark, eyes black, underside of body faintly reddish, the upper side with a deep tawny very short vestiture. *Distr.* Known only from this region. Mainly a Mexican genus.

422. *Lystronichus piliferus,* Champ.—Beaten abundantly from vine tangles of *Clematis drummondii* and other vines in palmetto thicket at Santo Tomas, in woods near Rock's Resaca and in tangled woods back of Fort Brown, June 9th to July 3rd. Also taken by Wickham and Schwarz. *Distr.* The species is distinctively Neotropical, extending from Southern Texas through Tropical Mexico and Central America to Brazil. I have taken this species at San Rafael, near Jicaltepec, Vera Cruz State. The genus is Neotropical.

423. *Lystronichus championi,* Horn.—One taken at light, June 22nd. *Distr.* Southwestern Texas and Mexico.

OTHNIIDAE.

424. *Ababa crinita,* Casey.—Taken by Wickham in July. *Distr.* The genus and species are both known only from this region.

MELANDRYIDAE.

425. *Allopoda lutea,* Hald.—One taken near Rock's Resaca, June 25th. *Distr.* District of Columbia and North Carolina to Florida, Louisiana, and Southern Texas.

426. *Polypria cruxrufa,* Champ.—One specimen beaten from *Mimosa* in palmetto thicket at Santo Tomas, June 27th. Also taken by Schwarz at San Diego, Texas. *Distr.* Southern Texas and Mexico. The genus is Neotropical.

OEDEMERIDAE.

427. *Oxacis cana,* Lec.—Swept at Santo Tomas, June 7th. *Distr.* Southern Arizona to Southern Texas and Mexico.

428. *Oxacis pallida,* Lec.—Swept with the preceding species. *Distr.* Arizona and Southern New Mexico to Texas and Tamaulipas.

429. *Oxacis,* sp.—Beaten by Wickham from sea-oats on the south end of Padre Island, June 29th. Length, five and one-half mm. Color, wholly dark metallic bluish-green. *Distr.* The genus is Antillean. Though extending to New Mexico, Arizona, and California, it is char-

acteristic of the shore and key fauna of Florida, Mexico, and the West Indies.

430. *Alloxacis pleuralis,* Lec.—One taken in crack of log in sand on beach at south end of Padre Island, June 29th. Also beaten by Wickham with the preceding species from sea-oats, same place and date. *Distr.* Coasts of Florida, Texas, and Mexico. The genus and species are Antillean.

MORDELLIDAE.

431. *Diclidia laetula,* Lec.—Three beaten from *Clematis drummondii* tangles in woods near Rock's Resaca, June 25th. *Distr.* Southern Texas and Tamaulipas to New Mexico and Kansas.

432. *Pentaria,* n. sp.—One specimen beaten with preceding species from *Clematis drummondii,* same place and date. A very small, tawny, yellow species. *Distr.* Known only from this region.

433. *Mordella marginata,* Melsh.—Beaten in woods near Rock's Resaca, June 26th. *Distr.* Atlantic coast to Southern Texas, Tamaulipas, California, and Oregon.

434. *Mordella serval,* Say.—Taken by Schwarz in June. *Distr.* District of Columbia to Ohio, Michigan, Florida, and Texas.

435. *Mordella carinata,* Smith.—Taken by Schwarz in June. *Distr.* Florida to Louisiana and Southern Texas.

436. *Mordellistena,* sp.—At light, June 11th and 19th. Four mm. to end of anus. Color, soft dark olive; middle and front legs yellowish, hind tarsi soft black. *Distr.* Known only from this region.

437. *Mordellistena,* sp.—One taken at Reynosa, Tamaulipas, May 10th. Length, three and one-half mm. Entirely black, slightly shining in places. Wholly clothed with a sparse microscopic gray pubescence. *Distr.* Known only from this region.

438. *Mordellistena,* sp.—Taken in corn field at Santa Maria, Texas, May 7th. Length, three mm. Color, soft black; thickly and delicately short tawny pubescent above and below and on legs. Head and prothorax reddish yellow or brownish yellow, as are also front legs and middle femora. Antennae about same shade, but slightly more dusky. The pubescence on the soft black background gives the appearance of a silvery blackish in certain lights. *Distr.* Known only from this region.

ANTHICIDAE.

439. *Eurygenius,* n. sp.—One specimen beaten in palmetto jungle at Santo Tomas, June 9th. *Distr.* Known only from this region.

440. *Anthicus sturmii,* Laf.—Beaten from cotton near Matamoros, Tamaulipas, June 19th. *Distr.* Oregon, California, Arizona, Utah, and New Mexico to Southern Texas and Tamaulipas.

441. *Anthicus spinicollis,* Champ.—Beaten from vines and foliage in palmetto thicket at Santo Tomas, June 9th and 16th. Also taken by Schwarz at Laredo, Texas, and Nuevo Laredo, Tamaulipas. *Distr.* A Mexican species, reaching Southern Texas.

442. *Anthicus clavicornis,* Champ.—Beaten in palmetto thicket, June 7th, and from cotton near Matamoros, Tamaulipas, June 12th. *Distr.* Mexico, reaching Southern Texas.

443. *Anthicus,* sp.—Two specimens beaten from bamboo cane, April 30th and May 2nd. Length, two and one-half to three mm. Antennae brownish, yellowish basally. Underside of head and thorax reddish brown. Legs blackish on femora and bases of tibiae, but more yellowish on other portions. Underside of abdomen rather shining blackish. Upperside of head and thorax and bases of elytra light to dark reddish brown. Rest of elytra shining blackish, each elytron with a small transverse reddish yellow marking in the center of the black. The rounded, widened-on-posterior-two-thirds shape of elytra, the narrow more or less collared head and thorax, the rounded shape of head, and the form of the antennae give this beetle exactly the appearance of a small ant. In fact a lens is absolutely necessary to prove to the observer that it is not a small reddish-brown ant, such as are commonly seen singly running up and down the stalks of various plants. *Distr.* Known only from this region.

444. *Anthicus,* sp.—One taken at Hidalgo, Texas, May 9th, and one at Fort Ringgold, Texas, May 12th. Length two and four-fifths to nearly three mm. Entirely black or dark brown, a little shining. Legs and especially underside of prothorax brownish, the antennae also being brownish in the Fort Ringgold specimen. *Distr.* Known only from this region.

445. *Anthicus,* sp.—Three specimens taken under pieces of drift wood on beach at south end of Padre Island, June 13th and 29th. Length, three mm. Color of elytra light yellowish, a little fuscous on bases in one specimen, and with a wide band of fuscous across the middle. Thorax and legs nearly same yellowish, or pale reddish. Head, antennae and underside more brownish yellowish. *Distr.* Known only from this region.

MELOIDAE.

446. *Nemognatha lurida,* Lec.—On thistle flowers at Refugio, Texas, May 14th. *Distr.* Kansas, New Mexico, and Texas to Arizona and Lower California.

447. *Nemognatha vittigera,* Lec.—A brownish yellow and a yellowish brown specimen taken on flowers at coast line south of Point Isabel, Texas, June 29th. *Distr.* Missouri, Kansas, New Mexico, and Arizona to Texas and Tamaulipas.

448. *Gnathium texanum,* Horn.—Taken abundantly on flowers of *Lepachys columnaris pulcherrima,* as many as five or six on a flower, near Matamoros, Tamaulipas, June 22nd. *Distr.* Texas and Mexico.

449. *Epicauta callosa,* Lec.—One swept at Santo Tomas, June 7th. *Distr.* Montana, Colorado, and Kansas to Texas and Tamaulipas.

450. *Epicauta nigritarsis,* Lec.—On flowers of mesquite, April 9th. *Distr.* Known only from Texas.

451. *Pyrota invita,* Horn.—One at light, September 16th. *Distr.* Known only from Texas.

452. *Pyrota dubitabilis,* Horn.—This species was found swarming by hundreds on mesquite near Santa Rosalia (below Brownsville), Texas, June 6th. The beetles were hanging in bunches on the twigs, some flying from tree to tree. Probably a couple of dozen mesquite trees (*Prosopis juliflora glandulosa*) were swarming with them, covering an area of an acre or so. They were eating the mesquite leaves ravenously. A solitary specimen was found not far from this locality near the palmetto thickets three weeks afterwards, June 27th. *Distr.* Mexico and Southwestern Texas.

453. *Cantharis dichroa,* Lec.—One specimen, April 9th. *Distr.* Mexico and Texas.

RHYNCHITIDAE.

454. *Rhynchites,* sp.—One specimen beaten in woods near Rock's Resaca, June 25th. Entirely black in color. Very small, almost minute. *Distr.* Known only from this region, but doubtless extends into Tropical Mexico. Unless recently described in the *Biologia Centrali-Americana,* this is a new species.

OTIORHYNCHIDAE.

455. *Epicaerus mexicanus,* Boh.—Seven specimens beaten from *Clematis drummondii* tangles in palmetto jungle at Santo Tomas, June 9th to July 2nd. Also taken by Schwarz and Wickham in palmetto thicket, on woody vines. *Distr.* This is a tropical Mexican species, reaching the Lower Rio Grande. I have taken it in the States of Vera Cruz and Tabasco.

456. *Tanymecus confertus,* Gyll.—Eleven specimens beaten from vines and foliage in woods near Rock's Resaca, June 25th and 26th. One taken inside fallen cotton square in cotton field near Matamoros, Tamaulipas, September 16th. *Distr.* Atlantic coast to Nebraska, Kansas, Southern Louisiana, Texas, and Mexico. This species was taken numerously by me in the States of Vera Cruz and Tabasco.

457. *Pandeletejus nubilosus,* Boh.—Three specimens doubtfully determined as this species were beaten from vines and foliage in palmetto

thickets and woods, June 16th to 25th. I have taken this species in the States of Vera Cruz and Tabasco. *Distr.* Tropical Mexico.

458. *Coleocerus marmoratus,* Horn.—Beaten from *Leucaena pulverulenta* and other plants in palmetto thickets and woods, June 7th to 25th. In copula June 9th. *Distr.* Southern Arizona and Southern New Mexico to Southern Texas and Tamaulipas.

459. *Compsus auricephalus,* Say.—Beaten from *Lantana camara, Ehretia elliptica* and other plants in palmetto thickets and woods, June 7th to 25th. A light green form of this species occurs in about the same numbers as the normal white form. One of the green specimens was taken inside a square of cotton, July 1st. This species has been taken by me in the States of Vera Cruz and Tabasco. *Distr.* Georgia to Louisiana, Missouri, Texas, and Tropical Mexico. According to Leconte and Horn, it also goes north to Colorado.

460. *Phacepholis,* sp.—One taken in soil at base of cotton sprouts, April 5th. It is very near to *obscura,* Horn, but may be a new species. Length, five and two-thirds mm. Color, wholly grayish. Underside finely sprinkled with brown. Upperside faintly marked with dusky, the thorax sprinkled with brown. Elytra longitudinally punctate-striate. *Distr. P. obscura* is known only from Texas.

461. *Eudiagogus pulcher,* Fab.—Abundant on leaves and branches of *Sesbania vesicaria,* in copula and eating leaves, June 5th to July 3rd. The larvæ probably live in the roots, according to Schwarz. Leconte and Horn separate the Florida and Texas specimens as varieties. *Distr.* Florida to Louisiana, Southern Texas, and Tamaulipas.

CURCULIONIDAE.

462. *Apion curticorne,* Fall.—A pair taken at San Diego, Texas, by Schwarz, in May. *Distr.* Known only from Southern Texas.

463. *Apion propinquicorne,* Fall.—Taken at San Diego, Texas, by Schwarz in May. *Distr.* Known only from Southern Texas.

464. *Apion fumitarse,* Fall.—One taken by Schwarz, in May, at San Diego, Texas. *Distr.* Known only from Southern Texas.

465. *Apion attenuatum,* Smith.—One taken by Wickham in July. *Distr.* Ontario, Michigan, and Illinois to Nebraska, Oregon, Southern California, and Southern Texas.

466. *Apion aculeatum,* Fall.—Both sexes taken by Wickham in July. *Distr.* Known only from this region.

467. *Apion subtinctum,* Fall.—Taken by Schwarz in June. *Distr.* Occurs in Texas as far north and east as Columbus and San Antonio. Fall identifies a specimen from La Chuparosa, Lower California, as this species. Probably occurs through Mexico.

468. *Apion xanthoxyli,* Fall.—Bred in numbers from seeds of *Xanthoxylum pterota,* issuing July 4th. Also bred from same seeds at San Diego, Texas, by Schwarz. *Distr.* Known only from this region. The species belongs to a Neotropical type, represented by *A. gibbosum,* Sharp, of Tropical Mexico.

469. *Macrops,* sp.—Two at light, June 10th and 11th. A small gray species. *Distr.* Known only from this region.

470. *Lixus,* sp.—Three specimens, including a pair in copula, taken on tall weeds, June 23rd. *Distr.* Known only from this region, but doubtless occurs in Mexico.

471. *Smicronyx,* sp.—On stalks of *Lantana camara,* April 29th; beaten in palmetto thickets and woods, June 16th to 26th. Length, one and four-fifths mm. Legs and upperside light brownish, underside with a leaden gray or whitish pubescence. Head, upper (outer) side of legs, scutellum and short median streak behind latter whitish gray pubescent. The brown of upperside somewhat mottled. *Distr.* Known only from this region.

472. *Endalus aeratus,* Lec.—Two specimens taken on *Abutilon,* sp., and another plant, June 5th. *Distr.* Missouri to Southern Texas. Leconte records a species near *aeratus* collected by Schwarz in the Transition of Colorado.

473. *Bagous bituberosus,* Lec.—One at light, March 19th. *Distr.* District of Columbia to Florida, Louisiana, Kansas, and Southern Texas.

474. *Otidocephalus,* sp.—One specimen taken at La Puerta, Tamaulipas, May 6th. Length, four and two-fifths mm. Color, entirely shining black, except a line or rim of white along side of body running from head to anus and following outer border of elytra. Form spider-like, the abdomen being long oval and elytra constricted on sides and above at junction with prothorax. Latter with head forms a narrower elongate oval outline, but nearly same width before and behind. Body thinly white hairy below, and posteriorly so above, the rest of upper portion being black hairy. *Distr.* This is a species new to the United States fauna. It doubtless occurs through Tropical Mexico. The genus is a southern one. Specimens of a larger species of this genus, with the same facies as the present form, have been taken by me in the States of Vera Cruz and Tabasco.

475. *Anthonomus grandis,* Boh.—Very common in the cotton fields throughout the season, breeding in the squares and bolls. *Distr.* Yucatan and Tabasco through Vera Cruz and Tamaulipas to Southern Texas, lower portions of the Mexican tableland, and the Pacific coast of Tropical Mexico.

476. *Anthonomus ligatus,* Dietz.—Rather numerously beaten from clumps of *Koeberlinia spinosa* in openings in the woods back of Fort

Brown, July 3rd. Also taken by Wickham. *Distr.* Southern Texas and Tamaulipas to Southern Arizona and Lower California.

477. *Anthonomus aeneolus,* Dietz.—Breeding in fruit of *Solanum eleaginifolium* at Eagle Pass, Texas, and Cuidad Porfirio Diaz, Coahuila, in July. Also taken at Brownsville. *Distr.* Southern Texas up the Rio Grande Valley to Southern New Mexico.

478. *Anthonomus leucostictus,* Dietz.—Numbers bred from seeds of *Xanthoxylum pterota,* July 4th. Also bred by Schwarz from same seeds at San Diego, Texas. *Distr.* Known only from Texas.

479. *Anthonomus xanthoxyli,* Linell.—Beaten in large numbers from *Xanthoxylum pterota* in edge of palmetto thicket near Santo Tomas, June 27th. From a handful of green Xanthoxylum seeds gathered on this date, fifty-two weevils of this species issued up to July 4th. On August 20th, only a few specimens were obtained by beating the Xanthoxylum bushes at the same place. Also beaten by Schwarz from the same shrubs and bred from the seeds at San Diego, Texas. The weevils apparently breed singly in the seeds. It is interesting to note that no parasites were bred from the weevils. *Distr.* Known only from Southern Texas.

480. *Anthonomus testaceosquamosus,* Linell.—Seven specimens collected in heads of flower buds and on stems of *Abutilon holosericeum,* June 17th to 24th. This weevil probably breeds in the seed capsules of this plant, as does *A. grandis* in cotton. *Distr.* Known only from Southern Texas and Tamaulipas.

481. *Anthonomus brevirostris,* Linell.—Taken near Brownsville in June . *Distr.* Known only from this region.

482. *Tychius sulcatulus,* Casey.—A large series taken by Wickham at Point Isabel, Texas, in July. *Distr.* This is a maritime species known only from the seacoast of the Lower Rio Grande region.

483. *Tychius inermis,* Casey.—A large series taken by Wickham in July. *Distr.* Known only from this region.

484. *Tychius,* sp.—One specimen taken at Agua Negra, Texas, May 8th. Length, one and four-fifths mm. Color, light mahogany brown, sparsely grayish pubescent. Underside more densely lead-gray pubescent. Antennae black. *Distr.* This is doubtless a new species inhabiting Mexico and reaching Southern Texas.

485. *Sibinia ochreosa,* Casey.—Taken by Wickham in July. *Distr.* Known only from this region.

486. *Laemosaccus* sp.—Two specimens of this doubtless new species were taken on stalks of *Abutilon holosericeum* at Santo Tomas, June 6th. On June 18th, two specimens were found in cells inside dead stalk of the same plant, and one on stems of a live plant. The species breeds in the stalks. A specimen was taken by Wickham on a live cotton stalk, June 28th, which would seem to verify my prediction that it may attack

cotton. Length, nearly four mm. In form stout, thorax and abdomen same width. Color, deep black; tarsi and parts of legs brownish. Underside with pits containing gray pubescence. Thorax and elytra beautifully sculptured, the latter longitudinally and the thorax longitudinally on disk anteriorly. One specimen is larger than the above measurement and has a reddish-brown tinge. *Distr.* New to the United States fauna. Tamaulipas and Southern Texas.

487. *Conotrachelus albicinctus*, Lec. var.—A number beaten from *Clematis drummondii* and *Celtis* in palmetto jungle at Santo Tomas, June 9th to 23rd. Also taken by Schwarz. *Distr.* District of Columbia to Georgia, Florida, Alabama, Louisiana, Southern Texas, and Tamaulipas.

488. *Conotrachelus belfragei*, Lec.—Beaten in woods near Rock's Resaca, June 26th. *Distr.* Known only from Texas.

489. *Conotrachelus leucophaeatus*, Fah.—One specimen taken on *Leucaena pulverulenta* in edge of palmetto thicket at Santo Tomas, June 7th. *Distr.* Mexico and Southern Texas, occurring on *Euphorbia marginata*, according to Schwarz.

490. *Conotrachelus*, sp.—Beaten at Rock's Resaca, June 26th. A species with two creamy patches on the back. *Distr.* Known only from this region.

491. *Conotrachelus*, sp.—One beaten at Rock's Resaca, June 26th. A large species with a white patch behind. *Distr.* Known only from this region.

492. *Rhyssematus pruinosus*, Horn (nec Boh.).—Two specimens beaten in palmetto thicket near Santo Tomas, June 27th. *Distr.* Southern Arizona to Southern Texas, breeding in seeds of *Acacia greggii* according to Schwarz.

493. *Rhyssematus*, sp.—One specimen beaten from *Clematis drummondii* in palmetto jungle at Santo Tomas, June 23rd. Also taken by Schwarz in June. A black, unicolorous species. *Distr.* Known only from this region.

494. *Chalcodermus*, sp.—Seventeen specimens beaten from an Acacia with pale bluish flowers near Rock's Resaca, June 25th. A rather smooth species of a fine metallic greenish color, with light reddish brown elytra. *Distr.* New to the United States fauna. Probably a new species, occurring in Tropical Mexico and reaching the Lower Rio Grande.

495. *Chalcodermus*, sp.—Seven specimens beaten from *Clematis drummondii* vines and foliage in palmetto jungle at Santo Tomas, June 9th to 23rd. *Distr.* This species is also new to the United States fauna and is doubtless a Tropical Mexican form reaching this region.

496. *Acalles clathratus*, Lec.—Very numerous on *Opuntia lepto-*

caulis, breeding in the ends of the shoots, June 5th. This species kills the ends of the shoots of this plant, the grub eating out the inside portion and forming a cell in which it transforms. *Distr.* Southern Texas and Tamaulipas to New Mexico, Arizona, and Colorado, where it reaches the high Transition.

497. *Baris transversa*, Say.—Four specimens beaten from *Cnicus virginianus* and a hemp-like plant in palmetto thicket at Santo Tomas, June 7th and 16th, two being in copula the latter date. *Distr.* Illinois to Missouri, Nebraska, Kansas, Southern Texas, and Tamaulipas.

498. *Baris aerea*, Boh.—One beaten in palmetto thicket near Santo Tomas, June 27th. *Distr.* Atlantic States to Florida, Louisiana, Texas, and Tamaulipas.

499. *Pseudobaris discreta*, Casey.—One specimen beaten from *Cnicus virginianus* in palmetto jungle at Santo Tomas, June 7th. *Distr.* Known only from Texas.

500. *Onychobaris mystica*, Casey.—Taken by Schwarz in June. *Distr.* Southern Arizona and Southern New Mexico to Southern Texas, on *Opuntia leptocaulis*, according to Schwarz.

501. *Madarellus cuneatus*, Casey.—Beaten from vines in palmetto jungle at Santo Tomas, June 16th. Also taken by Schwarz in June. Lives in the stems of *Vitis*, sp. *Distr.* Known only from the Lower Rio Grande.

502. *Centrinus penicellus*, Hbst.—Taken by Schwarz in June. *Distr.* New York to Florida, Louisiana, and Southern Texas.

503. *Limnobaris cana*, Lec.—One specimen taken on *Abutilon holosericeum* at Santo Tomas, June 6th. *Distr.* Florida (Enterprise) and Southern Texas.

CALANDRIDAE.

504. *Scyphophorus robustior*, Horn.—Six specimens found in burrows in extreme base of a dead *Yucca treculeana* trunk at Yucca Ridges, July 9th. They had eaten lateral horizontal burrows in several directions, so as to cut the trunk partly off, when a little exertion broke it squarely in two, disclosing the weevils. *Distr.* Mexico and Southern Texas to Southern California and the Cape region of Lower California.

505. *Calandra oryzae*, Linn.—One eating into loaf of bread, May 17th. *Distr.* Widespread.

506. *Yuccaborus*, sp.—This doubtless new species was taken in numbers in decaying trunks of *Yucca treculeana* at Yucca Ridges, July 9th. Wickham took over two hundred from one trunk. They vary greatly in size. The small ones occurred near the bases of the trunks, which were standing upright, and the larger ones were found farther up. Only one

or two larvæ were found, and a few pupæ, but there were hundreds of adults, all inside the trunks and not yet emerged. This therefore is the season of their appearance, as shown by the fact that a few adults were beaten from the lower dead leaves of the yuccas and some found under yucca logs. Length of the largest specimens, fifteen mm. or more, not including snout. The small ones are half that size. Color, brownish-black; elytra thickly sprinkled with pale, dirty cream color; thorax on sides with same color, more or less nearly meeting on margin behind, but not reaching front margin. In the smaller specimens the creamy sprinkling is less apparent or obsolete. *Distr.* New to the United States fauna, and probably occurring in Mexico.

507. *Macrancylus linearis*, Lec.—A colony of thirty or forty found by Schwarz under a log on the south end of Padre Island, June 8th. Eleven taken under drift on Padre Island, June 29th, Wickham on same date finding a colony of fifty on underside of wide flat plank, being a piece of wreck of oak wood. The latter is a larger colony than Wickham ever found on the Florida Keys. This genus lives only on the open coast line, not on lagoon coasts. It lives in colonies under drift wood, which must be pine (not oak) in Florida, or wood without bark and partly soft so that the larvæ can breed in it. The weevils are found motionless and clinging to the wood when turned over, and occur in not too wet or too dry places. *Distr.* The genus is Antillean. The species is strictly maritime and semi-tropical. Southern Florida coast and keys and Southern Texas and Mexican coast and keys. The species was originally found on the seashore at Haulover, Florida, by Hubbard and Schwarz.

508. *Amaurorhinus nitens*, Horn.—One specimen beaten from *Clematis drummondii* tangles near Rock's Resaca, June 25th. *Distr.* Southern States to Southern Texas.

509. *Amaurorhinus*, sp.—Taken by Schwarz in June. *Distr.* New to United States fauna.

SCOLYTIDAE.

510. *Hypothenemus erectus*, Lec.—Many specimens of this very small scolytid were bred from dead fig twigs, issuing all the time from March 12th to June 14th. In all more than forty were bred. *Distr.* New Jersey to Texas. Breeds in hickory and oak in New Jersey.

511. *Hypothenemus dissimilis*, Zimm.—Bred with *H. erectus* from dead fig twigs, but in less numbers. *Distr.* New Jersey and Georgia to Lake Superior and Texas. Breeds in grape and oak in New Jersey.

512. *Hypothenemus*, sp.—This probably new species was also bred with *H. erectus* from dead fig twigs. *Distr.* New to the United States fauna and probably occurs in Mexico.

513. *Phloetribus*, sp.—Beaten from foliage in palmetto thicket at

Santo Tomas, June 9th. *Distr.* New to the United States fauna and doubtless a new species inhabiting Mexico.

ANTHRIBIDAE.

514. *Toxotropis pusillus,* Lec.—Taken by Schwarz in June. *Distr.* Florida to Southern Texas. Occurs throughout the Southern States.

515. *Toxotropis,* sp.—Beaten from foliage in palmetto jungle at Santo Tomas, June 9th. *Distr.* New to United States and doubtless a new species inhabiting Mexico.

516. *Eusphyrus walshii,* Lec.—Two specimens bred from dead fig twigs, issuing March 19th and 25th. *Distr.* Canada to Florida, Southern Texas, and Tamaulipas.

517. *Phoenicobius,* sp.—All stages taken inside a dead leaf stem of *Sabal mexicana,* in palmetto jungle near Santo Tomas, August 14th. They occurred in the distal portion of the stem, which was abruptly bent in the middle, allowing the leaf itself to hang down. There were three males and four females, one of each sex being newly transformd and still yellowish in color. Also four male and two female pupæ, and two larvæ. One larva was about fully grown and the other about half grown. All the adults and pupæ were taken in cells made of dust of borings in stalk of leaf, some being in continuation of stalk which forms midrib of leaf. Their cells are thick, and are simply the hardened dust packed together, probably by means of some moisture from the insect. They became detached from the mass of dust borings inside the stalk when the latter was split, and thus fell out. Length, eight to nine mm. A weevil with long antennae in the male. Length of antennae of male, thirteen to sixteen mm. Antennae of female, five and one-half mm. Color, ocher gray, with a sprinkling of blackish. Antennae of female with black just before tip. *Distr.* New to the United States fauna and doubtless a new species inhabiting Mexico.

518. *Anthribus cornutus,* Say.—Taken by Schwarz in June. *Distr.* Georgia to Louisiana and Southern Texas. Throughout the Southern States.

519. *Anthribus,* sp.—A pair beaten from foliage in palmetto thicket at Santo Tomas, June 9th. The male has three black horns on thorax. *Distr.* New to the United States fauna and probably inhabiting Mexico.

520. *Anthribus,* sp.—Beaten in palmetto thicket in June. Small, gray, with black dots in two pairs on elytra. *Distr.* Known only from this region and probably Tropical Mexico.

521. *Brachytarsus griseus,* Lec.—Taken by Schwarz in June. *Distr.* Utah and Colorado to Southern Texas, Lower California and Mexico.

522. *Araeocerus fasciculatus,* DeG.—Three specimens, May 2nd to

June 11th. *Distr.* United States, West Indies, Africa, India, etc. Nearly cosmopolitan.

Note.—Probably all, or nearly all, of the specifically unnamed Rhynchophora, which are listed as "sp.," are new species. At Mr. Schwarz's suggestion they are not so listed, since until the completion of the *Biologia Centrali-Americana* it is next to impossible to know whether or not they are described. They are all new to the United States fauna and doubtless most of them inhabit Tropical Mexico.

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An Ideal History of Experiments on the Regular Pentagon.

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An Ideal History of Experiments on the Regular Pentagon.*

A Pedagogical Essay.

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Mathematics may be regarded from three fairly distinct points of view:

1. As a department of pure knowledge, having a philosophical and aesthetic value of its own, unrelated to other sciences or to utility.
2. As a servant of other sciences, pure and applied.
3. In its elementary branches, as a mental gymnasium wherein the youthful mind may be taught to reason soundly.

In order, these are the views of the pure mathematician, the scientist, and the teacher. Every one will admit the justice of each view, but will emphasize one at the expense of the others in accordance with personal taste and training. Yet so closely connected are these views that no advance in pure mathematics can occur without being accompanied by a corresponding advance in mathematical applications and, to a less extent, in mathematical teaching.

In recent years, if the platitude be allowable, the activity of pure mathematician, scientist, and teacher has been remarkable. The foundations of mathematics have been and are being very carefully scrutinized. The axioms and postulates of elementary geometry and algebra have been subjected to a criticism that requires some maturity and acuteness to appreciate, and to a revision that has an important bearing on the teaching of these subjects. Already our text-books are beginning to show some of the good effects of this revision, and one of the most encouraging signs of the times is the increasing interest of competent pure mathematicians in elementary instruction and in elementary texts. To Professor Moore, of the University of Chicago, much credit is due. Himself a pure mathematician and a teacher of advanced students, he is using his great knowledge and influence to bring about needed changes in elementary instruction. In England, Professor Perry and others are carrying on an active and radical reform movement, but are being stubbornly opposed by the almost stupid conservatism of the schoolmasters.

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*This paper was read at the regular formal meeting of the Texas Academy of Science in June, 1903.

The American Mathematical Society is now concerning itself officially with college entrance requirements and other allied subjects. Undoubtedly the text-books of the near future will differ considerably from those now in use, and will make mathematical instruction far more effective.

It is being seen more and more clearly that geometry and algebra can be studied effectively from grammar to graduate school. In other words, that portions of these subjects are sufficiently easy and important to be studied by the many, while other portions possess difficulties that render them worthy of the trained specialist. Thus the raising of any number to any power is a fit subject for the grammar school when by any number is meant any positive integer, whereas the same operation is worthy of study by the advanced college student when by any number is meant the complex variable. The obvious moral to be deduced from such facts is that very elementary mathematical texts must omit much and are to be judged almost as much by what they omit as by what they contain. Neither algebra nor geometry are subjects that can be given with entire completeness and rigor to high school or even young college students. Not only must much be omitted, but now and then a theorem completing a theory may be quoted, the proof being explicitly omitted on account of its difficulty. Of course, it is not for a moment to be maintained that what goes into an elementary text should be actually wrong, either in matter or logic. As far as the text goes it should be accurate and logical, and a further study of the subject ought to extend, but not revise, the knowledge furnished by it. Fortunately over-refinement is now regarded as almost as great an evil as an actual blunder. The good text-book will steer wisely between too great completeness and too great rigor on one hand and blunders and pseudo-proofs on the other.

To give some idea of the changes now going on in the teaching of elementary geometry and drawing it away from the strict Euclidean mode, we may note the growing popularity of models; the greater use of concrete figures drawn to scale, from which the truths of theorems may be inferred by Baconian simple enumeration; the testing of theorems by drawing several figures before attempting the formal proof; the immense increase in the use of co-ordinate paper; the breaking down of the walls that divide arithmetic, algebra, and geometry from each other; the tendency to simplify proofs by explicit assumptions or omissions; the growing disinclination to plunge the student into abstract discussions of axioms, postulates and definitions. The failure of the old methods to teach geometry to any considerable percentage of pupils and the vast number it marred in making have led and will lead to changes. More and more will we hear of inductive geometry and mathematical laboratory work, more and more will the geometric formalist and purist be relegated to graduate schools, rarer and rarer will become the arithmetician who introduces algebra problems into his texts without the appropriate algebraic apparatus. Elementary mathematics will become more concrete.

Amid all this, some, unable to appreciate in detail the value of the changes now going on, will fear that something of value is being lost, that the rigor of geometry will be injured, that the benefit to be derived from studying it will be impaired, that courses in geometry may fall into the general culture group.

By means of a concrete problem, treated somewhat after the manner of the reformers, it is hoped to show that such fears are groundless. Recall as much of the method of the geometry of your school days as you can and compare it with the method presented as we go forward. It is hoped that you will see that the new is not radically different from the old; that it is equally logical; that it gives a certain systematic view of geometric constructions that was before lacking; that it makes geometry almost as experimental as chemistry; that it asks the student to systematically look over old knowledge in attacking new problems; that it involves an attempt to follow the historical order; that it removes two just objections often made to the study of what are called "geometric originals." (The first objection is that such originals are, for most pupils, mere puzzles; while the second is the lack of a general method on the part of elementary synthetic geometry.)

A dozen lectures would scarcely suffice to show the value of what may be called the experimental way of studying geometric originals. If from what follows you get some notion of the method it is all that can be expected.

Let us imagine a Greek geometer living about 400 B. C., before the science had acquired text-books, axioms, postulates, and all the impedimenta of the later deductive formalism. This Greek would have known, let us say, eight or ten of the familiar theorems about triangles, including the Pythagorean theorem, a theorem or two about parallels, a few about polygons, six or eight about the circle, along with a knowledge of the elementary constructions, such as erecting perpendiculars and bisecting angles.

With this limited equipment, let us suppose that he becomes interested in the construction of a regular pentagon, which no one before him has succeeded in constructing and which even today constitutes a problem of moderate difficulty, judged by high school standards. Now the construction of the regular pentagon is a problem that naturally arises in the mind of our Greek geometer. He already knows how to draw an equilateral triangle and a square and, by aid of a circle and angle bisections, to draw regular hexagons, octagons, dodecagons, etc. In other words, he knows how to draw regular polygons of 3, 4, 6, 8, 12, 16, etc., sides. Naturally, he wishes to draw regular polygons of any number of sides and his first problem is to discover a method of constructing a regular pentagon. When he succeeds in this he can go on to the regular heptagon (where he would fail).

Our Greek, therefore, first attacks the construction of a regular pentagon, using only the unmarked straight edge and compasses in accordance with the traditional limitations. That he could easily solve his problem by what we call in practical life fudge work, and in mathematics successive approximations, is obvious. He could draw a circle and spreading his compasses a little wider than the radius of his circle, step around the circle, taking five steps. If at the fifth step the steps closed the problem is solved. If not, the compasses may be readjusted in accordance with the size and nature of the failure to close. With the readjusted compasses he can again step around the circle when the failure to close will again indicate the readjustment necessary. In this way a regular pentagon can be obtained with great accuracy, as accurately as one can draw. This is distinctly an applied mathematics way, one might even say an Anglo-Saxon way, of solving the problem. It is a way that is even invading pure mathematics more and more in widely diverse regions, and which is easily applicable to polygons other than regular pentagons. But our Greek, like the rest of his race, is a pure and not an applied mathematician, and seeks not practical but ideal accuracy.

After looking at the matter several days, let us say, he sees that one way at least of solving the problem is to draw a triangle, isosceles and with base angles double the vertical angle. Let us suppose that he considers other ways of solving the problem, but fails, and finally comes back to the triangle as the most feasible solution. His problem now is: To draw an isosceles triangle having the base angles each double the vertical angle.

Now our text-books all have this problem, giving *first* the construction, *then* the proof that it affords the desired triangle. Too often our students memorize both construction and proof. But our Greek, free from text-books, is unable at once to see how to construct such a triangle. What is a very natural human thing for him to do? It is to assume it somehow constructed and then to investigate its properties. Our Greek

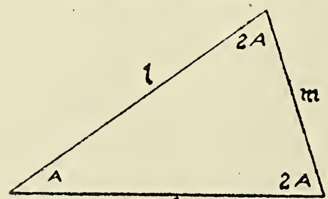

Fig 1.

examines the ideal triangle by means of a defective figure, very much as an entomologist examines a bug, labeling the parts. Now when one has a triangle in geometry one should think, sooner or later, in turn, of perpendicular bisectors of sides, of perpendiculars from vertices to sides, of angle bisectors, etc. Thus our Greek, taking up in order various familiar auxiliaries to the triangle (let us assume, without result, the waste that inevitably accompanies all research), comes eventually to think of the angle bisectors of this triangle. Immediately he sees (1) that the one from A is perpendicular to the opposite side and (2) that the ones from 2A gave rise to other isosceles triangles having angles A, 2A, 2A, and A, A, 3A.

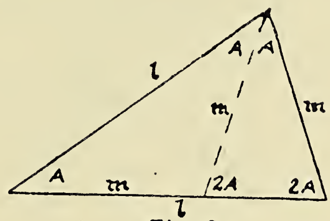

Fig 2.

Assuming that he considers the one from A without success (and it may be said that a variety of these ways assumed unsuccessful here are not so in fact) our Greek arrives at a consideration of the bisector of one of the 2A angles. Again he has the paraphernalia of perpendiculars, angle bisectors, etc., to think of in due turn. Sooner or later, then, he arrives at Fig. 3.

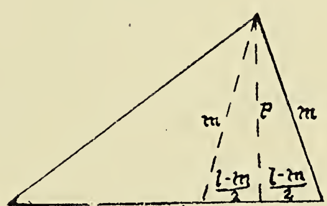

Fig 3.

Looking upon this, again let me say, as an entomologist upon a new bug, he can hardly fail to note the presence of three right angle triangles, two of them congruent. Now, being a sensible man (by hypothesis) and knowing but few theorems about right angle triangles, he could not fail to try to use these few in order. Very soon, then, he thinks of the Pythagorean theorem, and tries to use it. This theorem tells him that

$$p^2 = m^2 - \left(\frac{l-m}{2}\right)^2 = l^2 - \left[m + \left(\frac{l-m}{2}\right)\right]^2$$

when applied to the three triangles (one giving nothing new). Note that p is *common* to all three. It is to be remembered that our Greek knows practically no algebra and thinks these results in geometrical form as actual *squares*. Nevertheless, with him geometrically, as with us algebraically, it is mere routine work to deduce from these equations that

$$4m^2-(l-m)^2=4l^2-(1+m)^2,$$

and hence,

$$m^2=l(l-m).$$

It is now obvious that if our geometer can take a sect l and divide it into two parts, x and y, such that

$$x^2=y(x+y),$$

then the regular pentagon can be constructed.

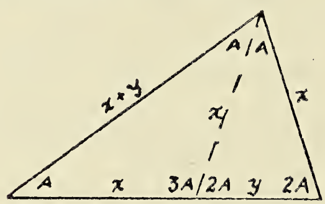

Fig 4.

Let us now assume that our Greek (I am not aware of any known historical facts to contradict us here), after trying a day or so to divide a sect in this way, gave it up and tried by other ways to draw his regular pentagon. Let us suppose that he tried in vain many years to get the solution in other ways and finally, almost in despair, came back to try to divide a sect into two parts, x, y, such that the square on one part was equal to rectangle of the whole sect on the other part.

Our Greek now has a sect, nothing more, with which to start; he seeks a point of division having a certain property. Some construction lines are obviously necessary. The whole plane is before him upon which to experiment. How shall the first construction line be drawn?

In order to get the right point of view let us make a rather violent assumption. Let us suppose that there was *one and only one way* of reaching this desired division point, and that this way consists (1) in producing the given sect by $\frac{1,417,682,342}{1,073,741,824}$ of its own length (this length being the only one that brings success and discoverable only by trial). Suppose it further essential to success (2) to lay off an angle equal to $\frac{763431}{1048576}$ of a right angle (one arm being the sect already drawn and produced and the fraction again discoverable only upon trial) and (3) to lay off on this second arm from the vertex a sect $\frac{523}{1024}$ of the original sect, when (4) a perpendicular at the end point of the last sect cuts the original sect at the desired point of division as (5) could be proved in some way.

It is needless to say that this construction does not give the desired division point. Had, however, this been the *only* way in which it could have been obtained, how long, think you, would our poor Greek have been in solving the problem? How long would he have been in *guessing* these somewhat peculiar fractions? Even if by accident he got one of them, how long would it be before he got the others to combine with it properly? This problem, with our present hypothesis, would be as difficult as, and very similar to, the unlocking of a combination safe of three turns where the turning possibilities are something enormous in each case. The Greek would have failed, and today it would be an unsolved problem.

As we go forward contrast the difficulty of this hypothetical condition with the simplicity of the actual problem. The contrast will bring out the fact that geometric originals are not mere puzzles, but can be solved by promising experiments combined with simple bits of reasoning.

Coming back to our geometer trying to divide a sect into two parts x, y, such that $x^2=y(x+y)$, let us imagine him attentively considering the promising ways of beginning his construction, some construction being obviously necessary. On looking over his limited knowledge of constructions he recalls the following as constituting most of his equipment: (1) Producing lines already in the figure by amounts equal to sects already in the figure. (2) Joining two points in the figure by a straight line, unless already so joined. (3) Erecting perpendiculars to already existing lines at favorable points. (4) Drawing parallels under similar conditions. Our Greek, to begin, may either produce, join, erect, or draw a parallel. To produce the initial sect is feasible, to join two points is not, to erect a perpendicular is feasible, to draw a parallel is possible but not promising, there is no favorable point to draw it through. As a *first* effort our Greek either produces the sect or erects a perpendicular to it. Let us assume that he produces the given sect, and, after trying a year or so to get the problem that way, fails. (As a matter of fact failure would not necessarily result.) He is now driven back to erecting a perpendicular. At what point shall he erect it? Many points may be chosen, of course, in fact the perpendicular might be erected at a random point. But our Greek would recall no case of a successful random perpendicular in his limited geometric experience and hence would try to select a suitable point. As a first effort would he not select an end point? If he failed there, then the mid-point could be tried, and, if failure resulted there, a trisection point could then be tried. As a first step in the desired construction, then, our Greek erects a perpendicular to the given sect at an end point. How long shall this perpendicular be made?

As a first experiment make it the length of the given sect. Various expiriments may now be made. Joining the two unconnected end points a right-angled triangle is formed. *Perhaps* half of this hypothenuse is x. But, alas, he observes that x, being half of this hypothenuse, satisfies the equation $4x^2=2(x+y)^2$, or $x^2=y(2x+y)$. Hence this x is not the one desired and something else must be tried.

Several other promising experiments may be tried here without success. Our Greek, then, let us say, after a thorough trial of a perpendicular at an end point equal to the original sect, either abandons (temporarily) the perpendicular at the end point or changes its length. Let us suppose that he first tries a different length. The new length should be either half or double the length of the original sect. Suppose he spends a week or so on the double length without success, finally trying the half length. Again, would he join the two free points as a further step. Again, would he try bisecting the new hypothenuse for x and again would it fail to be the x desired, as he could easily prove. Perhaps two-thirds of the hypothenuse, h, is x? He can easily prove that it is not. Perhaps one-third of the hypothenuse, h, is y? He can easily prove that it is not. Perhaps (h—l) is y? Perhaps one-third (l+h) is x? Perhaps $h-\frac{1}{2}l$ is x? A variety of simple hypotheses may be made and tested by our old geometer, all involving the sides of the triangle or simple fractions thereof with their sums and differences. Each hypothesis, as soon as made, must be tested. If it fails to stand the test, some further one must be made; if it does not fail, the problem is solved. Now our Greek in a few years could test several hundred such hypotheses. There are, perhaps, two hundred promising ones in this problem, certainly not over a thousand. Granting that only one of these is successful, our Greek ought to get his desired division point in a few years, or even in less time, if he goes about it in this systematic way. As a matter of fact, x is equal to $h-\frac{1}{2}l$ as may be easily proved. For

$$4h^2=5l^2,\ x=\tfrac{1}{2}l(\sqrt{5}-1),$$
$$y=l-x=\tfrac{1}{2}l(3-\sqrt{5}),$$
$$x^2=\tfrac{1}{2}l^2(3-\sqrt{5})=ly=y(x+y).$$

Hence a rather simple hypothesis leads to the correct division point.

It is hoped that this somewhat lengthy discussion of this one problem, which is quite a typical one, will point toward several conclusions. Geometry is in part, or can be treated as, experimental, and the experiments are not made altogether at random, and, if wisely made in any given case, are not unduly numerous Nevertheless, it is hardly fair to expect an immature student often to succeed in solving originals of any degree of difficulty, especially if asked to pay too explicit attention to the logic of his operations. But an immature student can be trained to try the promising experiments, and what is of more value, trained to go over his already acquired knowledge in a systematic way when attacking new exercises. The experiments that fail are often as useful to the learner as those that succeed, the proof that he has failed as logical as the proof that he has succeeded. It is not the result that is of educational value, but the method employed in reaching it. Of course, however, a student properly trained and of moderate capacity will soon learn the well beaten geometric roads and develop some capacity for actually solving originals. But success in actually getting an original is not the only basis for estimating a student's work. One can imagine that a student who fails to reach a successful conclusion may deserve a better grade than one who does not so fail.

In conclusion, notice that a strictly deductive geometry must often invert the historical order. In many geometries the problem of dividing a sect in the way just done is first given and then, later, this division is made use of in drawing the regular pentagon. Now, it is very probable that the problem of constructing a regular pentagon preceded that of the divided sect and gave rise to the need of so dividing, which, when accomplished, rendered the construction of the regular pentagon possible. In this way the probable historical order is often obscured and inverted. Obviously the historical order should not be followed, at all hazards, even if known. It would involve too much waste and the thought sequence of any discoverer of a new theorem is seldom known with entire accuracy even when thought out in modern times. But such thought sequence is precisely the true history of mathematics. Perhaps mathematical teaching, like so many other things, will profit by following loosely the course of those who built up the subject.

PROCEEDINGS

OF THE

TEXAS ACADEMY OF SCIENCE

FOR 1902.

THE TEXAS ACADEMY OF SCIENCE.

OFFICERS FOR 1902-1903.

PAPERS PRESENTED AT REGULAR MEETINGS.

February 21, 1902.

"A Consideration of S. B. Buckley's 'North American Formicidæ'" (by title), Dr. William Morton Wheeler, Professor of Zoölogy in the University of Texas.

"The Principle of Acceleration and Retardation in the Development of Animals," William Morton Wheeler, Ph. D.

April 25, 1902.

"Cretaceous and Later Rocks of Presidio and Brewster Counties," E. T. Dumble, Houston.

"The Present Status of Forestry in Texas," Dr. William L. Bray, Professor of Botany in the University of Texas.

Formal Meeting, June 11, 1902.

"Consciousness and Purposive Movements," Edmund Montgomery, Ph. D., Hempstead.

"Some Fundamental Characteristics of the Extensity of Sensations," S. E. Mezes, Ph. D., Professor of Philosophy in the University of Texas.

"De Vries' Mutation Theory," H. Ness, M. S., Professor of Botany in the A. and M. College of Texas.

"Mining—With Some Accounts of Russian Practice," William H. von Streeruwitz, C. E., Houston.

"New Departures in Cotton Mill Machinery and Appliances," Stonewall Tompkins and W. E. Anderson, Houston.

October 24, 1902.

"Regulations of the Issuance of Texas Railroad Securities," Annual Address by the President, Robert A. Thompson, M. A., C. E., Chief Engineer to the Texas Railroad Commission.

November 28, 1902.

"Contributions to a Knowledge of the Coleopterous Fauna of the Lower Rio Grande Valley in Texas and Tamaulipas, with Biological

Notes and Special Reference to Geographical Distribution" (by title) C. H. Tyler Townsend, El Paso.

"The Poisonous Snakes of Texas," J. D. Mitchell, Victoria.

"Iron Smelting," E. C. H. Bantel, C. E., Instructor in Engineering in the University of Texas.

FORMAL MEETING, MONDAY, DECEMBER 29, 1902.

"The Evolution of the Flower and Its Relation to Insects and Other Pollenizing Agents," Dr. William L. Bray, Professor of Botany in the University of Texas.

"The Effect of Weeds and Moss Upon Coefficients of Drainage in Small Irrigating Canals" (by title), James C. Nagle, M. A., M. C. E., Professor of Civil Engineering in the A. and M. College of Texas.

"The Decomposition of Potassium Chlorate at Fixed Temperatures" (by title), Eugene P. Schoch, Ph. D., Instructor in Chemistry in the University of Texas, and J. S. Brown, B. S.

"The Kinetics of Oxidation Reactions, Example I. The Equilibrium Between Potassium Ferrocyanide, Potassium Ferricyanide, Iodine, and Potassium Iodide" (by title), Eugene P. Schoch, Ph. D., Instructor in Chemistry, University of Texas.

"Contribution to the Chemistry of Fatigue" (by title), Henry Winston Harper, Ph. G., M. D., Professor of Chemistry in the University of Texas, and Margarat Holliday, M. S.

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FOR 1903,

TOGETHER WITH THE PROCEEDINGS FOR THE SAME YEAR.

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AUSTIN, TEXAS, U. S. A.:
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CONTENTS.

THE TEXAS ACADEMY OF SCIENCE.

[ANNUAL ADDRESS BY THE PRESIDENT.*]

NEOVITALISM.

EDMUND MONTGOMERY, PH. D.

Having been honored with the election to the Presidency of the Texas Academy of Science, I gladly conform to the customary practice of delivering an inaugural address.

Casting about for an appropriate subject, I felt, at first, tempted to choose something of general and popular scientific interest, which would probably have proved more welcome to an audience mostly composed of hearers who are not professional biologists. But falling back in my survey on my own special pursuits, it seemed to me, after all, that nothing could be of more serious and instructive interest than a concise account of the scientific attempt to reach a correct interpretation of the wondrous phenomena of vital organization.

So I concluded to select for my theme the principal researches and reasons which are now forcing biological investigators to substitute—as more profound and more explanatory—the theory of Neovitalism in the place of the hitherto accepted mechanistic view of vital phenomena.

After a period of biological interpretation in which purely physical theories were held to be adequately applicable also to vital phenomena, grave doubts have of late arisen as to the all-sufficiency of this mode of explanation. The conviction is gaining ground that no truly vital process takes place in strict accordance with what occurs in lifeless nature. Recent researches, and especially those relating to regeneration and ontogenetic reproduction, are leading investigators to recognize agencies transcending in efficiency those which are actuating physical phenomena.

Yet, living beings are so thoroughly interlinked with lifeless things, their vitality so completely dependent on non-vital agencies, that living and non-living bodies have inevitably to be looked upon as forming part of one and the same common nature. Living beings are out and out

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composed of the same chemical elements that are also composing lifeless things. Their vitality is from moment to moment sustained by the inhaling of outside air. And without the incorporation of foreign alimentary substances they themselves become soon reduced to lifeless matter, into which state they all eventually wholly dissolve. Furthermore, without the exquisitely attuned incitement of nature-revealing light, all would be indiscriminate darkness to every kind of living creatures. And without the rhythmic touch of ærial vibrations we would all be steeped in eternal silence. Indeed, it can be rightly maintained that the entire organization of living beings, down to their minutest structures, is functioning solely in more or less direct interaction with outside agencies, and in more or less important relations to the same.

But, though all this is undoubtedly true, there exist, nevertheless, no more striking, no more trenchant distinctions in nature than those obtaining between living beings and lifeless things. The most salient of these distinctions is perhaps the power of animals, and also of many plants, to move themselves; whilst all lifeless things, in order to be moved, have passively to await the impact of influences external to them. Besides, many more profound, if less salient, distinctions characterize living beings in contrast to non-living things. Living beings transform lifeless material into living substance, and coerce the same into definitely organized structures. They reproductively grow from tiny germs to specific adult stature. They propagate their own kind. They render outside nature in various ways subservient to their individual wants. In all this, and in much more, to their innermost core, living beings essentially differ from lifeless things.

No wonder that, in attempts at explaining the manifestations of life, special hyperphysical forces or powers have from time immemorial been invoked as actual agencies of the singular and marvelous phenomena of vitality. Not long ago it seemed unthinkable, even to professional biologists, that mere physical principles, such as are applied to the interpretation of lifeless nature, could possibly account for the minutely intricate organization, and the aimful vital activities, of bodies found physically to be composed of nothing but a few well-known chemical elements. Some vitalizing essence, force, or agent was, therefore, held to inhabit living bodies; quickening them, fashioning their organs, and directing their functions.

Most biologists of the first part of the last century still adhered in some form or other to the ancient hypothesis of a vital principle. Johannes Mueller, for instance, the revered teacher of Helmholtz, Du Bois-Reymond, Virchow, Haeckel, and many other prominent biologists, whose lectures I attended in my early student days, believed still in the existence of a creative vital force, that has power to generate from organic matter the organs which constitute the living being as a whole.

Meanwhile, however, atomic mechanics, originated and elaborated by the great philosophers and scientists of the 17th Century, and extended as an adequate explanation to the entire domain of perceptible nature, became more and more exclusively the creed of many naturalists. Gassendi had revived epicurean atomics. Descartes, inspired by Harvey's discovery of the circulation of the blood, was led to look upon the living organism as, out and out, a mere automatic machine mechanically actuated. Death, to him, meant no longer the separation of the vital principle from the material body, but simply the breaking up of the bodily machine.

Soon all activity in nature was regarded by most scientists as the result of mechanical impact applied to inert matter. Imparted motion was held to be the sole spring of action. And all bodily forms and structures were, under this aspect, necessarily held to result from the mere spatial groupings and acquired motions of the atoms composing them.

Robert Boyle, the founder of scientific chemistry, fully adopted the atomo-mechanical view as the true explanation of natural phenomena. And Newton in his ever memorable "Principia," expounded it mathematically with consummate precision and completeness. Among physicists, at least, there remained henceforth no doubt that perceptible nature consists altogether of material particles moved more or less swiftly, and grouped more or less compactly and orderly by imparted motion under mechanical laws. To them atomic mechanics was no mere working hypothesis, but a true interpretation of what really exists. These materialistic and mechanical conclusions followed, indeed, necessarily from the assumption of inert, indestructible atoms as the veritable building-material of the universe.

In the 18th century the physical materialism of the 17th expanded into general philosophical materialism, which reached its culmination in Lamettrie's "Homme Machine" and in Holbach's "System de la Nature," where even mental phenomena were declared to result from material motions.

Physiologists, however, in face of the marvelous manifestations of life, very generally resisted the purely mechanical interpretation. They could not yet see their way to dispense with the conception of a special vital principle in the explanation of the phenomena they were studying. It was not until the appearance of Lotze's celebrated article in Wagner's "Handworterbuch der Physiologie," that the ancient Vitalism was overcome by being shown to be grounded on nothing but metaphysical fictions; and that it was, in consequence, discarded by most biologists of the second part of last century.

Lotze, after carefully examining and refuting every argument that had been advanced in support of a special principle of life believed to be superadded to the agencies operative in physical nature, arrived at the conclusion that there exists no unitary vital force actuating and directing vital processes in fulfillment of a predetermined organic plan; that it is, on the contrary, a purely mechanical order of events in life, as everywhere else, which gives rise to the form and concatenation of all complex results in nature; and that these are entirely dependent on the co-operating efficiencies of the elements that compose all kinds of bodies. He maintained therewith that the efficiencies belonging to the elements are themselves fully competent to build up organic structures and to manifest the phenomena of vitality without the aid of any foreign agency. For, living beings—so he argued—arise out of the common store of nature and revert into the same. And as life derives all its means of existence from this common store, and develops entirely out of the substances yielded by it, it has in consequence to submit entirely to the general laws governing all natural phenomena alike. Organic bodies, being composed of the same elements that compose other bodies, are therefore like other bodies the outcome of the peculiar mode of composition and actuation of their sundry constituent elements. They form altogether part of the general mechanism of nature. Such were Lotze's antivitalistic views.

Lotze himself was no believer in inert material elements, but having disproved the existence of a special vital force, the way seemed now open to others for the scientific application of atomic mechanics to all vital phenomena. This task was, in fact, henceforth acknowledged by most leading biologists to be the true and final aim of their science. And when Robert Julius Mayer propounded the epoch-making doctrine of the indestructibility of force or motion, the all-comprising doctrine, namely, known under the name of the "Conservation of Energy," it seemed obvious to investigators of nature, that the perceptible world in all its multifold and changing forms is wholly the outcome of the play of indestructible matter energized by indestructible motion.

Believing that all physical phenomena of nature are produced by moved matter, and that all scientific knowledge is finally reducible to atomic mechanics, Du Bois-Reymond, in his well-known atomic fantasy declared, that a mind cognizant for the time being of the position and motion of all atoms composing the universe would be able in accordance with mechanical laws to deduce therefrom, in their minutest detail, all future and all past occurrences in the organic, as well as in the inorganic world.

But biologists, though theoretically convinced of the all efficiency of atomic mechanics, under whose sway the science of physical nature had made such astonishing progress, nevertheless proceeded in their own practical work to attack the essential vital problems from a more directly attainable standpoint. They endeavored to explain vital phenomena from what can be actually perceived as constituting organic beings, and as taking place during their functional activities.

And here the microscope proved to be the principal revealing instrument. With its aid it was discovered that all organic beings, save the very lowest, appear to be composed of a vast number of distinct elementary units, called cells; and that, moreover, these multitudinous cells are the offspring of a single so-called germ-cell. For the germ-cell is seen to divide into two daughter-cells. These again divide, and so on and on, until by means of such successive self-divisions the vast cell-aggregate is formed which constitutes what are called multicellular organisms. Such complex organisms are, consequently, held to be composed of myriads of aggregated elementary, autonomous beings.

This being the case, it is clear that all vital efficiencies must then exclusively reside in these separate cellular beings. And this, in fact, has been the generally accepted view, until new researches have lately been beginning to cast serious doubts upon its correctness.

In order, however, to harmonize the nature of the cellular beings with the principles of atomic mechanics, they are hypothetically conceived as made up of organic molecules, and these again made up of ultimate atoms somehow mechanically energized. Under the impression of the correctness of these biological interpretations and suppositions it was believed by investigators that they were explaining organization and vitality in strict accordance with mechanical principles, without having to assume in addition any hyperphysical, exclusively vital agencies. In this they strangely deceived themselves. For, first of all, it is utterly incomprehensible how, under purely mechanical laws, a host of elementary, autonomous beings can aggregate themselves so aimfully as to form a definitely predetermined, intricately constituted organism, and can then, moreover, so systematically cooperate as conjointly to actuate its multifold interdependent functions. Here, if the cell-theory is accepted, some hyperphysical, highly intelligent and efficient agent has necessarily to be evoked as directing so prodigious an achievement. Nevermore can such intelligence and efficiency reside scattered in myriads of elementary beings. This consideration alone renders obvious the incompetency of a set of elementary beings to produce something infinitely more complex and more highly developed than themselves.

It is not difficult to show that in still other respects the cell-theory, as a true and consistent interpretation of vital phenomena, is untenable, and in its logical consequences self-destructive. It is an essential tenet of the cell-theory that the cell is an elementary organism which multiplies by self-division. It should then, like all other organisms, propagate its own kind, dividing into two equally constituted organisms. The two daughter-cells, or elementary organisms, which result from self-division, have as lineal descendants to be faithful reproductions of the parent cell. In organic propagation like produces like throughout the entire scale of living beings, as also seen in the fissiparous division of so-called unicellular organisms.

In outright contradiction to the general law of generation, and to the essential tenet of the cell-theory, we find the germ-cell, which is emphatically declared to be a genuine cell, and therefore an elementary organism; we find it contrary to all theoretical expectations, and to all genuine organic propagation, producing by means of self-division a progeny differing altogether from itself. For, what remotest resemblance has, for instance, a muscle or a nerve-cell to the original parental germ-cell, of which they are said to be the lineal offspring? It is obvious that no mechanical, no purely physical explanation can account for an elementary germ-cell giving birth in successive generations to other kinds of highly differentiated and developed cells, or elementary organism.

Moreover, no application of atomo-mechanical principles to the self-division of so-called cells can render this eminently vital process in the least intelligible. For, even if in accordance with Haeckel, Nägeli, and others, the cell was really and simply composed of a group of equal vital molecules, the multiplication of such molecules, which must in this case necessarily preclude the self-division of the cell, remains mechanically inconceivable. Vital molecules can not possibly originate mechanically. And if the cell is regarded with Bruecke and most biologists of the present day, not as an aggregate of equal molecules, but as throughout an organized being, it becomes then quite as inconceivable how an organism can mechanically divide into two equal parts, each part consisting of the same differentiated structure. Surely, it is mechanically unintelligible how, for example, the highly differentiated substance of an infusorium can so divide that each half will consist, as it actually does, of exactly the same differentiated structure. This vital mode of division, this organized duplication of living beings, surpasses incommensurably anything that purely mechanical activity can possibly accomplish.

Reverting now, as of utmost importance to biological interpretation, to the multifold generative potentialities enclosed in the reproductive germ-cell, we have in explanation of them a number of ingenious theories advanced by our foremost biologists. These theories are mostly conceived in keeping with the cell-theory. The germ-cell is thus regarded as having been originally a simple cell or elementary organism, whose substance or content has in the course of phyletic evolution become differentiated and developed, so as now to consist of separate and diverse germs for every different kind of cells to be evolved in the course of ontogenetic evolution.

Darwin's pangenic gemmules, Haeckel's memory-endowed plastidules, Nägeli's clustering micellae, De Vries' intercellular pangenes, Weismann's germ-plasm biophores, and a number of other hypothetical vital units are assumed by different investigators, in order to explain the inherited store of generative potentialities contained in the germ-cell, and to explain also the successively differentiated progeny evolved therefrom during ontogenetic reproduction.

On other occasions, and also in a former paper read before this Academy, I have at length exposed the untenability of such molecular theories. Here I will only mention the fatal flaw lurking in their very inception. It is clear, that, if the germ-cell or the germ-plasm consists really of a cluster of distinct and disparate vital units, the evolution of the adult organism can take place only by a stupendous proliferation of the hypothetical vital units. Conceived as extremely minute, far beyond microscopical visibility, they have by means of proliferation to build up the comparatively enormous bulk of adult organisms. But in what way are they believed to multiply at such a prodigious rate?

Spencer's physiological units, Haeckel's plastidules, Nägeli's micellae are held to originate by spontaneous generation out of nutritive material. [By the by, a strange assumption, this spontaneous generation of vital units on the part of leading evolutionists!] Darwin's gemmules, De Vries' pangenes, Weismann's biophores, on the other hand, are declared to propagate by means of self-division. [Now it is an obvious fact, that all these different kinds of vital molecules have been expressly invented, mainly in order to account for the very same mysterious process of propagation, which in their case is tacitly taken for granted at so prodigious a rate. To explain the vital mystery of visible propagation, this great mystery of the production of offspring from parent organisms has here been merely shifted, wholly unsolved, into hypothetical invisibility. We ask for an explanation of the procreation of vital beings, and receive as answer, that it inheres as an original property in the vital units of which they are composed. Helmholtz somewhere remarks, that the assumption of atoms will yield no knowledge of anything with which they have not been themselves hypothetically endowed. In the same way, assumed vital units, in order plausibly to explain real vital efficiencies, have themselves to be hypothetically endowed with these very same efficiencies; which means in plain language that biologists are practicing here a delusive trick upon themselves.

Furthermore, molecular theories are evidently destructive of the cell-theory, from which they confidently started. For cells composed of a cluster of autonomous, self-dividing or otherwise multiplying vital units, as all cells are supposed to be according to molecular theories, such collective cells can no longer be regarded as being themselves autonomous organic beings, capable of propagating as such their own kind by means of self-division, as they ought to in accordance with the tenets of the cell-theory. It is in this case the separate units that propagate, not the cells.

Nowise can theories working with elementary vital units cast any steadfast light on vital phenomena. Rightly to explain the propagation of living beings, be they vital units or complex organisms, it has first to be shown by what means protoplasm, of which they all consist, manages to be alive, to be in fact, a living substance; how it is able to assimilate and vitalize nutritive material; how it comes to grow thereby from a morphologically undifferentiated tiny germ to highly differentiated and organized adult stature; and how it eventually produces new germs capable of repeating the vital process of reproduction. These fundamental problems have first to be solved before biology as a science of vital phenomena can be said to be erected on a sound basis. And I venture to predict that before long a satisfactory solution will be found for all these hitherto occult problems.

In order to accomplish this task the organic individual has, above all, to be recognized as forming one single indiscerptible whole, and not—as hitherto assumed—as consisting of a vast assemblage of other elementary beings. And then, the purely mechanical interpretation of vital phenomena, which is still attempted, will have to give way to what may rightly be called Neovitalism; a vitalism, namely, which does not, like the old vitalism, invoke as actuating agent the intervention of some *Deus ex machina;* but a vitalism which positively demonstrates the inherent activity of agencies specifically operative in the production of vital phenomena.

As regards the first of these desiderata, the recognition, namely, of the unity of the organic individual, speedy headway has lately been made in this direction. Leading botanists have actually or virtually forsaken the cell-theory in favor of organic unity. Strasburger, in an inaugural address delivered 1891, as Rector of the University of Bonn, says: "Until recently it was accepted that there existed no communication between the plasms of plant-cells. It had to be asked, how, under such conditions, is the co-operation of the sundry cells in the service of the organism as a whole at all possible, and how can the plant, as a unitary being, be thus formed? The problem found its solution in the discovery that the plasm of the different cells is connected by protoplasmic filaments. These traverse from cell to cell, and cause thus the living substance of a plant to be continuous. The plant, therefore, like the animal, constitutes a unitary, living organism." Pfeffer in his work, "Die Entwinklung," 1895, recognizes, that "all cells form equally participating parts of the whole continuous protoplasmic body." And Professor Vines, in his address as president of the botanical section of the British Association, 1900, declares that "the general continuity of the protoplasm of cellular plants has been established. Hence the body is no longer regarded as an aggregate of cells, but as a more or less septated map of protoplasm."

These are unequivocal dismissals of the cell-theory on the part of prominent botanists. This eminently plausible theory, grounded on actual appearances and sociological analogies, has hitherto completely dominated biological science, and has led astray the most acute and skillful investigators. Considering that it first originated with the botanist Schleiden, its rejection now in the botanical field, as no longer applicable to plants, may be considered a hopeful sign that the unity of the animal organism will also soon be scientifically established. Indeed, among zoologists there are already many signs that a transition is being effected from the view which regards the organism as an aggregation of a multiplicity of vital units, to that which recognizes its essential unity. The results of experimental ontogeny, and of experimental regeneration, leave, in fact, no doubt that the organism is an indiscerptible whole, and by no means an assemblage of aggregating and co-operating elementary lives.

In 1888 Roux killed one of the two blastomeres, or "cells," into which the egg first divides on its course towards ontogenetic reproduction, and the result—confirmed by a number of competent observers—was, that a complete half-embryo evolved from the uninjured blastomere. This fact alone suffices to overthrow the cell-theory. For, according to this theory, the two blastomeres resulting from the self-division of the germ-cell, as a mother-cell, should be each an autonomous self-rounded daughter-cell, in every respect equal to one another, and equal also to the mother-cell. Instead of this, they are found to be two complemental halves of one and the same whole. The germ-cell, therefore, does not divide in order to propagate its own kind, as demanded by the cell-theory. But it divides in order to evolve symmetrically the two halves of the one organism which is being ontogenetically reproduced. And all subsequent divisions or segmentations of the egg are likewise no genuine cell-divisions; but divisions which are all participating as complemental parts in the structural differentiation and development of one and the same organic individual.

The germ-cell itself, far from being essentially an elementary organism, such as a genuine cell ought to be, is, on the contrary, embodying in potential concentration all the results of phyletic elaboration. Its visible divisions signify, not any kind of propagation, but the actuation and unfolding of definite potentialities, within which all ensuing structural evolution is strictly predetermined. In its minutest details the adult organism is potentially predetermined in the egg-plasm.

It is not far-fetched to regard ontogenetic reproduction as a normally established case of regeneration. Lillie found that a piece of the highly differentiated infusorium,—Stentor,—measuring only the one twenty-seventh part of the volume of the entire individual, is still capable of fully regenerating its highly differentiated form. Boveri succeeded in evolving fully formed plutei from pieces of the egg of echinodermata measuring only one-twentieth of its volume. And Morgan observed that pieces less than one-fortieth of its volume can still produce gastrulae. Consequently, when even small fragments of egg-plasm have power to reproduce or regenerate the entire form and structure of the embryo, it is obvious that essentially the same reproductive or regenerative process enables the egg itself to evolve normally the embryo, and eventually the adult organism.

Eugen Schulz, who has carefully investigated many phenomena of regeneration, does not hesitate to conclude, that "regeneration is a primary property of living beings," and that "upon the original capacity of regeneration depends the evolution of the embryo." In this light ontogenetic evolution consists in the reproduction or regeneration of the adult organism from a fragment of its substance. And this fragment represents, therefore, potentially the future or prospective organism as a whole. The regeneration of the organism as a whole is what is aimed at from the very beginning in ontogenetic evolution. Pflueger's experiments with the eggs of frogs, an account of which he published in his Archive as early as 1883, involved logically the same conclusion. And in consequence of it Otto Hertwig and others had to admit that the whole exerts somehow an influence upon the evolution of its parts, Driesch concluded from his admirable researches in experimental ontogeny, that,—stated in his own words,—"not only as regards form, but also functionally is the adult organism structurally reproduced from the egg as a unitary whole." And that the construction of the whole "is the clearly recognized goal of the entire process of development." The main drift of Morgan's excellent work on "Regeneration" leads to the same conclusion. He finds "that the organism is not the sum total of the action and interaction of its cells, but has a structure of its own independent of the cells."

Johannes Reinke, when he declares that dead protoplasm is no longer real protoplasm; no more so than a watch ground to powder continues to be a watch, he thereby acknowledges the protoplasmic individual to be an indiscerptibly organized whole. And as all organism are protoplasmic individuals, they are therewith all indiscerptible wholes. Every biologist, moreover, who admits that the so-called cells of the organism are directly or indirectly connected with one another by protoplasmic bridges, virtually acknowledges the unity of the substance composing the organism.

The result of ontogenetic experiments performed by foremost biologists forces upon them the recognition of the unity of the organic individual. And considering all more or less positive acknowledgments of such unity now current, it is not too much to say, in the words of Professor Vines: "Hence the body can no longer be regarded as an aggregate of cells," which means that the organic individual is not an assemblage of elementary units, but is itself one single unitary being.

The recognition of the unity of the organic individual necessarily leads to the rejection of the purely mechanical interpretation of vital phenomena in favor of Neovitalism. Neovitalism discovers in vital phenomena specific hypermechanical modes of activity. It finds that vital phenomena are actuated by agencies exclusively belonging to themselves, and transcending mechanical modes of operation. There exists—as Driesch expresses it—an "autonomy of vital phenomena." The agencies known to be operative in inorganic nature prove to be incompetent to produce what occurs in organic nature.

Johannes Reinke admits that the question of Vitalism versus Mechanism is at present one of the most pressing in biology. Bütschli, himself a confirmed mechanist, concedes that "the complexly organized form of living beings originates in a manner which has no analogy in inorganic nature." A number of pamphlets have lately been written on this highly important question. Albrecht, in his "Vorfragen der Biologie," says: "All vital hypotheses mentioned testify by their mere existence, that beyond the physico-chemical analysis there must be problems, uncertainties, which we feel without being able to express them in current mechanical terms." He continues: "It seems to me that in all these vitalistic attempts a hitherto unsolved question is making itself more or less distinctly apprehended; a question which in its full import does not occur, and can not occur to rigorous mechanists; which, however, perhaps constitutes the essential ground and real object of the contention. *I mean the problem of the living Form.*"

It is, indeed, as Albrecht suggests, the problem of the evolution of the unitary living form, with all its structural differentiations that above all other questions can not be mechanically solved. The definite structural formation of an organism, even from a mere fragment of egg-plasm, and in every case with strictly specific localization of its sundry constituent parts or organs; this wonderful vital fact is what upset Driesch's confidence in mere mechanical modes of actuation, and drove him into the Neovitalistic camp. Many vain attempts are made to refute his irrefutable conclusion. Johannes Reinke, for instance, believes that recourse to vitalistic assumptions is uncalled for. Yet his own "Domenenton" theory, which he takes to be purely mechanistic, involves a vitalistic assumption surpassing all that Neovitalism claims. He rightly ascribes to the structure of the organism a force or influence directing the specific outcome of its vital manifestations. He holds, however, the organic mechanism to be the embodiment of an unconscious psychical activity, akin to instinct, which must then be the real agency dominating the direction of the working energies of the organic machine. This assumption of a psychical agency directing psychical movement or mechanical effects is evidently Vitalism of the ancient kind, and as such eminently hypermechanical. The relation of psychical influences to mechanical movements is, however, an epistemological and hardly a biological question, unless biology be defined as including also psychical manifestations.

It is an essential characteristic of Neovitalism to refrain from having recourse to other agencies than those belonging to the organism itself. Neovitalism is, however, for all that, well aware that the most fundamental of all questions is that of the true relation of psychical to physical phenomena. And it is aware also that vital phenomena are only symbolically revealed to our consciousness, principally through our organ of vision.

But, regardless of such transcendental considerations, it certainly remains mechanically inexplicable how a mere fragment of egg-plasm, taken from whatever part of it, can have power to regenerate the complex specific form and structure of the embryo. By force of this fact alone Neovitalism is justified.

Perhaps I may now be allowed to state, that my own protoplasmic researches, the principal results of which were published twenty-five years ago, led me positively and clearly to recognize the unity of the organic individual, together with its ontogenetic reproduction or regeneration from fragments of its substance; and also most emphatically the necessity of breaking with the purely mechanical interpretation of vital phenomena, by introducing what would now be called neovitalistic principles. This hypermechanical, neovitalistic view I expressed perhaps more tersely than on other occasions in a paper on muscular contraction published in 1881 in Pflüger's Archive. There I said: "The power of regeneration is in all cases the mechanically unaccountable energy of protoplasm to chemically reintegrate itself. Consequently its actuating energies, and even the mechanical capacity for work on the part of animal organisms, transcends the application of exact physical methods. We have here before us, as source of energy, an explosive substance which is ever restituting itself, and whose power of reintegration, grounded in endless phyletic elaboration, stands therefore in no direct relation to its environment. Neither the complemental restitution, nor the effects of stimulation are here mechanically transparent. They are, on the contrary, to be looked upon as processes in sharp contrast to modes of mechanical energy—concatenations." At that time the introduction in the explanation of natural phenomena of other than purely mechanical modes of energy, and especially the introduction of hypermechanical vitalistic modes, was considered scientific heresy, not meriting serious attention. Now, principally through the influence of Ernst Mach, nonmechanical modes of energy are admitted as operative even in the inorganic world.

The intrinsic power of the protoplasmic individual to reintegrate its identity as a whole, when externally encroached upon, is evidently the real formative efficiency in the functional life of organic beings, and in their regeneration from fragments of their substance. The organic individual is, in fact, a wondrously complex chemical whole, whose smallest portions are integrant, and nowise mere aggregated parts. And its identity as a whole can be maintained only by means of complete chemical reintegration, following whatever deterioration it may suffer, normal or abnormal, functional or otherwise. Without this constant complemental restoration of our organic identity, all would be for us senseless incoherency in the surrounding world, and we ourselves raving maniacs.

The living substance, of which all organisms consist, is in a philosophical sense the only real substance in our world, for it alone renders possible that a body can undergo changes, and display sundry active manifestations, properties, or attributes and yet remain identical. This identity under change is logically incomprehensible, and constitutes the most profound philosophical puzzle.

The power of functional integration, or so-called regeneration, on the part of living beings constitutes evidently a mode of energy not operative in inorganic nature. It is evidenced as such by the peculiar work it is performing, the work of functionally reintegrating the form and structure of organic individuals. It may, therefore, safely be looked upon as a vital and formative energy, without losing its character as essentially a chemical process.

If we now further ask what really constitutes the nature of chemical composition, we have to confess that this question transcends at present the limits of our knowledge. Suffice it to say, that, whatever theory we may form regarding the nature of so-called matter, chemical composition is clearly recognized as a mode of visible existence differing essentially from mere physical aggregation. It forms an integrant unit, in which all component elements are interdependently bound together by what is figuratively called chemical affinity. And it is certain that the specific modes of reaction of chemical compounds, which in the living substance display the wonderful qualitative manifestation that constitute its essential characteristics; it is certain that these characteristic modes of reaction are eminently hypermechanical.

Finally, a few more words regarding the unity of the organic individual. On the strength of my protoplasmic researches I have defended it, at first, single-handed against accepted aggregational theories. And I rejoice that foremost investigators are now reaching the same conclusion on different lines of research. In various publications, and also in articles which appeared in "Mind," 1880, which articles I expressly entitled "The Unity of the Organic Individual," I have fully expounded this neovitalistic view. And I have also in the same articles explained the vital phenomena of assimilation, growth, and reproduction as resulting from the power of living beings to regenerate themselves from fragments of this substance. In evidence of it, I beg leave to quote a few sentences: "Whoever has watched the division of highly differentiated infusoria with its exact duplication of every slightest detail of the complex organization ought to be aware that something very different from mere overgrowth is here conspicuously in operation. The upper half of the dividing animalcule has to reconstruct a lower half, and the lower half has to reconstruct an upper half. Evidently the same influence is here normally at work that repairs an organism when by accident it has lost one of its halves; and growth itself can mean essentially nothing but repair or reconstruction of the generical type from some fraction of an individual." Any portions of the unitary protoplasm of an organic individual, and especially its so-called germs, have to be considered in the strictest sense of the term, chemical radicals. Remove from a chemical compound a part of its integrant atoms; it is then no longer saturated, but represents a chemically disequilibrated residue with combining powers corresponding to the several atoms. Whenever occasion offers the radical will become resaturated; it will, in fact, restitute itself, will restore the integrity of the compound which it radically represents. Surely, this admitted chemical occurrence is that which underlies the vital phenomena of growth, repair, and reproduction." And I added: "To contradistinguish the theory of organization here briefly expounded from the prevailing cell-theory, I call it the Theory of Specification,—specification of one single protoplasmic unit, not association of a number of elementary organisms."

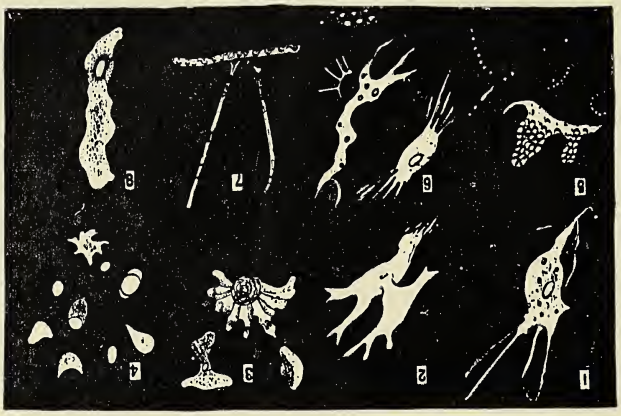
I think it will be admitted that, at that early date I had, on the strength of my long continued protoplasmic researches, clearly recognized what is now being confirmed by experimental ontogeny and experimental regeneration.

To those who are not themselves scientists it may seem of little general and practical consequence whether or not we are scientifically found to consist of an assemblage of inferior beings, and whether we are or are not really composed of inert atoms mechanically moved. But it would not be difficult to prove that the fate of whole philosophies is pending on the decision. Indeed, progress in the interpretation of natural phenomena underlies all other progress. History abundantly sustains this assertion. The three great scientific generalizations of last century: the conservation of energy; the progressive evolution of living beings; and the co-naturalness of all heavenly bodies revealed by spectrum analysis; these comprehensive scientific generalizations have been, and are still, remoulding our entire view of things. And it might, for instance, be shown that to the scientific work of Newton, Boyle, and other 17th century natural philosophers we owe the religious and political freedom we are now enjoying. For Locke, who first effectively urged religious tolerances and who promulgated the sovereignty of the people in opposition to the alleged divine right of kings, was immediately and essentially influenced in his way of thinking by the study of natural science in accordance with what has been called the Newtonian and also the empirical method. It was principally this scientific method which guided the widely liberating thought of the 18th century. Rousseau, a foremost expounder of this thought, received the impulse to his reformatory mission directly from the study of Locke. And it was Rousseau's kindling influence which inspired Thomas Jefferson to write the glorious Declaration of Independence.

In fact, progress in all directions, and not merely in what is called natural science, is effected by gaining a more and more correct interpretation of natural phenomena, and by overcoming thereby more and more efficiently erroneous conceptions of the universe and our life therein.

PSEUDO-ORGANIC STRUCTURES OF COLLOIDAL SILICATES.

A. L. HERRERA,
Chief of the Commission of Parasitology, Mexico.



(AFTER MICRO PHOTOGRAPHS.)

1. Silicate of sodium and ether. 2 and 4. The same. 3. Silicate of sodium and aluminium sulphate. 5 and 6. Silicate and alcohol. 7. Silicate of sodium and sulphate of aluminium Potass. 8. Silicate and salt.

While analyzing the reagents which are generally used for the imitation of the protoplasma (as phosphates, tannates, oleates, ferrocyanides), I have found traces of silicates, and I have continued the study begun by Moniez and Vogt. The results are quite noteworthy; but I shall limit myself to the summary thereof after stating that photographs have been taken of most of the structures and that I remit herewith several direct microphotographs. I have operated with strongly antiseptic liquids,[1] containing an excess of alkali, whereon never appeared any mould, bacteria, or any incidental organism.

The silicate of sodium, or potassium, was treated with the following

[1]The sirupy silicate of sodium and potassium always contain a large surplus of alkali.

reagents: Chloride of lime, chloride of alumina, alcohol of 0.850, common ether, chloride of ammonium, sulphate or nitrate of alumina, salt.

According to the proportions and the way of forming the silicates, the following structures were obtained: Vesicles, tubes, filaments, granules; an imitation of the *amœba coli, amœba proteus, streptococcus,* myceliums of fungus, vacuoles, nucleus, radiolaria with very fine pseudopodia, concentric layers, amœboid motions, direct division through strangling, radiations as of attractive spheres, large refractive nucleus, plasmodiums, protoplasmatic and granulated strings.

The most interesting structures are those formed by alcohol and ether, as they present transparent *amœbæ* with vacuoles, exactly like the *amœba coli,* but dissolvable in water, or colonies of microbes, also dissolvable.

It seems that the difference in the action of the reagents is due to the rapidity of their diffusion in the alkaline-sirupy silicate. The ether is, in fact, very quickly diffused and produces very fine and pretty structures; salts, on the contrary, produce coarser structures which grow hard and are not dissolvable in water.

As silicates exist in the whole of nature (egg, utero gravido, pancreas, seeds, etc.), and as the colloidal silica and the clay have very curious absorbent properties, and combine with innumerable bodies,[2] I have asked myself whether they might not be the cement of the protoplasma as well as of the majority of the minerals. But this subject is not as yet well known, and therefore I intend to pursue its study.

[2]Joly and Curie—Encyclopédie chimique de Frémie, t-II., p. 113. J. Thoulet —Les dépôts sous-marins. Revue scientifique (3 juillet, 1892). Dana—A System of Mineralogy, p. 188.

Hugo Schulz, *Ueber den Kieselsaeuregehalt menschlicher und tierischer Gewebe.* Die Kieselsäurebestimmungen lieferten folgende Resultate:

	Mittlerer SiO_2-Gehalt der Asche in Prozenten.	SiO_2-Gehalt in 1 kg. Trockensubstanz.	Gesamtmittel der SiO_2-Werte der Aschen in Prozenten.	Gesamtmittel der SiO_2-Werte in 1 kg. Trockensubstanz.	
Fleisch	0,0346	0,0182			Tierische Gewebe.
Fleisch	0.0510	0,0257			
Fleisch	0.0545	0,0213	0,0826	0,0423	
Fleisch	0,1042	0,0578			
Fleisch	0,1688	0,0885			
Aorta	0,2846	0,0987	0,2846	0,0987	
Sehnen (Kalb)	0,2292	0,0730			
Sehnen (Rind)	0,5682	0,1155	0,4864	0,1086	
Sehnen (Rind)	0,6617	0,1374			
Bulbuskapsel	0,2644	0,1412	0,2373	0,1141	
Bulbuskapsel	0,2102	0,0871			
Milzpulpa	0,1847	0,1632	0,1651	0,1495	
Milzpulpa	0.1429	0,1358			
Milzkapsel	0,4168	0,2038	0,4556	0,1879	
Milzkapsel	0,4944	0.1720			
Glaskörper	0,1762	0,5805	0,1593	0,5814	
Glaskörper	0,1424	0.5824			
Muskel	0,0422	0,0191			Menschliche Gewebe.
Muskel	0,0558	0,0257	0,0531	0,0239	
Muskel	0,0612	0,0270			
Haut	0,1090	0,0385	0.1484	0,0447	
Haut	0,1878	0,0510			
Sehne	0,1051	0,0408			
Sehne	0,4249	0,0865	0,3385	0,0637	
Sehne	0,4856	....			
Dura mater	0,3361	0,0870	0,3361	0,0870	
Fascie	0,2462	0,1064	0,2462	0,1064	

Der Kieselsäuregehalt in den einzelnen Organen ist direkt von ihrem Bindegewebesgehalt abhängig.

Ferner wurden gefunden: Für 1 l Eiter 0,0046 g, bezw. 0,0039 g SiO_2. Der Inhalt zweier Ovarialcysten gab 12,1257 Prozent, bezw. 29,6275 Prozent Asche; dieselbe enthielt 0,0314 Prozent, bezw. 0,0306 Prozent SiO_2. Glutin gab 1,4760 Prozent Asche mit 1,5397 Prozent SiO_2, so dass 1 kg. Trockensubstanz 0,2272 g SiO_2 enthielt. (Pflüger's Arch. 84. 67—100. Greifswald. Pharmakol. Inst. der Univ.) —SIEGFRIED.—Chem. Cent. Bl. 1901, Bd. I.

PROCEEDINGS

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FOR 1903.

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PAPERS PRESENTED AT REGULAR MEETINGS.

MARCH 14, 1903.

"Some Wholesome Educational Statistics," W. S. Sutton, M. A., Professor of the Science and Art of Education in the University of Texas.

"Steel Making," E. C. H. Bantel, C. E., Instructor in Civil Engineering in the University of Texas.

APRIL 17, 1903.

"Mechanical Interlocking Devices at Railroad Crossings," R. A. Thompson, C. E., Chief Engineer of the Railroad Commission of Texas.

"The Effect of Carbon Upon Steel," Eugene P. Schoch, Ph. D., Instructor in Chemistry in the University of Texas.

FORMAL MEETING, JUNE 10, 1903.

"The Ideal History of Experiments on the Regular Pentagon," Dr. H. Y. Benedict, Associate Professor of Mathematics and Astronomy in the University of Texas.

"Two New Lecture Experiments in Physical Chemistry," Eugene P. Schoch, Ph. D., Instructor in Chemistry in the University of Texas.

"The Northwest Boundary of Texas," Thos. U. Taylor, C. E., Professor of Civil Engineering in the University of Texas.

"A New Texan *Kœnenia*" (by title), Augusta Rucker, M. A., Instructor in Zoology in the University of Texas.

"The Vegetation of the Sotol Country (an Ecological Study)," William L. Bray, Ph., D., Associate Professor of Botany in the University of Texas.

"Some Recent Discoveries Concerning the So-called Ant 'Mushroom Gardens'" (by title), A. M. Ferguson, M. S., Instructor in Botany in the University of Texas.

"Notes on the Topography of Texas" (by title), Frederic W. Simonds, Ph. D.

OCTOBER 23, 1903.

"Neovitalism," Annual Address by the President, Edmund Montgomery, Ph. D.

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FOR 1904

TOGETHER WITH THE PROCEEDINGS
FOR THE SAME YEAR

VOLUME VII.

AUSTIN, TEXAS, U. S. A.
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CONTENTS.

THE TEXAS ACADEMY OF SCIENCE.

[ANNUAL ADDRESS BY THE PRESIDENT.]

THE SOCIAL SCIENCES.

DR. MILTON BROCKETT PORTER.*

We often hear it said, nowadays, especially by those that confuse the applications of science with science itself, that the dominant ideal of the modern world is scientific rather than esthetic or ethical.

The varied and brilliant applications of scientific theories to questions concerning the physical well-being of man has bred in some quarters a certain self-complacent philistinism which pronounces nothing worth while which is not practical, with the implicaton, of course, that only those things are practical which concern physical needs and satisfactions.

These people often speak of what they call applied science with the bated breath of unintelligent admiration, the names of financially successful inventors are often on their lips, while of the artists whose imaginations created the splendid theories which made these inventions possible they have never even heard. Thousands know the names of Edison, Bell, and Tesla who never heard of Faraday or Maxwell. Nay, since the exploiter of the applications of scientific theories brings the good things within the reach of the consumer, it not infrequently happens that the latter thinks the blessings due solely to the financier that supplied the funds, on the same principle doubtless that the waiter and not the cook usually gets the tip!

The reason for all this is fairly plain; the appreciation of the intrinsic beauties of a scientific theory is the reward of those that cultivate the science, while a recognition of the bearing and importance of scientific theories on social progress could only be expected of those who have intelligently read the lessons of the past.

As a matter of fact the essence of the latter day scientific ideal has been a matter of slow development. No doubt in the beginning, when men lived in caves, the accident of some blind experiment may have led

*Professor of Mathematics, University of Texas.

to the discovery of a way to smelt iron, but the history of the past shows that few things are found in this way, the cultivation of socalled theoretic science must be an end in itself. The alchemists succeeded in prov-science was possible if the end be gain and not increase of knowledge. The history of today reinforces the lesson. Germany owes her manufacturing supremacy in greatest measure to her universities; there the theories which are her source of wealth and power were elaborated without any thought of how they might be applied.

The sciences which have contributed most largely in the past to the comfort and pleasures of man have been what from most points of view must be called the simpler sciences. Of these Geometry and Mechanics are the oldest and have made such progress that they already admit of an aritmetic formulation. By this is meant that the fundamental concepts of these sciences admit of such a characterization that they may be manipulated by the condensed algorith of mathematics; so that the diffuse description of ordinary language is replaced by a terse symbolism or shorthand which mechanically, so to speak, puts in evidence relationships not otherwise easily discernable. This was done for space thousands of years ago by men whose names even we are ignorant of; for force, by Archimedes, Galileo, and Newton; for light, heat, and electricity and the varied forms of energy, by a great galaxy of men that belong to the last two centuries. So great has been the progress along these lines that modern physics is largely a matter of differential equations, and whether we call the theory corpuscular, undulatory or electromagnetic, these differential equations remain the same, and the names of the theories merely serve to indicate the discovery of new and hitherto unnoticed relationships.

It was the brillant successes of physical science, no doubt, that led some enthusiasts to dream of an arithmetization of all science, and even of doing this with no other fundamental elements than matter and energy. While the dreams of these enthusiasts were doomed to disappointment and a dynamic explanation of psychic and social processes is no longer demanded, it is still believed that even the facts of consciousness and social development admit and demand an explanation in terms of a limited number of fundamental and social activities. And it is this demand that has given rise to a multitude of social sciences—the Science of Society, of History, of Economics, of Religion, and others too numerous to mention. It is clear that we are here considering the many aspects of a single thing—the varied activities of man as an individual and as a social being, and the question presents itself, in what sense can our study of such complex phenomena be properly characterized as *scientific?*

Now the highest attribute, the distinguishing feature, of a science is its ability to predict from the certain known data what will come about in the future. This gift of prophecy the physical sciences undoubtedly possess. Where a given planet will be fifty years hence can be calculated with accuracy; what reaction will take place when we mix certain substances can be determined; we traffic in electricity and measure it as accurately as any material commodity—all these sciences have reached the mathematical stage, and the yardstick, chronometer, and balance can be used to measure all the determining elements. Certain forms of zoology even are making strenuous efforts to take on this phase of mathematical exactitude. But when we come to the human individual with his limitless capacity for folly or wisdom, or, granted that he is the slave of his environment, when we consider the almost limitless complexity of the elements that determine his choice in any particular juncture, we stand appalled at the difficulty of the question before us. If we assume that society as the totality of individuals is equal to the sum of its parts, we are impotent before the complexity of the single element.

How shall we integrate elements so heterogeneous? so obscurely complex and intricate? When we consider, moreover, the comparative simplicity of the problems of the chemist and phycist, how insoluble still appear most of the enigmas presented for their consideration, how complicated the explanation of even the activities implying merely matter and energy are becoming with our widening horizon, the mere possibility of a science of society in the exact sense, dealing is it does with materials infinitely more complex, becomes a matter of serious doubt. It is not a question of framing a mere general hypothesis; it is a very different thing to say that the protoplastic slime of forgotten centuries has developed under purely natural laws into the varied forms of life that we now know, and to say that we can intelligently account for all these changes and formulate their laws. On the other hand no one is so optimistic as to hope for a solution of the problems thus proposed. The division into separate sciences is a tacit confession that no such solution is expected, and may be regarded as an attempt to simplify the problem by considering only certain aspects of one too general; but even these separate sciences, though they contemplate only a survey of a limited field of the problem, have to face the same fundamental difficulties. It is for these reasons that I think we must admit that starting with the individual human atom, even though he may epitomize in his own proper person all the past and future of his race, we can arrive at no effective theory as to the past or future structure of human society.

The question then arises as to what hypotheses will prove useful in describing the phenomena, often simple enough, which the history of the past and the observation of the present stage of our social development bring before us.

The only refuge in such a juncture seems to be in the apparently paradoxical assumption that social organisms, though consisting of such marvelously complex elements, are yet subject to many laws that admit of a comparatively simple and therefore intelligible statement. Unless, indeed, this be so we can never hope to have a science dealing with even partial phases of social development.

That such an hypothesis is not really paradoxical, is, I think, largely in the nature of an assumption or axiom by which is merely meant a general principle conditioning all other hypotheses, and one which is suggested by our experience. That the paradox is only apparent and to clarify our notions we may borrow a familiar illustration from the kinetic theory of gases. According to this theory a gas is to be regarded as consisting of a large number of molecules flying about at comparatively high rates of speed in every direction, impinging on each other and on the sides of the vessel in which the gas is contained. Now, while we have here a highly complicated state of things looked at from the standpoint of the individual molecule, and one of which it might at first glance seem impossible to predicate any very simple laws, yet it is found that for a given temperature the pressure of this gas is proportional to the space it occupies; such a gas has other properties capable of equally simple expression. We have here what may be called a statistical effect, where many complex agencies combine to produce an effect which may be formulated in a simple law. A large and important part of modern physics and physical chemistry has to do with statistical effects of this sort which admit of simple and easy description. It is not, of course, claimed that these physical laws are perfectly exact. Even if they were we could never find it out, for all our measurement of verification are only accurate to within the limits of instrumental errors.

Now the thesis I wish to maintain is precisely this: that the problem we are considering, demands for its successful treatment not only a development of the theory of statistics, but a suitable formulation of the fundamental elements or co-ordinates which characterize a given phase of the changing organism.

The difficulties in the way of such a formulation are unquestionably great, but already the progress in the domain of vital statistics is considerable, and the economists have made no small progress in applying these methods to the mechanism of exchange and the theory of values. It would not be going too far to say that the essence of the modern historical method is statistical; an attempt is made to determine racial or national tendencies by a method of weighted averages. The great difficulty being the determination of the proper weight to assign to any particular fact or group of facts. It is precisely at such points as these that the mathematical theory would be of most service. Moreover, that statistics can be interpreted to indicate large tendencies in the development of society has long been known, and aside from the difficulty, often impossibility, of getting reliable statistics, it has been clearly realized that incautious inferences from such data may be exceedingly misleading.

Furthermore, it must always be borne in mind that, as to the character of the inferences we are to draw from our statistical data, they must be in the nature of an evaluation of probabilities, and that individual events or facts are in the main trivial. For example, I throw a die; each individual throw may be any one of the six faces, but if I continue to throw the die, what will be observed is that in the long run—if the die is not "loaded"—any particular face, as for example, the ace, will be thrown one-sixth of the time. What, then, must be the attitude of the historian towards particular events as marking a tendency or as diagnostic of healthy or degenerative change? We are here dealing with a case of loaded dice; if we consider such facts, disentangled from their emotional setting, removed from the perspective, under which they presented themselves to the national consciousness, they cease to be the living tissue from which the social organism is built up and it is here that we come upon the main difficulty of the statistical study of social phenomena.

It is indeed doubtful whether we can ever come to know or adequately picture to ourselves the emotional attitude of even contemporaneous peoples who have been nurtured under widely different traditions from our own. We are often astonished and perplexed by their ways of looking at things—the emotional halo, roseate or sombre, through which they see life. The difficulty does not, of course, end here. We meet it with our fellows nurtured under conditions so similar to our own.

In considering social tendencies, therefore, we have not only the difficulty of dealing with peoples alien in time and perhaps race, but we have another difficulty which seems to me greater than all the others—namely, what may be called the national personality, the composite of all the personalities of the people, or as we might call it the statistical personality.

Now it would seem that any attempt to arrive by introspection at a realization of what this civic or national counsciousness is like, is out of the question. Of how small a part of our own brain activity are we really conscious? In the case of an aggregation of individuals constituting a society, coöperating in innumerable ways, dominant popular ideals can hardly be identical with the diverse motives of its constituent elements.

Thus it would seem probable that the ideal of a people, the statistical consciousness of a race, that complex of characteristics which goes to differentiate one civilization from another, just as that indescribable thing character distinguishes one man from another, may be, must be, a very different thing from the individual characters of the individuals that compose it.

This mighty organism which we call Man—whose breath has animated the "weary generations of men" through all the ages; in whose immortality we, though mortal, shall assuredly be deathless—this unifying spirit can be no mere magnified individual man, for thus we fall into the old anthropomorphic fallacy of the infant world. Call it what you will—Time-Spirit, Cosmic Consciousness, or what not—its thoughts are not the thoughts of individual men nor are its purposes his purposes. It is the blind attempt to characterize its manifestations that we use such words as destiny and social progress.

It is this persistent racial consciousness which unifies all the phenomena of growth and decay, which must be invoked to explain the rise and fall of every very human institution that the world has known. It is precisely this dominant spirit which eludes the individual imagination, which is the unpredictable element in social development, and which can be studied in its past manifestations, like the reefs of the coral polyp or the fossils that strew the fens of prehistoric times.

This personality of a people, while it may be a less complex thing than the personality of the individual, must be regarded as something more than an average of the conscious psychic life of its individual constituents. In a striking passage in his Diseases of the Personality, Ribot says that "It is the organism with the brain, its supreme representative, that constitutes the real personality; comprising all in itself all that we have been, and all the possibilities of all that we shall be. The whole individual character is there inscribed with its active and passive aptitudes; * * * the part thereof which emerges into consciousness is little compared with what remains buried but nevertheless operative. The conscious personality is never more than a small fraction of the psychic personality. The unity of which we are so strongly conscious is not the unity of a single entity, but the fusion of a number of different states perpetually arising within us and having for their common bond of union the vague feeling of our body."

This view of the individual personality, namely, that it is a co-ordination of many disparate elements, active and potential, the major portion of which forms no part of our psychic life, but goes on like the processes of digestion and assimilation without our being conscious of it, needs, perhaps, a little elaboration, and such elaboration is the more desirable in that it seems probable that we may call the submerged psychic life of the ındividual is in many ways closely analogous to the superconsious personality of the social organism.

Everyone present in this room realizes that there are things going on about him which make so feeble an impression on his senses of sight or hearing, or what not, that he is not conscious of them. A clock may strike and you do not hear it; objects pass through your field of vision and you do not see them. We may express this by saying that such sensations do not rise to the level of our conscious life; they lie beneath the threshold of consciousness. When we sleep few stimuli rise above this threshold. In a state of hypnotic sleep an artificial insensitiveness to all sorts of stimuli can be produced, so that we feel no pain if burned with a match or pricked with a pin. Many of the curious so-called phenomena of spiritualism are to be explained by means of this unconscious activity of the mind. The dictum of the older psychologists—that the mind never sleeps—is a partial statement of this vegetative function of the brain. Even the most complicated rational processes imply a period more or less long of unconscious incubation. Most of us like to sleep over a difficult decision; the thought processes started in our waking hours are carried on the unconscious currents of the brain; the storehouse of memory is ransacked, and the difficult decision of yesterday admits of an easy solution today. Everyone has probably had the experience of laying aside some knotty, long brooded-over problem to which no answer suggested itself, and finding after the lapse of days or years that, although so far as we could recall no attention had been paid to the matter in the meantime, it became readily answerable when we again considered it.

Deliberate experimentation on this function of the mind is difficult, but some abnormal individuals afford a striking insight into the possibilities of this sort of brain activity. Everyone has beard of the phenomenal calculating boys who perform feats of computation in a few seconds which would require hours for the most expert computer. Cases of this sort have been experimented on; these peculiar people are generally of inferior mentality, and may be even entirely ignorant of the rudiments of mathematics. The gift usually manifests itself at an early age, before there could be any question of a highly developel conscious rational process. It would be nonsense to say that these lightning calculators perform the feats they do with any conscious appreciation of the processes involved. With the disappearance of this faculty later in life no trace of it remains in the mind of the subject, nor can they describe their modes of calculation while in possession of the faculty or afterwards.

While these cases are abnormal in a sense, they show in a striking way the marvelous activities of the subconscious intellectual processes and tend to demonstrate the extraordinary effects of such processes when, through some abnormality, they are concentrated in a particular direction. Pathological examples of this sort are numerous, but I shall not weary you with more. But enough has been said, I hope, to establish the contention that probably the larger part of our mental life is unconscious, and like the nervous reflexes go on without our being conscious of them.

Thus it seems that just as, in explaining the individual personality, we must recognize a dual mental life, one part under the limelight of the consciousness, the other in the twilight or darkness of the subconscious, so it would seem we must explain, if we explain at all, the personality of social man.

The problem of our social psychologist would thus be to disentangle by statistical methods from the seeming chaos of history the ideals that underlie the sinuous advance of society and formulate them into laws which, like the laws of gravitation or thermodynamics, would make the phenomena of society as intelligibly explicable as the motions of the planets or the behavior of gases.

In possession of such laws, we might hope to know how the manifold institutions that shape human society—religious, ethical or political—came into being, and what needs of this social creature they were created to satisfy.

In an attempt to evaluate these social motives, historians of all ages have laid great stress on the activities of great men, geniuses of all types; lawgivers, religious teachers, inventors, and scientists have been taken as iconic of their environment. In all mythology we find many of these functions blended into one personage in essence historical, but often clothed in many fictitious attributes and often deified. The biografic theory of history thus rests essentially on the hypothesis that the history of a race is in the main that of its great men.

That this conception has in it a large element of truth no one will deny. As a social being man is characterized by the fact that the human organism has the power of producing from time to time as the necessities of its development may require, superior beings gifted with an insight of a far higher order than their fellows, who in themselves epitomize along certain lines the net statistical progress of the race, and whose function it is to give explicit expression to some phase of such progress in such a way as shall make it a consciously realized part of the general assets of society. From one point of view these men may be regarded as the incarnation of the dumb, unconscious cosmic self. From some points of view the mutation theory of the origin of species is the analogue of this on the physical side.

On the other hand the "special creation" theory of genius, like the special creation theory of species, seems to hardly accord with the observed facts. If we examine the history of science, for example, we find that the great discoverers have blazed out when and only when their environment had reached a proper state of preparedness—a stadium of development that makes their appearance necessary for further progress. What makes them shine like stars in their less luminous surroundings is the fact that their environment was inarticulate, blind, and uncoordinated. A Shakespeare but gives utterance to the mighty intellectual and moral forces of his race, tells it what it thinks and why it thinks thus, brings into the glare of conscious intellection the slowly wrought betterment of ages and interprets the national consciousness to itself. It is no wonder that such men are regarded as the visible incarnation of the tendencies that would otherwise have remained dumb and unseen. Racial ideals to become efficient must be made flesh and dwell with us. The history of the world's religious and ethical development is epitomized largely in her Moseses, Gautamas, Christs; the genesis of the esthetic development in her Phidiases, Rembrants, and Beethovens; and so on through the categories of science and arts.

If the life history of great men were completely representative of social progress, the theory of the social sciences would be vastly simplified. Unfortunately this does not seem to be the case: for not only are the activities of genius confined to certain limited fields of social progress, but there is always the personal equation of the individual to be disentangled from the universally significant elements, the evaluation of the abnormal or pathologic phase. That in the fullness of time criteria for making this distinction between the personal and the impersonal element in the activities of genius will be afforded by investigations of the kind we have been considering is not improbable. In any event we can be certain that the exact or predictive phase of the social sciences is conditioned on the formulation of laws governing the activities of society as a whole and not its individual elements.

OBSERVATIONS ON THE HABITS OF SOME SOLITARY WASPS OF TEXAS*

ILLUSTRATED WITH ORIGINAL PHOTOGRAPHS TAKEN IN THE FIELD

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LIST OF ILLUSTRATIONS.

OBSERVATIONS ON THE HABITS OF SOME SOLITARY WASPS OF TEXAS.

INTRODUCTION.

On morphological grounds wasps may be divided into two main groups, the Sphecina or digger-wasps, and the Vespina or true wasps, the latter of which have their wings folded in plaits when at rest. (Compare Figs. 1 and 2.) For the purpose of this paper, which is a study on habit, wasps may best be divided into the social and the solitary. This classification, based on habit, does not coincide with that based on the condition of the wings, for while the Sphecina are all solitary, the Vespina also include a large group of solitary wasps, the Eumenidae.

To render my account more complete, I shall briefly compare the habits of the social and the solitary wasps, transcribing from others.

A social community includes three castes: queens, drones, and workers. The queens alone survive the winter after mating with the drones, which, with the workers, perish of hunger and cold. In the spring the queen builds the first comb and rears the first lot of workers. These immediately take up the work of building the nest and feeding the young, while the queen devotes herself exclusively to egg-laying. Before long, many hundreds of workers are busy in the nest, and, late in the season, many queens and drones also appear, and the cycle of life is started anew.

The solitary wasps have only two sexes, the queens and the drones, and there is no division of labor, though some genera (Pelopaeus, Bembex and Microbembex) build their individual nests close together, forming colonies. There is a great diversity of habits both among the Eumenidæ and the Sphecina. In either group the nests may be made of mud and attached, for shelter, under rocks, the eaves of buildings, or the hollows of trees, or they may be attached to the stems of plants. The nest may be tubes in the stems of plants, in boards or in the ground, either found ready made, or, as is usual, newly bored or dug by the individual wasps using them.

The adult wasps live on the nectar of flowers or on animal food, namely the same insect prey which they give their offspring. This usually consists in a given species of wasps of a particular kind of insect, one capturing only caterpillars, others only spiders, flies, bugs, beetles or other insects as the case may be.

The solitary wasps mate in the spring or summer. The female alone engages in the work of rearing the family. When the egg-laying time arrives, she digs or builds a nest, secures her prey, which she either kills outright or merely paralyzes, stores it in her nest and lays her eggs among the store of provisions. In most cases, the food is carried home once for all, the nest is closed over the egg and the mother flies away and digs a nest in another place, paying no further attention to the old nest. In a few genera, the mother maintains a further connection with her offspring, feeding the growing larva from day to day until it has spun its cocoon.

The egg of a solitary wasp hatches in one to three days into a maggot-like larva, which feeds on its store of provisions and grows for two weeks or less, when it spins its cocoon and becomes a pupa. In this state it remains two or three weeks in summer before emerging as the perfect insect; or if cold weather comes on, the insect remains quiescent in the pupal state until the following spring. It is probable that no adult solitary wasp survives the winter.

The solitary wasp emerges from its cocoon in possession of all the instincts of its ancestors. It is, moreover, born into the world alone, and there is no chance for imitation of its fellows, as is the case with social bees and wasps. Wonderful as these instincts are, they are not so perfect as was supposed, for observation has shown that they are to a high degree variable, and often show remarkable adaptation to circumstances, which is called by some, intelligence. The study of the habits of animals had been too little studied to bring out the fact of variability, for it is apparent that, to detect variations, be they in morphological characters or in actions, the type of structure or the normal action of the animals must first be determined. The present paper is a contribution in this direction, as it embodies observations of some twenty-eight species of Texas solitary wasps.

The principal students of the habits of solitary wasps, in fact, the only ones that have studied them comparatively, are M. J. H. Fabre of France and Mr. G. W. and Mrs. E. G. Peckham of Milwaukee, Wis. M. Fabre has given us the results of his keen and careful observations in his interesting and delightful papers, "Souvenirs Entomologiques." The Peckhams published their equally interesting results with sound deductions on the instincts of animals in "Observations on the Instincts and Habits of Solitary Wasps", Bulletin No. 2, Wisconsin Geological and Natural History Survey, 1898. It was this work which first induced me to take up the study of solitary wasps as a summer's recreative work and from which I have derived many helpful suggestions in my study. The remaining literature on the subject comprises short papers that record, for the most part, only individual observations.

Most of the observations recorded in the present paper were made in July, August and September of 1903. The work was not done continuously during this time, but in periods of from three to fourteen days, because of frequent interruptions, chiefly on account of rains, which were very heavy and long continued, drowning out many wasp larvae.

The scene of action of these exciting dramas of insect life was the sandy woods five miles southeast of Austin, on the high south bank of the Colorado River. The woods are a favorable place for studying solitary wasps, for they are numerous both in species and individuals and it is, moreover, easy to observe and to follow them because the sandy soil will support but a sparse vegetation, in which, in less favorable places, a wasp is often lost to view. In point of comfort to the observer, the woods offer a decided advantage, for, in the first place, he can often make use of the inviting shade of the spreading post-oak and hickory trees, though he often has to resort to his umbrella for protection against the burning rays of the sun. Wasps, it must be remembered, revel in hot, clear days and work best in the heat of noon-day when the mercury is flirting with the 100 mark. Indeed, on dreary days most of the wasps will not work at all, but will fly listlessly about, sipping nectar from the flowers. The second point of comfort is derived from the absence of "red bugs" and ticks. These pestiferous creatures are found on vegetation and since almost the only herbs found in the woods are grass-burs and bull-nettles, which one assiduously avoids anyhow, it follows that one collects few, if any, "red bugs" and ticks in the place in question.

The observations are recorded below by species and theoretical considerations have been intercolated wherever it was deemed necessary or desirable. These latter have been summed up in the "Conclusions" at the end.

I wish to take this opportunity of thanking Dr. S. Graenicher of Milwaukee and Dr. H. W. Ashmead of the Smithsonian for the identification of the Solitary and the Parasitic Wasps.

I. TWO EUMENIDAE.

(a) Odynerus Dorsalis, Fabre.

On September 2d, just before noon, I was walking through a cornfield and chanced upon a wasp that had just dropped clumsily on the ground between the blades of a clump of grass. I had, several days before, seen another individual of the same species drop down in a similar place and caught her without searching the premises. This time, however, having become more suspicious, I waited and watched. The wasp moved about slowly for a while, always looking at me with what seemed a stare, which was due to two yellow spots like eyes on the sides of her face. Gradually she walked further back; and as I stooped, I saw under the grass five neat mud cells. One of these was open and contained several small caterpillars (cotton-worms) already stored away. Soon the wasp flew away, presumably after more prey; I should have awaited her return and watched every step of the work of storing and building had not some digger wasps engaged my attention at the time. I therefore left the place before the wasp had returned. At 2:30 I went back to ascertain Mme. O.'s progress and found that the open cell had been closed with an out-turned saucer-shaped mud lid and that another cell had been begun. By 6:30 in the evening this was finished though still open and was occupied not by caterpillars, but by the wasp herself, which was lying inside and looking contentedly out. At 11:25 o'clock the next day the wasp must have been at work for several hours, for the cell had been nearly filled with caterpillars, which is the condition shown in Fig. 3. At 11:52, she came back carrying another caterpillar in her mandibles. I had pulled away some of the grass-blades above the nest and had my camera set up to take the picture of the nest. But this disconcerted her very little, and I was surprised at the ease with which she became accustomed to the change. After once flying away for a minute and circling about once or twice, she settled and placed the caterpillar in the nest. This was done in a peculiar manner. The wasp laid the caterpillar down at the opening of the cell and supported herself with her fore-feet on the edge. She then, with her mandibles, passed the caterpillar on as far as she could reach, took a second hold and pushed it on further, repeating the operation until the whole length of the caterpillar was inside.

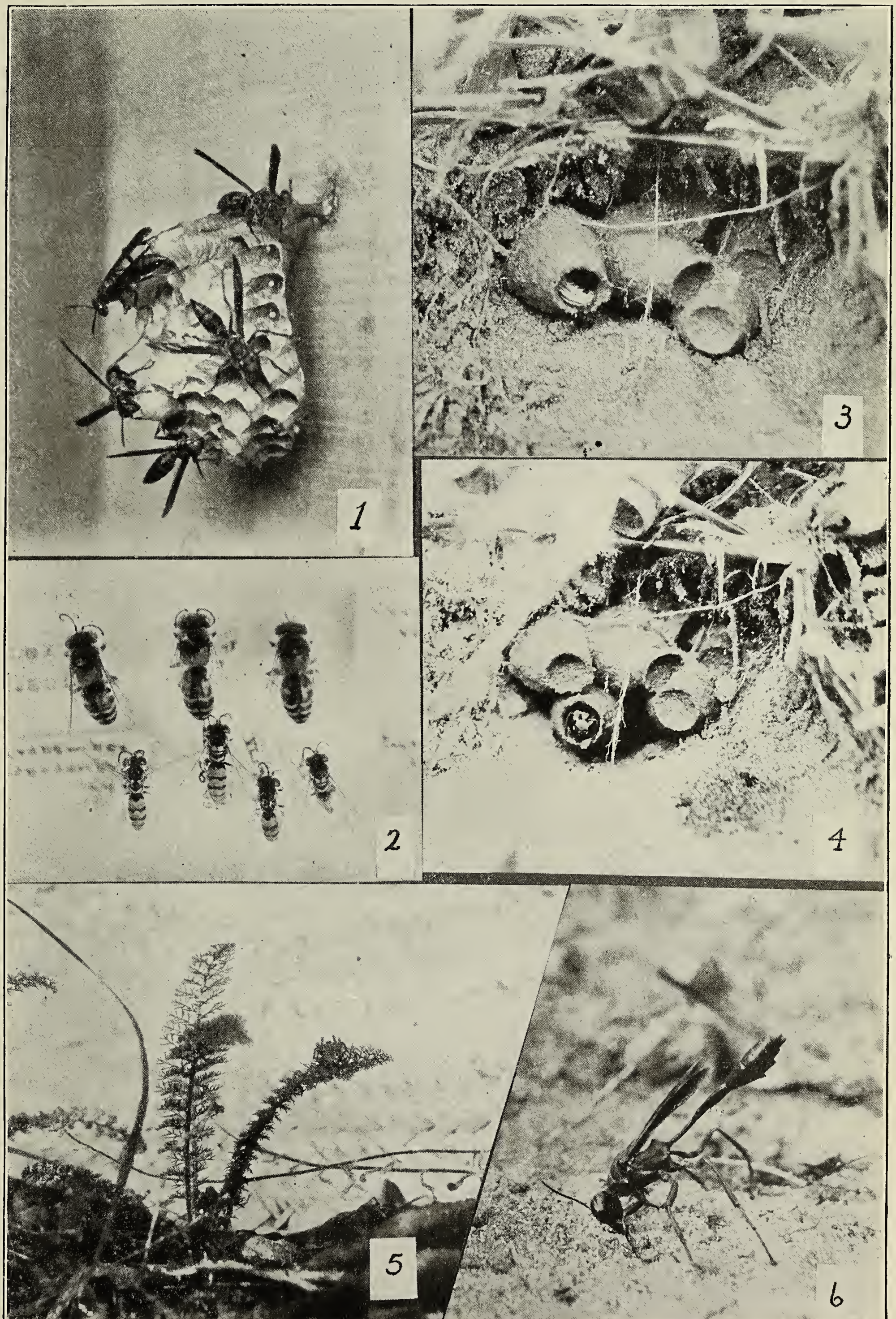

Plate I. Hartman, Solitary Wasps.

Then she crawled up and with her head stuffed all the caterpillars as far back into the chamber as possible. This done, she cleaned her antennæ and flew away without seeming to take her bearings. She had evidently made so many trips to the spot that a study of the locality had become unnecessary.

By 7 p. m. the cell had been closed and another built, which the wasp was occupying for the night. A day's work with *dorsalis* evidently consisted of storing a cell, closing it, and building another to be used in the first instance as a lodging place for the night. Thus I found her still at home at 7:45 the next morning (September 4th), as shown in Fig. 4. She was lying in the cell, which her body comfortably filled, and was amusing herself with picking up unwary ants that chanced to pass too close to her threshold and, like the Harpies of old, grinding them in her jaws. I allowed her to store this cell, as well as build another; then I caught her and carried the cells home.

O. dorsalis. builds pretty mud-cells on the ground, choosing a place hidden from view by a clump of grass. The cells are broadly spindle-shaped, pointed at one end, which is left open until the cell is stored. The chambers do not touch each other for more of their length than is necessary for their mutual agglutination. This almost entire independence of the cells entails a considerable waste of building material as compared with the habit of *Pelopaeus cementarius,* which builds her cells side by side in rows and tiers of rows. It seems probable that the former method is the more primitive one, and that the latter has been superinduced by the mud-dauber's habit of building on flat surfaces. It is to be noticed that the lumen of a mud-dauber's cell still remains, in spite of the irregularity of the outer surface, cylindrical. The entire structure made by *dorsalis* is not only held together by the slight adhesion of the more or less fragile cells which compose it, but is also partially suspended by grass-roots imbedded in the plastered walls. The shape of this nest with the grass-roots attached can best be seen in the figures which are photographs taken at different stages in the construction. (Figs. 3, 4, 10, 11.)

The first wasplet emerged on October 7th, the others on October 8th, 9th, and 11th, respectively. One wasp failed to emerge and was probably from the fourth egg laid, and would normally have emerged on October 10th. If one cell was stored each day, the first egg laid was on August 30, and the total period of development would be thirty-nine days. The wasps emerged (Fig. 11) by a small round opening gnawed in the cell wall. This hole was in three cases near the last sealed end, in one case at the opposite end.

One cell, the last one stored, I broke open to examine the condition of the caterpillars. I was especially anxious to see this, as I had once observed a specimen hang from a twig by one of the hind legs and chew the head of a cotton-worm, holding the caterpillar with her front and middle legs. I had often seen *Microbembex* do this in exactly the same way, and as this species feeds her larva on any insect, dry or fresh, or on any part of an insect in almost any condition, I concluded that she sucks as much of the insects' juices as she needs for her own sustenance and feeds the rest to the larva. Charles Janet has likewise observed this with *Vespa crabro,* where the workers, when the colony is threatened with over-population, kill some of the larvæ and pupæ, suck their juices and feed the remainder, rolled up in balls, to the surviving larvæ. In the case of *Odynerus,* I am pretty certain that she takes a caterpillar occasionally for her own delectation. I could draw quite near to the chewing individual and could see every movement, even of the mandibles, during the process. The condition of the caterpillars in the cell I opened, moreover, pointed to the fact that in chewing the caterpillar she was not preparing it for her offspring, but was satisfying her own hunger. Of the seven caterpillars found in the one cell, all were in good condition, and four responded very perceptibly to stimulation, one of the latter moving spontaneously. All remained in practically the same condition until attacked by the growing larva. (Fig. 10.)

I watched the growth of the larva until it was ready to spin its cocoon (September 26th). But as I had torn away a goodly part of the wall of the cell, it could not spin its cocoon all around and died. But the absence of the wall was not the chief cause of the pre-pupa's death. When I returned to her on October 7th, I found the pupal skin completely covered with egg cases of a parasite. On close examination, these proved to contain myriads of mites in various stages of development. Such egg-cases I have often noticed on dead digger-wasp larvæ, and they usually appear on the articulating membranes between the segments.

From cell No. 4 the imago failed to emerge. In November, when I broke open the cell, I found the nearly mature wasplet dead. The cause of its death was easy to understand, as I found protruding from the sides of its abdomen a number of the egg-cases above mentioned.

As regards the length of developmental periods, the above data only give the total length of development as thirty-nine days and that of the egg and larva together twenty days.

(b) ODYNERUS ARVENSIS, SAUSS.

This species of *Odynerus* does not posssess the architectaral skill of its cousin just described. Its home is not such an elaborate domicile, built, as it were, for show as well as for use, but consists of any convenient crevice in a wall or fence-post. The nest is completed by closing the opening of the crevice with mud, much after the fashion of *Trypoxylon*. I have made a few observations on two nests of this *Odynerus;* those on the conditions of the caterpillars found in the nests are of particular interest. In general, the following facts do not justify Fabre's conclusions which he based on the habits of *O. reniformis.*

At noon, August 4th, a female *arvensis* was closing her nest in the niche of a brick wall. A few days before a *Trypoxylon* had emerged from the very niche now intended to be the cradle of another wasplet. I immediately opened the nest and drew out eight caterpillars, all of which were alive, six of them, in fact, so lively that they wriggled around in the small vial to which I had transferred them. I found no egg at first, but, looking carefully into the dark recess, I discovered the egg suspended from the ceiling of the little room. After breaking the suspensory thread with a knife and brushing the egg out, I placed it among the caterpillars in the bottom of the vial. Very few wasps' eggs could stand the rough handling which this egg received. The explanation of its endurance lies in the toughness of its shell. The larva hatched in two and one-half days, having shed a tough, translucent shell which could safely be handled with a pair of forceps. After fifteen hours the larva had attached itself to a writhing caterpillar and had grown perceptibly. The remaining data are as follows:

August 9. Five days after the nest was closed, two caterpillars have been devoured and the remaining six are still alive, of which four move spontaneously. The wasp larva is as large as one of the caterpillars. The larva takes a long rest this morning.

August 10, 6 p. m. All parts of all the caterpillars have been devoured.

August 11, 6 p. m. Larva nearly finished spinning cocoon.

August 29. Adult emerges.

Thus the length of the egg stage of *O. arvensis* is about two and a half days; of the larval stage, four and a half days; of the pupal stage, eighteen days.

Another nest which I observed an *arvensis* store and close on August 14th I opened nearly a month later (September 9th). I was expecting to see a wasp emerge by this time, and had placed a bottle over the entrance to receive it. I found in the nest no offspring of the wasp, but the red pupa of a fly and fourteen caterpillars, of which four had dried up, three were dead though in good condition and seven actually alive. The caterpillars' length of life is so striking that I deem it desirable to add the following table:

CONDITION OF CATERPILLARS.

Date.	Begun to shrink.	Dead but plump.	Alive.
September 9	4	3	7
September 14	....	5	5
September 19	5	1	4
September 26	....	2	3
September 29	3	1	1
October 11	....	1	....

Thus three caterpillars lived 43 days, one 46 days and one remained, *for 58 days,* in a condition good enough to be added to any waspling's bill of fare.

A survey of these few facts would seem to indicate that, while the suspension of the egg and the young larva is a desirable condition and increases their chances of successful development, yet it is not an essential condition, as Fabre has contended. Nor is it essential, in consideration of the longevity of the paralyzed prey, that the caterpillars be devoured in the order in which they were stored.

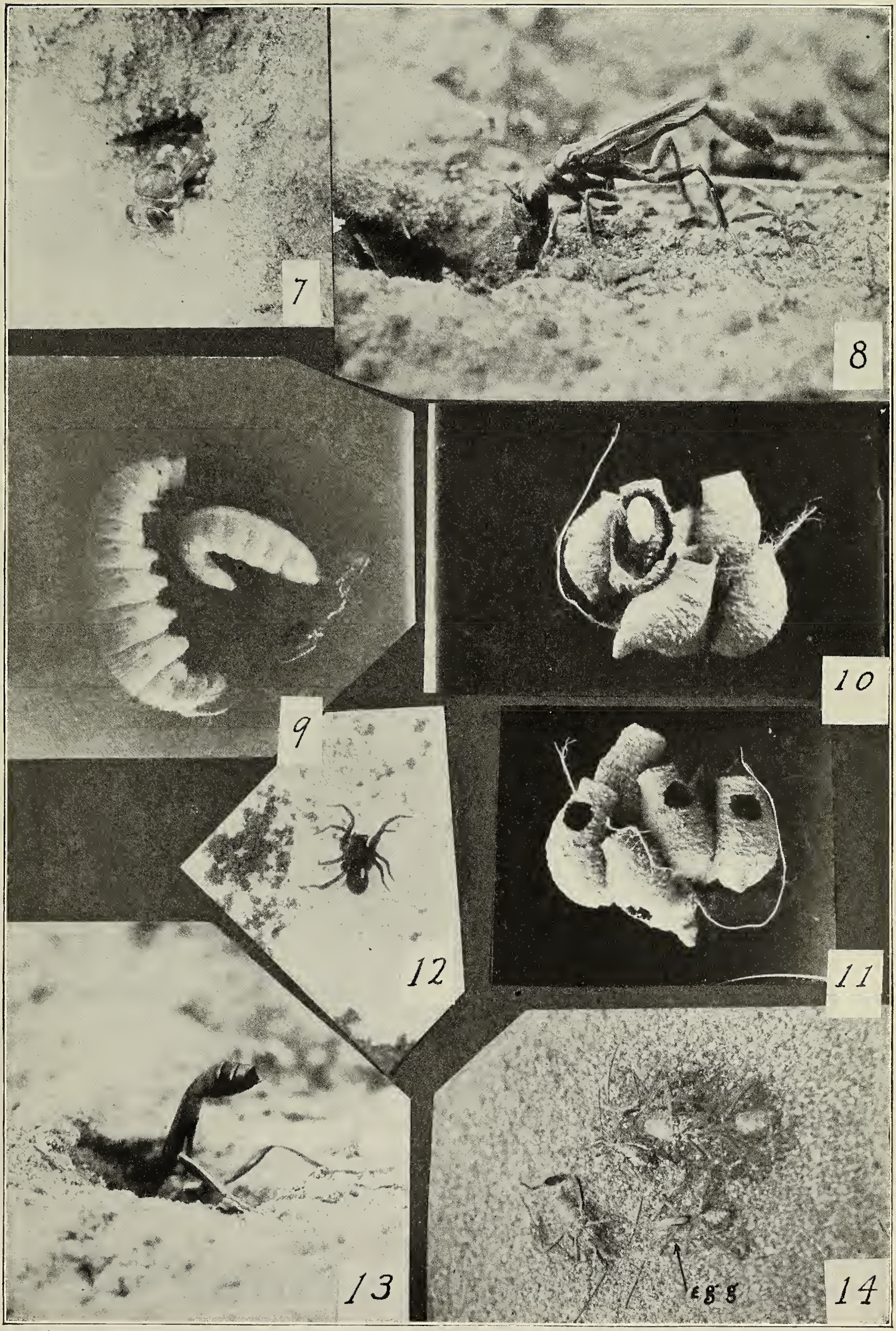

Plate II. Hartman, Solitary Wasps.

II. AMMOPHILA PROCERA, DAHLB.

Ammophila is perhaps the most famous of all the digger wasps. Her homing faculty is most wonderful and is perhaps mainly responsible for the assumption of the sixth sense in insects, the sense of direction; the accuracy of her stinging instinct was long regarded as perfect. She has been several times observed to use a pebble as a tool with which to tamp the ground, so that a claim for her superior intelligence will not easily be contradicted. She is, moreover, a delightful subject for observation because of her tolerance of human company as well as her easy grace and her calm and dignified, though business-like ways.

In the course of the summer I was fortunate enough to observe six different individuals of *Am.* at work, four of which allowed me to witness the carrying home and storing of the caterpillars, while two individuals performed for me the whole process of digging, storing and closing up the nest, leaving me in the dark on only one step of the process, namely, the capture of the prey. All the individuals observed belonged to the species *procera*. It includes the most formidable members of the genus in America. The species is very variable in size. Five of the specimens whose acquaintance was made were among the largest; the sixth was much smaller and differed from the others in the number of caterpillars captured, as will be seen below. In the present description of *Ammophila's* habits, I shall follow the whole history of a nest from the beginning.

When *Ammophila* feels the necessity for doing so, she flies around in search of a suitable place to dig her nest. She is hard to satisfy in this respect, for I have seen her alight at a dozen different places and begin to dig before she finally decided on a place as good enough. To test the ground she does not waste time by digigng long at any one place, as does *Pompilus*, which often abandons six to eight half-finished nests before deciding on one to suit her; but *Ammophila* merely scratches the surface a little and, if dissatisfied, flies or runs off to another place. Some over-fastidious individuals have been known, however, to abandon the old nest and dig a new one near by after the former or even the ground around it had been slightly disturbed.

After the location has been chosen, *Ammophila* does not waste any more time deciding what to do next, but sets to work digging her nest, the tomb of her victim and the birthplace of her offspring. If the surface of the ground is dry and sandy, the hole is started by scratching out the sand with the front legs as is usual with most digger wasps. These use their front feet during the whole digging process, employing their mandibles only to bite loose the more solid earth or to break up the larger lumps. If the ground is hard at the surface, *Ammophila* begins by biting off pieces of earth and carrying them to one side, continuing this method until the nest is finished. The need of this mode of excavation as compared with the scratching method employed by most digger wasps becomes apparent when the shape of the nests are taken into consideration. The tunnel leading to the pocket of *Ammophila's* nest is nearly vertical (Figs. 22 and 18), while the nest of other digger wasps is a nearly horizontal tube with a slight dilation at the end (Figs. 19 and 21. Fig. 6 represents *Ammophila* beginning her nest by biting the ground loose with her mandibles. Fig. 13 shows the nest farther advanced with the wasp already reaching down to bite off a "mouthful" of dirt. The work progresses rapidly, for *Ammophila* is a zealous and steady worker. Only now and then does she fly up and circle about a little to fix the locality of the nest in her mind. At first sixteen to eighteen loads of earth are carried out a minute, and as the nest deepens the time required for going in and out increases, so that as the nest nears completion, only eight to ten trips are made to the surface per minute. The wasp goes down the hole head first and backs out, turning around at the surface and running over to the dumping ground a few inches away. Here the load is flung down with a flirt accompanied by a joyful, enthusiastic buzz. After thus hurling away the lump of earth *Ammophila* gives a jump, turning suddenly face about, and goes back, half running, half flying, after another load. Fig. 22 shows the pile of sand carried out by the wasp on the left of the picture, i. e., on the side of the nest opposite the pocket towards which the entrance gallery 'opes (at x).

The work of excavation occupies about thirty-five minutes in the loose soil of the woods where the observations were made. The completed nest, in general always characteristic of the species, varies somewhat with the individual and the condition of the soil in which it is dug. From above (Fig. 8) the nest appears as a perfectly round hole about half an inch in diameter leading nearly straight down as far as one can see. Where the surface of the ground is soft and dry, the hole will be wide-mouthed like a funnel, due to the caving in of the sides.

On cross-sectioning the nest its true shape is revealed. The gallery, nearly vertical near the top, runs down in a gentle curve till it becomes nearly horizontal, where it widens out into a spacious pocket which received the caterpillar. Fig. 22 represents a nest of average size and typical shape. The distance from the mouth to the farthest end of the pocket is three inches; this is ¾ inch high and 1½ inches from the surface of the ground and the tunnel is ⅜ inch in diameter. The pile of excavated sand at the left is 3 inches from the entrance. Fig. 17 represents two smaller nests also dug by large individuals. The nests are of a different shape from the typical. Both have short tunnels; the pockets, one inch below the surface of the ground, have their long axes at right angles to the tunnels.

After the completion of the nest, the next problem confronting Mme. Ammophila is the procuring of a supply of food for her future offspring. Caterpillars always constitute the victim of the Ammophilæ, and the number varies with the species of the wasp and the size of the caterpillars. The large individuals of *procera* capture and store but one immense green "tomato" caterpillar, the subject of the photographs. The smaller store several small caterpillars of about the same length of their own body.

Before setting out on the chase, some species of *Ammophila* take the precaution of making a temporary closure of the nest, particularly if the provisioning is to be postponed to the next day, and the degree of care with which the closure is effected varies with the species and with the individual. A lump of earth may be laid over the entrance and this covered with a number of pellets so as to make the location indistinguishable. Another individual of *Ammophila urnaria* has been observed by the Peckhams to wedge a good sized stone deep into the neck of the burrow and then fill the space above, solidly, with smaller stones and earth. A third individual of the same specie neglected to close the nest at all. Fabre describes *Ammophila argentata* and *Ammophila sabulosa* as closing the nest immediately after it has been ma- but *Ammophila holosericea* as leaving it open until it is co pletely stored. The last mentioned species stores five to six caterpillars, and Fabre thinks she leaves the nest open on account of the inconvenience of closing it so often. Dr. Williston, however, has observed *Ammophila varrowi* take the greatest pains to close and conceal the entrance each time a caterpillar is brought in though she stores four to five of these. This is also the case with the smaller *procera* observed by me, for when she brought in the third caterpillar she scratched out much sand, bits of wood, etc., which she threw away. Finally she pulled out the plug at the bottom which she laid down close by for use at the final closure. The five larger specimens of *A. procera* observed by me agreed with the French *hirsuta* of Fabre, in that each stored but one large caterpillar and was thus relieved of the necessity of closing the nest. *Procera* differs from her French cousin in that she digs her nest before catching her prey as two to six hours elapse between the digging of the nest and the bringing home of the prey. It is thus seen that the habit of closing the nest while the wasp is off searching for her prey does not depend on the number or size of the caterpillars but seems to have developed independently and to different degrees in the different species and is by no means constant for any given species.

At 9:40 a. m. on July 22d, while busy observing the doings of *Monedula carolina* I saw a small *Ammophila* running over the sand carrying a good sized caterpillar in her mandibles. She soon dropped her victim and flew away, preumably to visit the nest and make sure of the road. In a few moments the wasp came back and searched right and left for the caterpillar. Twice she passed within two inches of it without noticing it, which would seem to indicate a rather weak sense of smell.

Again the caterpillar was picked up and carried off at the rate of five feet a minute over obstructions in the way, to her nest located in the shade of a clump of saplings. Here the caterpillar was laid down on a smooth surface several inches in diameter where the wasp began to open up its nest. Sand and dry twigs and leaves were pulled out and cast away promiscuously. The last piece of wood brought up was the largest and most compact and was not cast away like the others but was carefully laid down near the entrance. Ammophila did not forget the caterpillar during these few minutes but frequently approached and touched it with her antennae. When all was ready the wasp backed into the tunnel, got hold of the caterpillar and pulled it down. The caterpillar was sufficiently alive to grasp a blade of grass and hold on, but the wasp tugged till it had dragged the caterpillar into its grave.

After remaining inside three minutes, the wasp came out, walked around a while and finally picked up the chip which it had taken out last and replaced it in the tunnel, reaching down as far as possible to press it in. This plug of wood probably served as a shelf to receive the bits of rubbish and the sand with which the tunnel was now being filled. Dry leaves and twigs were dropped into the hole and sand scratched in on top of these while all was stuffed down with the head. In eleven minutes the nest was filled and smoothed over. *Ammophila* then flew away and returned three times, remaining away eight minutes at a time. The nest which the mother wasp was soon to leave forever, seemed to have had a strange attraction for her. The last time she returned (at 10:27) she carried pieces of leaves and earth over the nest as if she wished to obliterate every trace of the work.

This small *Ammophila*, having to bring in three caterpillars, which necessitates making three hunting trips to store the nest, is, of course, benefited by closing up the nest each time before departing to keep out the flies and Mutillids bent on mischief. Her larger sisters are powerful enough to carry off the largest caterpillars; they therefore capture a single victim large enough to supply the larva and so have no need to close the nest while on the hunt, which may occupy from two to five hours.

It is a strange sight to see a large *Ammophila* carry her heavy burden home to the nest. The grass green caterpillar and the slender black wasp with her red metallic wings and abdomen girdled with bright red form a marked contrast to the grey sand over which they glide. It is a sight that never fails to excite one's interest to the utmost. One can not but admire the wasp for her immense strength and wonder that so small a creature can carry such a load. In spite of the disproportion between the wasp and the boat shaped burden, her rate of progress is rapid enough for she travels along at the rate of ten feet a minute over sticks, clumps of grass and inequalities of the surface. (Fig. 16.)

The most wonderful thing about *Ammophila*, however, is the almost unerring manner with which she finds her way back to the nest. Sometimes, it is true, she will drop her burden temporarily to fly away and assure herself that she is on the right road. But usually she will march on uninterruptedly in one general direction and come exactly to her nest in spite of the hundreds of crooks and turns around the various obstructions in her path.

Having arrived at the nest the caterpillar is laid down and the wasp goes inside to see that the way is clear and to determine whether the tunnel is large enough to admit the caterpillar, for the wasp always, before pulling the caterpillar in, brings out a number of mouthfuls of earth and on each trip approaches the caterpillar as if to measure its thickness. Sometimes only a few, and sometimes many trips are made before the caterpillar is taken inside and it is usually a tight fit and requires considerable tugging on the part of the wasp.

Before the caterpillar is pulled in it is dragged over to the nest and laid down with its head nearest the entrance. Then the wasp backs down, grasps her prey with her mandibles and pulls it in. *Ammophila* usually remains inside five to six minutes to arrange the caterpillar and to lay the egg. Figs. 18 and 22 show the position of the egg (4 mm. in length) of one wasp which fixed it on the 10th segment from the head. The position varies anywhere from the 6th to 10th segment. The egg is always securely attached by one end (the head end of the embryo) to the side of the caterpillar and points with its free end towards the caterpillar's venter. When the larva hatches it occupies the same position that the egg did. It merely pierces the skin at the old point of attachment to suck the caterpillar's juices.

Ammophila now proceeds to close up the tunnel and leave her offspring to its fate. The tunnel is usually closed very carefully; some individuals are more or less careless, however, as were Nos. 72 and 73 whose nests are represented in Fig. 17. One nest was left open, the other was closed in a very perfunctory manner.

Ammophila searches in a radius of a yard and picks up large and small pieces and carries them to the nest (Fig. 8). If the piece is too large the wasp may carry it to the nest and try to fit it in or may discard it before she gets to the nest. She seems to have the power of judgment to a certain degree, for she evidently is able to determine whether a thing is too large to suit her use or not. Not only is debris thrown into the nest but the wasp alternates by scratching in the loose sand at the surface and tamping it down with her head. When the nest is full enough for the wasp to reach down comfortably she presses the separate pieces firmly down before she lets go and accompanies the strenuous operation with a cheerful buzz. Now it sometimes happens, especially towards the end of the operation, that a piece of wood is pressed down tightly, then pulled out and pressed down again and this repeated several times, so that one might suspect that the wasp were here improvising a tool with which to tamp down the sand. Indeed this very act was observed by the Peckhams and Dr. Williston on *Ammophila urraria* and *Ammophila Yarrowi*. In each of these two cases the wasp used a pebble to tamp down and smoothe over the ground, not once merely, but several times, laying the pebble aside each time while she brushed on more sand. The use of the piece of wood by *Ammo-*

phila procera in a similar manner is not so decisive since she presses a number of articles into the nearly closed entrance before she uses the last piece in any way approaching its use as a tool. Perhaps the use of the pebble by *A. Yarrowi,* the prairie species, is an extension of the more generalized habit of *procera* which lives in the woods where rubbish of all kinds is easily accessible and the whole tunnel is filled with it as shown in Fig. 18.

After the nest has been closed and the tunnel filled flush with the surface, sticks, whole leaves or blades of grass, etc. (things are not too large now), are carried over the nest to obliterate all traces of the wasp's work. In fact this is sometimes so skillfully done that unless one makes a mark he fails to find the nest again except by cutting vertical sections in the direction of the nest until this is opened.

The process of thus concealing the nest is, or course, highly protective to the human eye, though it can hardly be its real purpose to delude man or to entertain an admiring observer. The habit is probably a mere extension of the one which impels the wasp to carry debris into the tunnel to hold the sand which helps close the entrance.

The finishing touches having been applied, Ammophila is usually off and away immediately, though sometimes the fond mother seems unable to sever her connection with the nest so recently made and remains in the neighborhood visiting the nest occasionally to make a few changes. Once I caught a wasp in a neighboring tree after she had apparently finished her work; but she escaped through a hole in the net. For the next hour she continued to come near the nest again and again though she assiduously avoided me and my net. Gradually, however, she seemed to forget her experience and became so bold that I could approach close to her and easily captured this artist of her race.

Fig. 17 represents a section of the nests of wasps Nos. 72 and 73. It is a rare thing to observe two *Ammophilae* digging their nests so close together at the same time. Their behavior under these conditions seems to me to justify a special description of them here.

When on September 18th an *Ammophila* flew up in front of me, I knew from her actions that she had business interests in the neighborhood and so repaired to the inviting shade of a hickory tree to observe her. She settled and began to dig near an open *Ammophila* nest and I supposed that it belonged to her and that she was just closing it up. But she continued to dig another nest close by. Her work was not destined to go on smoothly, however, for hardly had five minutes passed, when a second individual (No. 73) came strutting along bearing a large green caterpillar. Wasp No. 72 remained ignorant of the approach of her sister until the latter came somersaulting over a stick at which the former was working. A fight ensued, the two clinching several times and even drawing their deadly weapons. They then flew away and No. 73 was the first to return. She took up her caterpillar, carried it to her nest, but returned to it, laid the caterpillar down, and proceeded to carry out sand as usual. At 2:02 No. 72 came back, while No. 73 was within her nest hidden from view, and was about to make off with the caterpillar which she found so handy. The rightful owner intercepted the thief, however, and in another duel, succeeded in recovering the purloined property. She then took the caterpillar up and carried it off for a distance of two feet, where she stopped to reconsider. It seems that the struggle for the recovery of the caterpillar must have reminded the wasp of the struggle to capture it, and that her next idea was to carry the caterpillar home, but she discovered her mistake in a moment. It certainly looked as though some such reflections were going on in the mind of the wasp. After hesitating a moment she turned around, carried the caterpillar back, laid it down at the entrance and hurriedly carried out only *one* mouthful of sand before dragging the caterpillar within. She then closed the nest in a slipshod manner and flew away at 2:23.

No. 72 returned and finished her nest without interruption where she had begun. By 6:45 she had not yet returned with her prey and I feared that she would not, since it was already very cool and since there were chances of her having been hurt in the struggle. She brought home a caterpillar, however, as I found one in the nest several days later, though she did neglect to close the nest. I found both caterpillars in good condition (Fig. 17) but without an egg. It is possible that in the duel the mature eggs, ready to be laid, were lost. Thus affairs sometimes go wrong even with the brilliant Ammophilae.

It is a significant fact *Ammophila* No. 72 picked up the stranger's caterpillar and walked away with it when she did. She had not yet dug the nest and therefore, according to Fabre, the instinct to procure her prey should not have yet manifested itself. This author experimented on *Sphex ichneumonea* which places her grasshopper at the entrance to her nest and then runs in and out again before dragging it down. He took advantage of a moment when the wasp was out of sight below to move the prey to a little distance, with the result that when the wasp came up, she brought her cricket to the same spot and left it as before, while she visited the interior of the nest. Since he repeated this experiment about forty times, and always with the same result, he concluded that nothing less than the performance of a certain series of acts in a certain order would satisfy her impulse. The Peckhams tried the same experiments and found the American *S. ichneumonae* would, after being fooled five or six times, carry the grasshopper inside in various ways but without first running down. It is thus apparent that wasps may perform certain instinctive acts though they be out of the usual routine, as was the case with my *Ammophila* which was about to procure the caterpillar before she had dug her nest.

The stinging habit of *Ammophila* and the resultant condition of the caterpillars have long been subjects of both the reason and the imagination among naturalists. I here append my own observations on the condition of the caterpillars. A discussion of the subject follows in the concluding chapter of this paper.

Notes on the condition of Ammophila's caterpillars.

I. No. 16. July 22d, 9 a. m., three small caterpillars, all respond to stimulation.

July 23d, 6 p. m., caterpillar containing egg dead, others still alive.

II. No. 28. August 17th, caterpillar responds to stimulation at both ends of body.

August 20th, more lively than on August 17th.

August 23d, it is nearly dead.

III. No. 55. Egg laid 4:50 p. m., September 1st. Caterpillars move both ends of body spontaneously.

September 3d, caterpillar passed fœces twice and is more lively than the day before, moving front legs and posterior end of body spontaneously.

September 4th, 7 a. m., egg apparently hatched, larva occupying same position as egg. 4 p. m., caterpillar has passed fœces again; will move only on stipulation; larva growing.

September 5th, 9:30, larva 6 mm. long, still occupying same position; caterpillar shrunken and nearly dead; can move head end on stimulation.

September 6th, a. m., larva nearly as long as caterpillar is wide. Sucking movements visible in larva.

September 8th, larva has sucked the skin of caterpillar dry and is devouring parts of this.

September 9th, caterpillar all eaten up except head and tail. Fig. 9 shows full grown wasp larva with a remnants of a devoured caterpillar together with a fresh caterpillar for comparison.

IV. No. 61, September 5th, caterpillar moves both ends slightly.

September 8th, egg dead. Caterpillar nearly dead; only extreme ends capable of slight movements on irritation.

V. No. 72. September 18th, first four and last three segments movable; has turned pink.

September 22d, head end responds to stimulation.

September 26th, posterior end jerks when pinched. Anterior end is shrinking.

September 27th, posterior end still alive, anterior end stiff.

VI. No. 73, September 18th. Head and last two segments move a little on stimulation.

September 22d. Several anterior segments respond to stimulation.

September 25th. Dead.

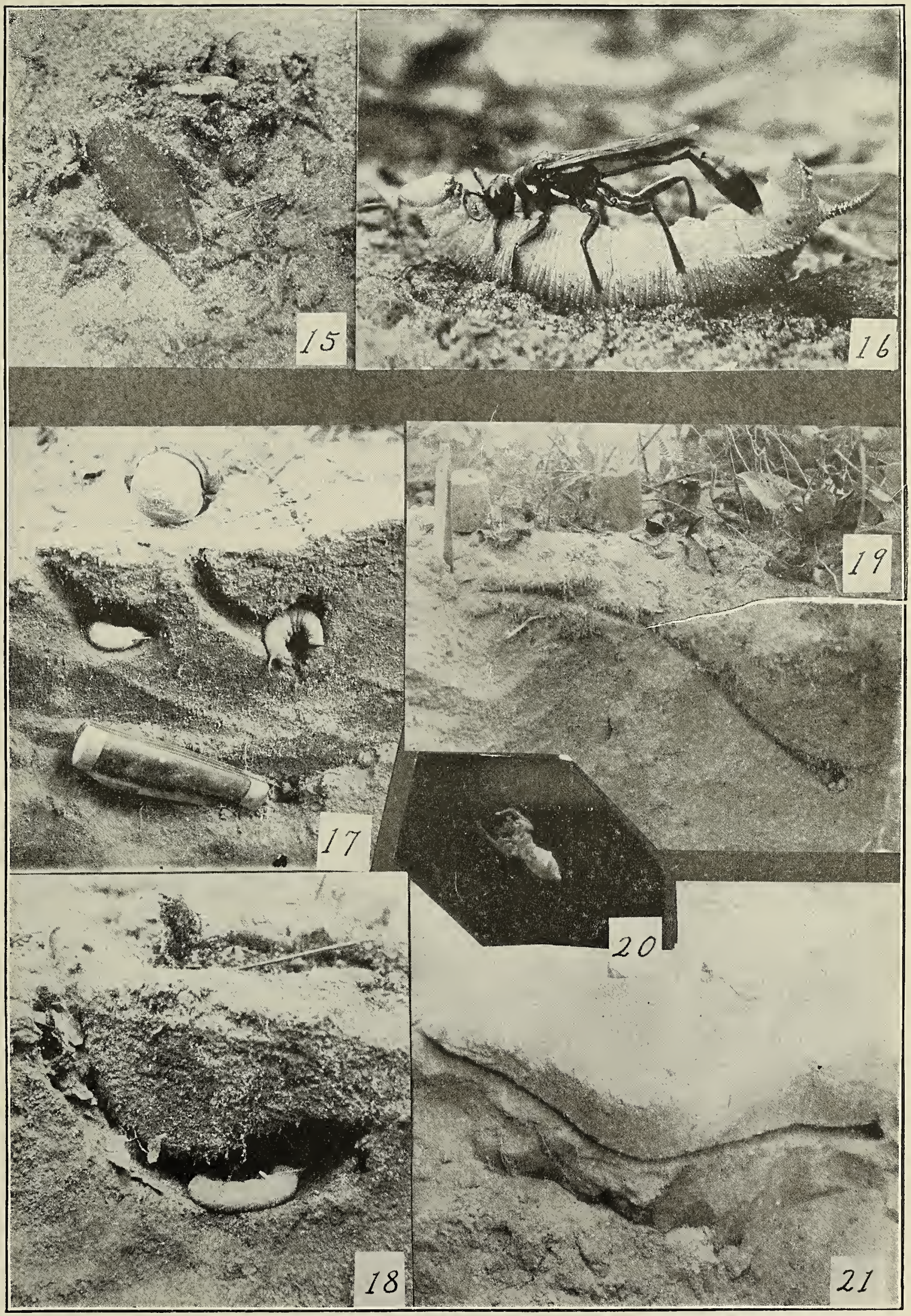

Plate III. Hartman, Solitary Wasps

III. BEMBEX TEXANUS CR. AND MICROBEMBEX MONODONTA, SAY.

Microbembex and *Bembex* (Fig. 2) are both common in the sandy woods, where they often form large mixed colonies, building their nests side by side in great numbers. When a novice first comes upon one of these populous colonies on mid-day, when business is at its height, he is bewildered by the great number of wasps engaged in the general hubbub around the many holes that riddle the ground (Fig. 24). What confuses him more than anything else is the presence of the two kinds of wasps that look and act so much alike. Gradually, however, he becomes accustomed to the sight and soon begins to be able to distinguish easily the two species as they rest on the ground.

Microbembex monodonta is somewhat smaller and more slender than *Bembex Tex.* and the stripes across her abdomen are greenish yellow, while those of *Bembex* are yellowish blue. With practice one soon learns to distinguish the two species at a glance, by their actions as well as appearance. The manner of flight is characteristive in each case. *Bembex,* as she flies around, is always in a hurry, flying in a zigzag course and giving a buzz at each sudden turn like a blue-bottle fly. *Microbembex* is calmer in her movements, she never seems in a hurry but flies gracefully about like a bird skimming the water. Particularly on the hunt, as will be pointed out below, is the diffeffrence very marked. Often while digging in front of the nest the wasps will rise and leave their work for a moment, especially if disturbed by idlers flitting leisurely about. *Bembex Tex.* usually settles immediately to resume work, but *Microbembex* considers the interruption an opportunity to take a few moments of well-earned rest and bask a while in the sunlight.

Both of the species under consideration go through about the same actions in digging at their nests, the only difference being the quicker and more nervous ways of the smaller species. Here we notice the manner of digging in general characteristic of all the *Bembecids.* The body of the wasp, balanced, as it were, on the middle pair of legs, represents a teeter-totter in miniature. Each time the head goes down, the tail bobs up and a stream of sand pours out from under the wasp, propelled by several smart strokes of the front legs in quick succession. Then there will follow a brief pause while the wasp rests with head in air as if looking around an instant to survey the landscape.

Activities in one of these Bembecid colonies does not begin until the rays of the sum have warmed the ground; and when the rays beat down from above, business is at its height and a gentle hum betokens the hustle and bustle of the inhabitants. When one visits the colony early in the forenoon, when scarcely a wasp is about, comparatively few of the nests are visible, since *Microbembex* closes up her nest from the outside and sleeps elsewhere, while occasionally a *Bembex Tex.* will have her nest closed from the inside. Towards ten o'clock, however, the doors are thrown open, one by one, and soon the actual population of the colony is manifested. On cloudy days, the wasps are not as busy, but lounge about, often resting for hours at the entrance and looking out upon the world.

Having thus located ourselves in the midst of this mixed colony, I shall follow *Microbembex* more closely and leave a detailed description of *Bembex texanus* for a time, when I shall have collected more data on this interesting wasp.

Microbembex is unique among the solitary wasps in the variety of the insects with which it feeds its larval offspring. *Bembex* takes several species of flies, but never anything but flies; similarly, a bug-catcher takes only bugs and a spider-ravisher only spiders. The greatest variety of the prey of the solitary wasps of which I can find any record is *Monedula punctata* described by Bates, who says that this species catches fire-beetles as well as flies. Our *Microbembex* will take home for provisioning its nest and insects that it finds already dead, or it will capture the living prey. On account of this great variety of food, I shall give a detailed list of the articles of food together with notes on the behavior of the wasps in capturing or in carrying home the prey.

(1) *Slender red caterpillars,* 1¼ inches long. I saw five of these carried home by different individuals. The caterpillar is carried home on the wing, though not directly, because of the weight of the burden, but in spurts. The wasp grasps her prey by its head with her mandibles and flies suddenly in a kind of jump to another point, one to three feet away, where she lays the caterpillar down and rests. Sometimes the wasp will fly off for a moment , leaving the caterpillar lying in the sand. When she returns, to search for her prey, she does so by flying slowly round and round in the vicinity of the caterpillar.

These tactics expose the prey to considerable danger from parasitic flies. Indeed, I once noticed two grey Muscids with reddish abdomens follow a wasp with her caterpillar for a great distance. Their persistence greatly agitated *Microbembex,* and she several times left the caterpillar and pounced upon one or the other fly and threw it to the ground. The blow was, however, not serious, for the fly continued without fear as before. Why the wasp did not kill the interlopers on the spot, I can not understand. Fabre, as well as the Peckhams, wonder at the laxness of *Bembex* in her treatment of parasitic flies which she keeps driving away instead of killing them once for all. This would be easy for her to do, if she were so inclined; a single sting, applied as it is to another fly that is to serve as food, would forever rid her of one of these troublesome intruders. Both the French and the American observers fail to offer an explanation for the phenomenon. It may be that the sting is not used on other occasions than the capture of prey, just as is the case of the queen domestic bee the sting is never drawn except in mortal combat with a rival queen. Since it is always certain species of parasitic flies that are in attendance upon the wasps, it may be through mere familiarity with the flies, and the presence of those so near to the nest, that they are so much tolerated. For the flies are in every way treated like other wasps of the same species. I have seen a *Bembex* knock down another *Bembex* or a *Microbembex* and have even seen them clinch as if earnestly engaged in fighting, but they never drew their stings.

Notwithstanding the half hearted efforts of *Microbembex* to rid herself of her enemies, these follow her to her nest. Having arrived at the nest the wasp opens it, grasps the caterpillar with her hind legs and drags it inside, walking in head foremost. *Ammophila,* it will be remembered, backs into the nest and pulls her caterpillar in backwards.

(2) Another common object brought in by *Microbembex,* was the *leg of a grasshopper.* On several occasions I saw this carried along in the same way that the caterpillar was carried. Once an ant was making away with the leg of a grasshopper which it had probably purloined from the *Microbembex* herself. The wasp many times picked up the leg but the ant would not let go, but forced the wasp to drop it, until the latter gave up the fight.

(3) *Twelve small queens of ants.* These had been dead for some time. They all probably came from the same spot, as they were brought home in quick succession. The nest was left open while the queens were brought in, which is an exceptional thing for *Microbembex* to do.

(4) *Large red ant. (Pogonomyrmex Apache.)* I once saw a *Microbembex* pick up one of these fierce species and fly with it to a mesquit bush. There she hung from a twig by her front legs and held the ant with her other legs, while she bent her abdomen under her in her attempt to apply her long protruding sting. The ant seemed dead when I first saw the wasp pick it up and had probably been stung before; or the wasp may just have found the ant dead. That *Microbembex* does attack the living ants seems probable from a struggle I once saw between a wasp and two red ants, one of which had probably fastened its hold upon the wasp at the start until joined by the companion. The wasp was evidently dead when I took the two into a bottle with some sand. As I turned the bottle and so covered the insects with sand, the ants crawled to the surface and immediately began to dig down again to pull forth their dying adversary.

(5) *Flies* of various kinds, particularly Syrphids. On one occasion I noticed a wasp fly to a weed and hang there by one of her hind feet while with the remaining five she held an apparently dead Syrphid. I could approach very close to her and could see how she held the fly and alternately apply her mandibles and proboscis to the fly's thorax. It is probable that *Microbembex* was this time enjoying a little fly-juice for herself. Her action reminded me of *Odynerus dorsalis* which hung from a bush in the same manner and chewed a caterpillar, which she never does when this is intended for her larvae. Most solitary wasps suck the nectar of flowers for their sustenance.

While *Microbembex* was working on the fly, she several times dropped it and found it again without any trouble, knowing evidently that the fly was to be found on a plumb-line from where it was dropped. Once when the wind blew the fly out of the plumb-line, the wasp had some difficulty in finding it, as she persistently searched where the fly should have been. Thus spider-catchers have learned to find their spiders if these fall straight down from the place where they have been lodged.

(6) *Bugs* belonging to five or six different species and varying from two to twelve mm. in length. Some of the bugs were perfectly dry, others were fresh when brought into the nest.

(7) *Small tree-hoppers, Tettigonia bifida, Say,* the species which form the sole prey of *Allyson melleus* and of *Rhopalum abdominale.*

(8) *Polistes rubiginosus,* so dry that it broke apart while *Microbembex* was carrying it.

(9) *Fresh grass-hopper,* which I killed and threw on the nesting-ground, was picked up by a *Microbembex,* as was also a dry Syrphid.

(10) Dry yellow Mutillid.

(11) *Old Orthopterous pupa-case* with dry dead pupa inside. Of all the things which *Microbembex* feeds to her larvae, these last two things are the toughest. The Mutillid must have been a most indigestible morsel, for the skeleton is so tough that in the fresh state it is very hard to drive a strong pin through it. The Mutillid was broken in two and the halves were carried off separately.

The above account gives one a very fair idea of the diet of larval *Microbembex.* It thus seems probable that the larval food consists mainly of insects, which the mother finds already dead and often dry. This is, moreover, borne out by the manner of the wasp's hunting, in which she differs decidedly from the solitary wasps and resembles markedly *Polistes* and *Vespa. Bembex* hunts her flies in a stormy fashion, flying around louder and faster than the prey she captures. *Microbembex* can be seen calmly flying through the woods much like a dragon fly, steadily maintaining a level of a foot from the ground. That she also attacks live insects is shown in that she attacks ants and in that her caterpillars are always limp and fresh. A fresh juicy caterpillar sandwiched in between a lot of old dry insects must indeed be a very welcome morsel for the growing larva.

It would thus seem that *Microbembex,* contenting herself with any insect she finds, has an advantage over *Bembex,* her nearest relative, and *Monedula,* both of which feed their larvae from day to day. But quantity alone does not bring the advantage. No doubt *Bembex,* knowing the habits of her prey, and having developed a skill in its capture (being a specialist in the art of fly-catching), can collect as much real nutritive substance as *Microbembex.* Though more generalized in the manner of procuring food, *Microbembex* has developed an improvement in her condition over *Bembex tex.* in that she closes her nest before leaving it, often smoothing it over with considerable care. In this way she is spared the inroads that commensalistic larvae make into *Bembex's* store of food.

In their semi-social habit *Bembex* (and this would apply to *Microbembex)* has been regarded as transitional between the truly solitary and the social wasps. Both genera are more solitary than social for their only social trait consists in a tolerance of each other's presence in the immediate neighborhood. Beyond an occasional quarrel or the stealing of each other's flies the wasps preserve the peace of the colonies. This recalls by way of contrast the fierce combat of two *Ammophilae* which happened to dig their nests near each other. *Bembex* is furthermore said to show a social trait in the co-operation of the individuals in driving away parasitic flies. This is, however, more imaginary than real, for the fly is not killed nor is it driven away from the colony but merely from one individual's nest to another's.

Both *Bembex and Microbembex* are common species throughout the sandy woods. Every path or road or other area devoid of vegetation is occupied by individuals of these flourishing species. If an open spot is a favorable nesting place, wasps may congregate there in numbers sufficient to riddle the surface with holes, thus forming an extensive colony. Now, since such spots are not common, the thought suggested itself that the very numbers of the wasps forced them to occupy the same patch of ground, to dig their nests side by side, and thus by virtue of their familiarity with one another to live together in comparative peace. The tolerance of one another's presence would then be the first trace of the social instinct. The fact that the *two* different genera live together as peacefully as does *Bembex* with *Microbembex* seems to point to the same conclusion. Moreover, neither genus seems to show a marked predilection for living in the colony, for isolated individuals of both will be found throughout the woods, evidently as happy as when joining in the busy hum of a colony in the noon-day sun.

May it not even be that in this way numbers was the first stimulus toward social life as shown by a trace of it in *Bembex* and *Microbembex?*

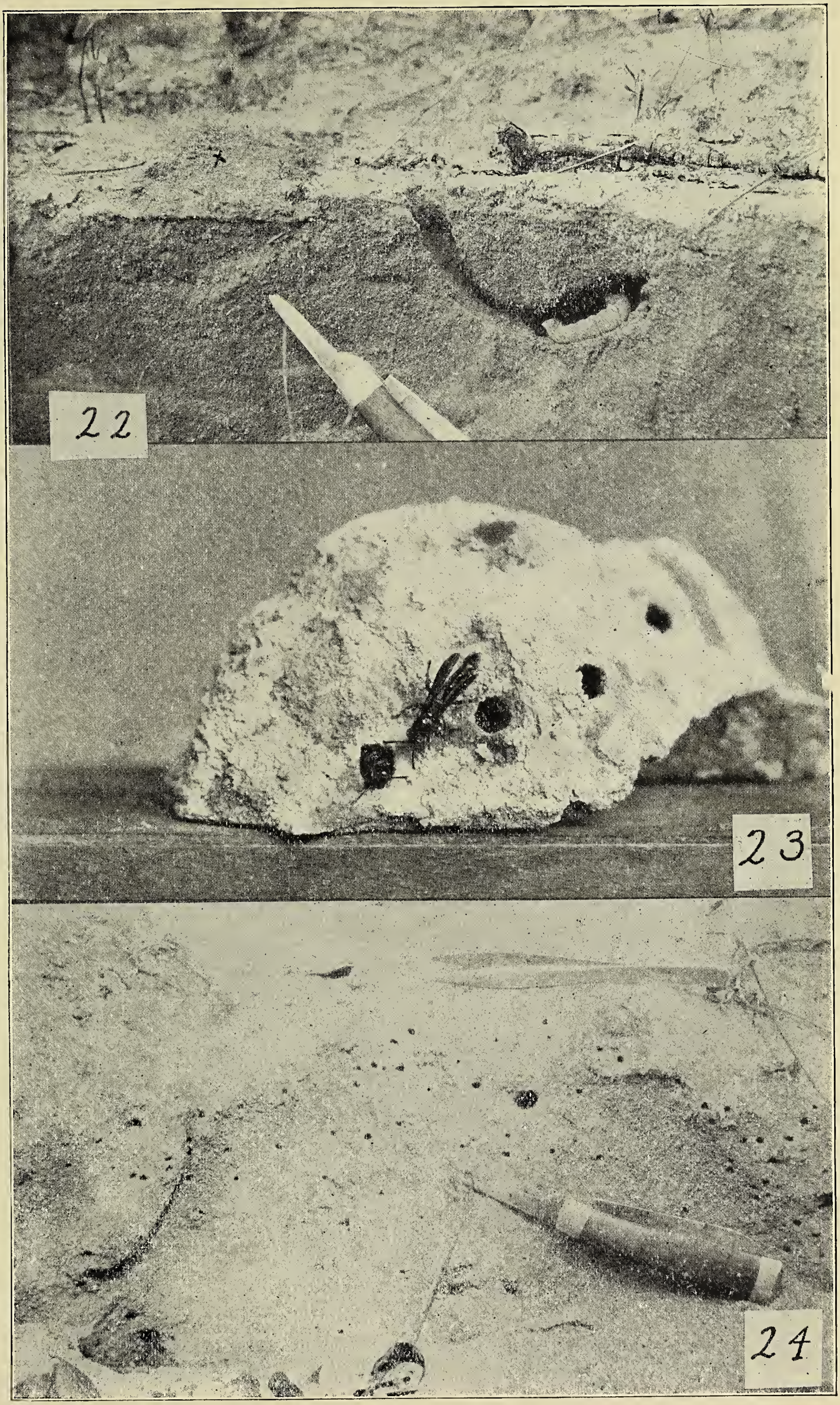

Plate IV. Hartman, Solitary Wasps.

IV. SOME FLY-CATCHERS.

(A.) MONEDULA CAROLINA, DRURY, THE BIG FLY CATCHER.

Monedula carolina is our largest digger-wasp with the exception of *Ammophila procera.* But the caterpillar-wasp looks comparatively weak, being slender, while the big fly-catcher has a most formidable appearance on account of her bulk and the warning yellow stripes of her abdomen. In the hot months of the year the wasp is often met with in search of prey or digging her nest in the sand, where she cuts a conspicuous figure. You cannot proceed far through the woods before one of the big fellows will come flying toward you with the loud threatening buzz of a bumble-bee. The wasp will fly around you to examine you on all sides, keeping her face turned toward you and as you advance, she will advance with you flying backward before you. This backward flight of Monedula, almost unique among insects, recalls the habit of the South African wasp, cited by the Peckhams, which is said to fly backward before a moving horse and catch the flies hovering over it. On the authority of a friend of mine, I can say the same for Monedula, which often followed his ox-team, picked off the flies and "buried" them in the ground. I have myself seen as many as three *carolinas* around a horse or cow at the same time and there can be no doubt that they do not hover around for curiosity's sake merely.

M. carolina spends three or four days digging her nest. The first two days she applies herself assiduously for hours at a time and will scrape out an astonishing pile of sand. Her working hours are, however, extremely irregular, especially on the third and fourth days. She may return to her nest at any time of the day, taking an hour or two for recreation in the midst of her work. I have seen her begin her nest in the morning before any digger-wasp was astir, work several hours with diligence and then close the nest and fly away, perhaps not to return again for work until late the next afternoon after *Bembex tex.* had retired or was playing hide and seek among the nests of her colony. *Carolina* is, moreover, least susceptible to the influences of the weather; for, while other digger-wasps will lie listlessly about on a cloudy day or sip nectar from the flowers, she may be as busy as ever.

Like the La Plata species, *Monedula punctata, Monedula carolina* lays a single egg in the empty nest and waits for the larva to hatch before she begins to lay in a supply of flies. This explains her leisurely behavior on the third and fourth days of the nest, when she digs spasmodically or even visits the nest without working at all.

After the long and slender egg (six mm. in length) has hatched, the larva is kept well supplied with flies. These belong to any of the common species in the woods, *Musca domestica, Calliphora vomitoria* and especially the large *Volucella escurieus, Fabr. var. Mexicana, Macq.* She does not confine herself to a single species of fly as does *Thyreopus argus,* which preys on a species of *Dolichopus.* The size of the fly is not graduated to the size of the larva, as is said to be the case with Bembex, but it appears that the first fly met with, large or small, is captured and brought home. The wasp carries the fly with her middle pair of legs and on entering passes it deftly back to the last pair. This habit seems to be characteristic of the Bembecids in general.

The larva is fed for at least eleven days; I observed one individual continue this from Aug. 17th to Aug. 28th. During this time, twenty-four or more flies had been brought in, since, when I dug up the nest, I found the large larva, (which spun its cocoon the next day) surrounded by the remains of empty dipterous skeletons: 24 heads, 11 thoraces, 8 abdomens and many wings, the hardest parts of the different species of flies having been left. Fig 15 represents a pupa surrounded by the remains of flies in the sand.

M. carolina shows a remarkable variation in habit in that she sometimes closes her nest before she flies away, sometimes leaves it open and this applies to some individuals as well as to the species as a whole. Of the eleven specimens that I observed, six closed the nest carefully each time they left it; two always left theirs open; two closed theirs once or twice in a slip-shod manner leaving it open at all other times; and one closed hers carefully until she begun to carry in flies, when it was never again closed until the larva was full grown.

Each individual performs the final closure with scrupulous care, the whole tunnel being filled with sand and the surface smoothed over in the radius of a foot. One wasp kept returning to the nest occasionally for several days to throw more sand over the entrance to her old nest until she had kicked up a pile of sand three inches deep.

Monedula's nest is the largest digger-wasp nest I know. The entrance, seen from above, has the form of an arch which measures about an inch across the base and three-fourths of an inch in height. Fig. 7 shows the wasp just crawling forth from her nest. The nest is a cylindrical tube more or less bent. It is three to five-eighths of an inch in diameter and runs down in a gentle slope for eighteen inches to a slight dilatation, the chamber, nine or ten inches below the surface. Fig. 21 is a photograph of a nest in section. It shows at about its middle point a rather abrupt turn to the left.

If the nest has been closed, *Monedula* opens it without dropping her prey which she may happen to be carrying home. If the fly is accidentally dropped it is always discarded, even carried off to a distance and flung away.

This fly-catcher, like the other fly-catchers of the family, stings to kill its victim. Every fly that I examined was dead, even those just brought home and dropped before the entrance.

(b.) Notes on the Stinging Habits of Tachysptex Texanus, Cr., Bembex Texanus, Cr. and Notoglossa (Oxybelus) Americana, Rob.

It has been supposed of a number of fly-catchers that they pounce upon their victim in mid-air. This seems to have been the case with a specimen of *T. texanus* that come under my observation. I was busy working in the sand when I heard a light buzz at my right. *Tachyptex* was inflicting the death-sting on a fly of the domestic species, much larger than herself, and the two had dropped to the ground from above. Possibly the fly had been attacked while resting on a branch of a near-by tree but circumstances pointed rather to the conclusion that the struggle had begun with both on the wing. The fly lay helpless on its back and the wasp lay across the fly's thorax curled around the left side with her sting fixed in the fly's sternum. I placed the tow in a collecting-bottle with some sand. For two minutes the wasp held the fly impaled on her sting while she spent some time washing her face and antennae. She also walked around in the bottle, still carrying the fly, until she discovered that she was imprisoned, when she dropped her victim and flew excitedly around.

This observation recalls Fabre's assertion that *Oxybelus* carries home the flies impaled on the sting. The Peckhams, however, found that the wasp holds the fly with her hind legs and allows it to protrude so far beyond the abdomen as to give it the appearance of being attached to the sting.

About the noon hour on a hot, sunny day, when the impulse to hunt is at its height, *Bembex* can be seen following her favorite occupation. One would suppose that where flies are most plentiful there the wasp would most often be seen. And this is found to be a fact. The hunting and stinging habit of *Bembex* may readily be observed by watching a pile of horse-droppings near a Bembex colony. Flies collect and a wasp soon comes along to collect flies. She buzzes furiously about and the timid flies instinctively creep away as if to hide from their hereditary mortal enemy. The wasp makes a dozen or more circuits in the wildest zig-zag fashion darting again and again at flies on the dung-heap. Flights of this kind alternate with periods of rest on the sand near by, where the wasp stops to wash her face and smooth her wings while the motion of her abdomen betokens the rapid breathing occasioned by the strenuous exercise. After a number of trials, usually many, *Bembex* succeeds in pouncing on a fly. Quick as a flash the wasp is off for her nest with her victim. The operation is performed so quickly that it is utterly impossible to determine how the fly is captured and stung. I therefore captured a fly and pinned it down. *Bembex* returned, took hold of the fly with her legs and at the same time arched her abdomen under and stung the fly on the under surface of the thorax. The fly failing to yield to her efforts, the wasp immediately rose, caught sight of another fly and succeeded in capturing it. After a few moments she was back and attacked my fly as before. I then removed the pin. The wasp took up the dead fly four times, rejecting it each time after having risen several feet in the air. It did not take her long to find out that there was something wrong with her capture.

A wasp will return to the same hunting grounds until her larder is filled for the day. I have seen one wasp carry off as many as eight flies in quick succession. A number of times, too, I have amused myself by allowing a wasp to take a dead fly from my hand, so that I could feel the active little creature as well as observe its every movement. Two wasps of a species cannot agree to hunt together at the same place—they will quarrel in angry tones until one will withdraw and priority seems, in vespine races, to be the claim usually recognized.

But the tiny black *Notoglossa* with her red-tipped abdomen will pay no attention to the big *Bembex* buzzing about. Though scarcely a quarter of an inch in length she hunts much like her comparatively gigantic congener. Her prey consists of gnats and other very small flies which she catches with greater facility than *Bembex* catches her prey. I have seen *Notoglossa texanus* rest on horses' feet and "loaf around" for hours, apparently on the lookout for her quarry. On one occasion I saw a tiny wasp appear repeatedly among a swarm of gnats that had gathered around a sore on my horse's ear.

V. THE BUG-HUNTERS.

(a) Bembex Belfragei, Cr., the Big Bug-Hunter.

Four times during the season I had the pleasure of observing individuals of this interesting species at work. The species is rather a common one, and I should have observed more individuals had I had time. She is enjoyable company, for she does not object to one being near her. Her prey, however, I should think, might consist of a more inviting kind than the bug she captures, being stinkbugs at that.

B. belfragei is one of the first solitary wasps I saw in the field and is chiefly responsible for inducing me to spend several weeks among them. I came upon the first specimen on July 16th at 9:12 o'clock a. m. digging her nest in a wagon track. She had already made considerable progress in her work, for she seemed to bring the sand from some depth. She would remain out of sight for thirty to fifty seconds, then push up a load of sand and kick it out of the entrance. Fifteen to twenty seconds she would spend on the surface scattering the sand away from the entrance, as is more extensively the habit of *Bembex tex.* and *Monedula carolina.* When at work digging *B. belfragei* cuts about the same figure as *B. texanus* described above. The tibiæ and tarsi of the front legs with their long spines are used to scratch the sand and throw it back under the wasp's body. Each time the head goes down, a single stroke of the leg is given and not several, as is the case with *Bembex texanus.*

Once a Mutilled, five or six species of which are common in the woods, came running along the wagon-track, looked into the nest and greatly excited the owner, for the latter flew up with an angry buzz, darted at the intruder and put her to flight.

At 11:40 the wasp began to interrupt her work by rising into the air, circling several times, settling some distance from the nest and then returning to work. She repeated this three or four times; finally at 11:47 she came up from her nest, headforemost, instead of backwards, with sand, as she had been doing. She then closed up the entrance by scratching in sand until the entrance was covered flush with the surface and then flew away. After an absence of twenty-eight minutes, she returned and entered the nest without my seeing it, remained inside one minute and came out, closing the nest as before. This time she flew off without first circling about the nest.

While the wasp was gone on the second hunting trip, a large Mutilled again came along, scratching at a great many places, here and there. Thus also she removed the sand from the entrance of the wasp's nest, though she did not enter, but merely looked in and passed on.

At 11:33 the wasp came back again with a large gray bug, alighting with it just in front of the entrance. I expected her to show some agitation at the disturbance made at her nest by the Mutilled; she appeared not to notice it, however, but holding the large bug with her middle pair of legs and balancing herself on her hind pair, she dug away some sand with her front pair. She then dropped the bug and crawled over it into the burrow. In a few moments she came up, head foremost, grasped the bug by an antenua with her mandible and drew him inside. In one and one-half minutes, she came out again, closed her nest carefully and flew away.

During the afternoon *belfragei* came home without a bug. A wagon had just came along and unfortunately cut away several inches of the burrow. Such a widespread disturbance in front of the nest would drive an ordinary wasp out of her wits. But this level-headed bug-catcher seemed, in spite of it, to know just where her nest was located and went to work clearing away the sand that had caved in. As she progressed, more and more sand fell from above and I assisted her by making an arch-way above with a piece of white paste-board to hold up the sand. Soon she had the nest open again and at 4:33 she flew away, this time leaving the nest open.

At 8:25 on the following morning, wagon-wheels had again covered up all the trace of the nest and *belfragei* was again in a quandary. Believing that she could not find her nest this time, I proceeded to find it for her by cutting off slices of sand with a hoe in the direction of the nest until I came upon the tunnel four inches from the original entrance. All the time the wasp remained near the hoe like a playful kitten,—a remarkable performance for a wasp. She flew away before I had quite finished but returned in three minutes and went straight into the hole which I had prepared for her, resuming her work as though nothing had happened.

At 8:42 the wasp flew away leaving the hole open. At 10:55 she had been back with a bug, which she took in as before, and had flown away after closing the nest behind her. This was the last I saw of her. On July 21st, I returned to dig up the nest but failed to trace it.

The individual whose actions were just described (No. 39) was the least sensitive to my presence of all the wasps I have known.

Once I took her up in a bottle, and as soon as released she went on the even tenor of her ways. Other specimens I observed, while not annoyed at my presence, resented any movement on my part. They differed rather markedly also in the manner of their approach to the nest and of carrying their prey.

My second example of *B. belfragei* having dug the nest completely in the forenoon, carried into it four bugs from 1:42 to 4:10. Holding the bug venter uppermost with her middle pair of legs, the wasp would settle upon the sand that closed the entrance and stop there for nearly a minute in a listening attitude. Perhaps she was getting her breath after the long flight with her burden, for her abdomen would heave up and down after the manner insects have of breathing. At any rate, the delay in getting the bug under cover must be disadvantageous to the species for the reason that it gives parasitic or commensalistic flies more time to smell the bugs and find the nest. The habit is widespread within the species, for nearly all the individuals I saw act in this way. This hesitation at the entrance forms a striking contrast to the habit of *Rhopalum* which dives into her open doorway.

Assured that all is well, *belfragei* opens up the nest with her front legs, still holding the bug with her middle pair, and walks in. When just inside, she passes the bug back to the third pair of legs, or, dropping it, she advances until she can conveniently grasp it with the third pair. Then she picks it up again and passes on, the bug now projecting beyond the tip of the wasp's abdomen.

At 4:10 p. m. the last bug was brought in and the wasp began to permanently close the nest. After remaining inside for seven minutes, she came forth scratching the sand back to fill up the tunnel, biting it loose from the sides, pulling it from the surface and pressing it down with her abdomen. I caught her when she had nearly finished, and opened the nest. The tunnel, three-eighths of an inch in diameter and ten inches long, was entirely filled with sand and could be traced only by virtue of the dryness and the light color of the sand stuffed in. The pocket was one inch long and five-eighths inch in diameter and was five inches below the surface of the ground. It contained seven bugs. The egg was attached to the mesosternum of the bug and was directed forward so that it extended for a distance along the proboscis (Fig. 14.)

The bugs taken from the nest were all of the family of *Lygaeidae*. Of the seven, three kicked violently when touched and the remainder showed some signs of life. After a day and a half three bugs were still alive, while the other four had just died. The former lived at least half a day longer. On Aug. 28th three large fly-maggots (Muscids) were crawling around the sand in the bottle as if trying to get out. The egg had disappeared.

My third specimen (No. 46) came swooping down from the tree tops with her heavy burden. I have never seen the species out on the hunt, probably because she hunts altogether among the trees, the home of her prey. Each time No. 46 came home with a bug she descended out of the tree that overshadowed the nest. She carried in five bugs in two and a half hours, completing her labors at 7:00 p. m., when she closed the nest. The nest was probably dug and provisioned on the same day (Aug. 27th), as was that of No. 39, judging from the late hour at which the bugs were caught. I failed to trace the tunnel this time but came upon the chamber containing the bugs, which were all broad, gray ones of the genus *Crytomenus*, excepting one, a slender purplish bug belonging to the *Lygaeidae*. This latter was the first brought in and contained the egg which was attached in the identical manner as that of No. 39. If the egg was laid just after this first bug was carried in the length of the egg stage of this species is forty-one hours. The larva died after three days. Three bugs lieved two days; the other two were brought in dead. These bugs and the wasp's egg are shown in Fig. 14.

The fourth and last specimen on which I have notes finished digging her nest by 10:12, Aug. 31. As was the case with No. 1, she made a series of locality studies in preparation for her first departure by walking around on the sand in the neighborhood of her nest. At 10:12 she closed up the entrance carefully and flew away. At 1:00 o'clock I returned to the nest, which was closed. At 1:27 the wasp returned, coming down out of the neighboring trees. She did not descend in a sudden continuous swoop, but in gentle jerks as if she were descending a flight of stairs and had to pause at each step to adjust her load. This jerky motion goes on until she hovers over a bush two feet high standing between the wasp and the nest. Then she takes a sudden dive through an opening between the branches of the bush and lands on her nest. This strange mode of approach was used each time a bug was brought home, at 1:27, 2:17, 3:27, 4:41. It thus required over an hour for this individual to catch a bug as against one-half hour for the others.

The chamber of this nest, which was closed like the others, was about the same dimensions as noted for the nest of No. 39. It contained five bugs, one of which was dead, three nearly dead and one so little paralyzed that it kicked spontaneously. Three of the bugs lived one day, while the lively one lived for five days.

The egg had the conventional position on the sternum of a bug, but it was soon lost. A Muscid larva pupated on Sept. 3d and some Phorid pupae were also present in the bottle on Sept. 15th.

It is thus seen that *Bembex belfragei* displays a considerable amount of individual variation in general disposition, in the manner of approaching and leaving the nest, in the time required to dig and store it. The effect of her sting is also variable, the victim being killed outright or living as long as five days. It may be said that this wasp is a novice in the art of stinging her prey, though she shows considerable more skill than *Bembex texanus* or *Monedula carolina.*

(b) Bembidula Parata, Prov., and Bembidula Pictifrons, Smith.

Of these interesting and rather common species my notes show observations on only four individuals. From a study of their habits I concluded that I was dealing with a single species. However, No. 58 below was identified for me as *B. parata* and No. 48 as *pictifrons*; of the others I am in doubt. Since the habits of the two species agree so closely, I shall describe them as if they were really a single species. The wasps are smaller and stouter than *Bembex belfragei,* big bug-catcher, and the yellow bands on the abdomen and thorax are comparatively broader and more intensely yellow than those of the latter, so that as the wasps fly around the impression of yellow is the predominating one over that of black, the predominating color of *belfragei.*

Specimen No. 58 I observed from the time she was flying around in search of a suitable place to dig her nest up to the final closing. The wasp began digging at several places and finally chose the side of a shallow pit where only the day before I had dug up an *Ammophila* nest. The pit was six inches deep and the nest was begun three inches below the upper edge of one side.

Bembidula digs much like the other members of her family already described: *Bembex, Microbembex* and *Monedula.* During the progress of the work of digging the wasp makes short excursions, (on foot chiefly), around the neighborhood. Wasp No. 58 continued digging for about two hours and at 12:30, when she had finished, she closed the entrance with sand. Before venturing away from her nest for the first time, she made a rather careful study of the locality, flying in and out among the herbs and bushes. In closing her nest, No. 58 had more difficulty than her sisters because her nest opened on a sloping surface like a cave on the face of a precipice. In other cases, where the nest ran down from a level surface, there was left after closing a shallow elliptical depression like a gentle finger imprint almost characteristic of the species. I frequently made use of this depression to tell whether or not a wasp had visted her nest during my absence: I would smooth the entrance over and if the pit was visible on my return I had reason to believe that the wasp had come and gone. Bembecids as a rule are not easily disturbed by changes around their nests, as is the case with the Pompilidae to a high degree. In the case of the species under consideration, I often smoothed over the sand covering the entrance, but this in no way, as far as I could detect, disconcerted the wasp on her return. Sometimes I would, in addition, lay a blade of grass over the nest. The wasp would nevertheless find the nest immediately, and merely kick the obstruction away. One individual, with a temper, once picked it up with her mandibles, carried it off to a distance and flung it angrily away.

At 12:30 the nest of wasp No. 58, which I began to describe, was completed and the wasp had flown away. I was at the time trying to keep four nests of three different species under observation and therefore failed to see this one enter her nest on her first return.

At 3:07 she came back again and descended slowly toward the nest. When within three inches of the surface, she hovered an instant, then dropped suddenly like a dead-weight and after a moment's pause at the entrance opened it up and walked in. As she entered I could see her pass a very small bug back to her hind legs in so deft a manner as would do credit to a slight-of-hand performer. She remained inside but a minute, then came out, closing the nest behind her. In every case that came under my observation this species closed the nest thoroughly before flying away. On her return she approaches cautiously and, when just over the nest, drops suddenly upon it. Moreover, she always carries the bug with her middle pair of legs and passes it back to the third pair on entering.

At 3:39, the wasp was back again. Her manner of approach this time was quite different than before. Instead of flying directly down toward the nest, she flew back and forth above it in nearly parallel lines like a pendulum with ever shortening oscillations. This manner of approach she employed nearly every time. Other individuals of the species showed a habit approaching this, though not so marked.

At 4:31, No. 58 came back again, but not straight to the nest. She flew around from bush to bush in the vicinity, hanging from the twigs a minute at a time. Once she allowed me to come close enough to see distinctly that she was hanging upside down by her first and third pairs of legs, while with her middle pair she clasped a small bug, holding it by its interior end, head directed forward. After thus "hanging around" for some minutes, she returned to the nest after her wonted manner.

The next two days, Sept. 4th and 5th, were also spent in procuring provisions. The nights were not spent in the nest; this was carefully closed at the last departure in the afternoon and the night was spent in other parts. I have seen the species late in the evening dig a shallow nest and crawl into it for the night, closing it from the inside.

At 5:33 the wasp brought in her last bug. It was fourteen minutes this time before she again made her appearance for the reason that she was now making the permanent closure of the nest after the manner of *Bembex belfragei*. After the burrow was filled with sand she scratched the sand all around the nest, even climbing to the top of the bank three inches above pulling down the sand. In this way all trace of the nest was obliterated. I immediately dug up the nest. Eighteen bugs were found in the lower, somewhat dilated end. There was no wasp egg or larva but three large fly-maggots were busy eating the store of food.

Specimen No. 48 began digging her nest at 9:15 a. m., Aug. 31st and finished at 10:55. She, too, made an extensive locality study among the weeds in the vicinity, returning to the nest several times before flying away. She stored five bugs the first day. A parasitic fly, *Masiena sp.*, kept hovering around the nest and twice, when the wasp returned with a bug, the fly flew up four feet or more to meet the wasp and as the latter descended, gradually the fly flew backward ahead of the wasp, maintaining a distance of about three inches from her until the two reached the nest. After this was opened and the wasp had entered, the fly went in also and came out just ahead of the wasp. In the nest I found five bugs, one of which held the egg which was attached exactly like the egg of *B. belfragei*.

No. 50 began digging her nest at 9:30, only five feet from that of No. 48, also on the same day. She stored her bugs in the afternoon of September 2nd. As the wasp had not visited the nest after 11:20 Sept. 2nd, I opened the nest at 8:00 a. m. Sept. 3rd and found a large larva among ten bugs, the viscera of most of which had already been eaten away. The nest is shown in Fig. 19. It was a compound curve sloping downward and toward the right for a distance of eight inches. The pocket, four and one-half inches from the surface, was one-half inch in diameter and three-fourth inch in length.

The larva began spinning its cocoon at 10:00 a. m. Sept. 5, i. e. on the fifth day after the egg was laid. It never quite finished spinning, though the pupa lived for ten days.

(c) HOPLISOIDES, SP?

This is a little brown wasp with yellow stripes, inconspicuous on account of its small size but of very energetic and business-like airs —like certain under-sized people. The species is rather rare, as I have seen only several specimens and but one actually at work on her nest. While I was standing in the shade, awaiting the return of several bug-catchers that had gone hunting, a Hoplisoides dropped down in front of me. She was carrying something which she let fall and immediately began digging for the entrance to her nest. She had evidently lost trace of this, for she dug at a number of places in vain. Bits of dried leaves and bark were strewn about and these were kicked away as though they were the cause of the wasp's mistake, instead of being fit land-marks by which the wasp might have been guided and the mistake prevented. As it was, some minutes were spent in finding and opening the nest. When this was done the wasp walked in. Assured that all was right, she came out and seized a piece of wood of the size and shape of the bug she had brought, rose on the wing to the height of a few inches, settled at the entrance again and walked in. I expected her to take in the bug lying in the entrance; but the piece of wood was carried in first and this I afterwards found in the chamber among the bugs of the wasp's collection. She came out after this delay of a few minutes, seized the bug, rose on the wing after the usual manner, settled at the entrance and walked in with the bug, holding it under her abdomen with her middle legs. When only half inside the bug was dropped while the wasp crawled inside over it. After ¼ minute the bug was pulled inside from within, as is occasionally done by *Bembidula*. In one-half minute the wasp came out, closed the nest and after making a few detours at the height of three to four feet, flew away.

At 4:10 she came back again with another bug. This time also she encountered some difficulties in finding the entrance though there were many sticks and leaves about to guide her to the exact spot. *Bembex* or *Microbembex* or *Ammophila* never has so much trouble in getting into her nest even when there are no well recognized land-marks present to guide her. But instead of "making haste slowly," this wasp loses time and energy in the hurry. She immediately begins to dig for the entrance after having dropped the bug, unlike Bembex, which continues to keep hold on the fly for some time while digging. After the nest has been opened, the bug is taken in exactly as before. In a minute the wasp comes out again backwards, scratching out sand, possibly some that had caved in. Finally she comes out head first scratching out sand, closing the entrance imperfectly, and flies away. By 4:51 she had come back again and was busy excavating the nest, scratching the sand with her forefeet and pushing it out with her abdomen. In this way she soon closed the entrance from within and remained inside one minute. At her appearance this time, she came out head foremost, scratching in sand as she came, after the fashion of the larger bug-catchers above described, when they are ready to close up the nest and leave it. This I supposed *Hoplisoides* to be doing in this instance and my suspicion proved to be wellfounded, because, when the nest was nearly filled with sand, the wasp began to carry into it bits of debris, that lay scattered about continuing at the same time to scratch in sand on top of them, like *Ammophila* is wont to do. While busy on the surface *Hoplisoides* holds her wings extended out obliquely like the social wasps. When held at a certain angle to the sun's rays, the wings have a metallic blue lustre.

Convinced that the work on the nest was nearing completion I caught the wasp and immediately dug up the nest and came upon the chamber three-eighths inches in diameter and one-half inch long, five inches from the entrance and two and one-half inches below the surface of the soil. The passage from the entrance to the chamber was filled with sand and could be traced only near the ends.

The chambers contained seven bugs, among which lay the above mentioned piece of wood as though the wasp had carried it in, supposing it to be a bug. The bugs were all nymphs of the same species, one of the family *Membracidae*. Three of the bugs responded to stimulation. The egg, 2 mm. in length was attached to the ventral surface of the bug close to and parallel to the margin of the thorax opposite the first and second pairs of legs. From its position I supposed this bug to be one of the last brought in.

On September 4th, two days later two bugs responded to stimulation by a slight twitching. The egg looked dead on this day and finally withered.

(d) ALYSON MELLEUS, SAY.

A. melleus is a slender wasp, less than half an inch long, in shape and size much like Agenia, the little spider-ravisher. Black is the predominating color of her body, her head, antenuae, tip of wings, and abdomen having that color, while her thorax and wings are red. She is, moreover, easily recognized by the pair of round white spots on the sides of her abdomen. She resembles the *Agenia* mentioned also in the easy grace with which she flits from place to place when on the hunt, which is mostly done on herbs and bushes. She runs swiftly up and down the stems and over the leaves, both the upper and the under sides, often darting like a flash to another branch or to another plant.

The species must be rather common in the woods, for I have often seen her on the hunt and have several times seen her at work on her nest. She always selects the sloping sides of a pit as a location for her nest, at least I have never seen it at any other place. Fig. 24 is a photograph of the side of a pit perforated by holes dug by a number of species of *Oxybelus, Alyson, Bembex,* and others. There is an evident advantage to such a location over the usual position of a *Bembex* nest, which runs down from a level surface, for Mutillids of various sizes, running around in great numbers, never climb up a sloping surface to find the nests of digger-wasps.

The nest of *melleus* is always left open, day and night, which might give inquilines and parasitic flies a chance to get in. But the narrowness of the nest (two or three mm. in diameter) would keep out large flies and the great depth (12 inches) would tend to prevent smaller flies from finding the store of food.

The excavation is carried out after the usual manner of wasps, the sand being loosened with the mandibles, scratched back with the forefeet and kicked out with the hind pair. The work of digging the nest is all done at once, though some dirt is brought up from time to time after the provisioning has been begun.

My first specimen, No. 15, alighted in the bottom of the pit shown in Fig. 24 and walked over to her nest. It is the habit of the species to alight from three inches to a foot from the nest and then run over to it. No. 15 carried in her mandibles a small green leaf-hopper (*Tettigonia bifida, Say*). She entered the nest, remained inside a few seconds and was off again. She returned in three minutes with another leaf-hopper and made two more trips in seven minutes each by 5:19 p. m., when I left her. On my arrival at 10:00 the next morning she had been doing a little digging. At 10:30 she came up to the entrance waving her long antennae at me and looked out. She then protruded her whole head, examined the weather and slowly crawled forth. Soon another individual was running around, evidently getting ready for the day's hunt. This one was, however, destined to be shortlived, for she ventured too near a spider's nest, whose owner, a perfect mimic of the sand, was lying in ambush. Quick as a flash the spider was upon the wasp, gave it a bite and as quickly returned to its lair. The wasp collapsed in the same instant.

At 11:15 the first individual which I had been watching and which had returned into the nest, now came forth and, after making a locality study, was off.

As a storm was approaching, I captured the wasp on her next return, eighteen minutes later and dug up the nest. I found it to extend downward in a gentle slope for a distance of twelve inches to a chamber of one-half inch in diameter. The chamber contained seven leaf-hoppers but no egg.

Alyson oppositus is also common. It is somewhat smaller than *A. melleus* and shows its consanguinity to this species by the small round dot on each side of its abdomen as well as by its actions while on the hunt.

(e) RHOPOLUM (CRABRO) ABDOMINALE (FOX).

This wasp is rather abundant in August and September. The sexes can be readily distinguished as they fly around the low vegetation of the woods. The males have but one color, being wholly black, while the abdomen of the females is bright red in color. The thorax is very broad, which makes the abdomen, tapering gradually toward the pedicle as in the case of *Trypoxylon,* look very narrow. *R. abdominale* reminds me of *Trypoxylon* more than any other wasp in the manner of its flight, for both, while out hunting, are almost constantly on the wing and have a way of displaying their curiosity by touching with their antennæ every leaf or stick or blade of grass in their path.

Like *Diodontus americanus,* so well described by the Peckhams, *abdominale* has the habit of flying into her open door-way. It was this which first called my attention to her on September 14. The entrance to the wasp's nest was a tiny hole in the middle of a small flat elevation in the sand. The wasp approached the nest from various sides, but whatever direction she came from, she first took up a position directly opposite the entrance to her nest, where she hovered for the twinkling of an eye,—just long enough to give me a glimpse of the green leaf-hopper, which protruded a little beyond her red abdomen. After this momentary quiver in front of the nest, *abdominale* takes a beautiful bee-line right into her open portal. It is a pretty sight to see this dive into the nest; it seems to indicate a wonderfully keen sight for an insect thus to see the tiny hole from the height of four or five inches and to judge her flight so truly.

R. abdominale captures the same prey as *Alyson melleus,* leaf-hoppers of the species *Tettigonia bifida, Say.* She is a wasp of half the length of her competitor, but it takes her less time to catch her prey. On September 14th, she brought home seventeen to twenty leaf-hoppers, thirteen of which I saw carried in. The times at which this was done are as follows: 10:40, 10:55, 11:05, 11:20, 11:27, 11:35, 11:53, 11:57, 1:50, 1:57, 2:05, 2:09, 2:37. On each trip she remained inside but a few seconds. Her white silvery face was the first to appear at the entrance. Here she waited but an instant before she was off like a flash, often so quickly that I did not notice the direction of her flight.

Thyreopus (Crabro) argus shows the same haste in getting away from her nest and displays great acrobatic powers in the grace with which she slips into it on her return. Only once did *abdominale* hesitate a little, flying around the nest in a zig-zag manner, before leaving. The work on the nest was continued for at least three days, since two days were spent in storing alone. I failed to trace this nest, belonging to No. 67, but succeeded in tracing that of No. 70. This went in nearly horizontally for two and a half inches and then down nearly vertically for four inches with a uniform diameter of two mm. The tunnel had a small pocket at the bottom containing a number of leaf-hoppers, but no eggs.

VI. AGENIA, THE AMPUTATOR OF SPIDERS' LEGS.

(a) Agenia, sp. nov. and Agenia Accepta, Cress., Two Diggers.

The species of *Agenia* are the most agile of all wasps not even excepting those of *Pompilus* and *Aporus*. The genus is unique in that its members, I believe without exception, have the habit of cutting off their victim's legs. I have gotten glimpses of the doings of four species of Agenia; the two species first considered dig holes in the ground for their nests; the other species, which are considered separately below, build elliptical cells of mud in which to rear their young. Yet, though their nest-building habits differ so widely, their general appearance and their behavior when abroad in daylight make the genus easy of recognition.

Agenia (sp. nov.) and *Agenia accepta* are very closely related both as to habits and structural characters. The latter is half again as large as the former, is darker in color and has clouded wings. Both species have made a strong impression on my mind because of their striking resemblance to the Texas red ant, *Pogonomyrmex*. The new and undescribed species I have seen only in the sandy woods on the river bank below Austin; *A. accepta* only on the limestone hills in and about the city. The same fact of distribution obtains for the common species of *Pogonomyrmex; P. barbatus,* so common everywhere else in the surrounding country, does not occur in the sand land where *Poccidentalis, var. Comanche,* with its disc-shaped mounds, is very common. These two species of ants differ markedly in color and somewhat in size, Comanche being the smaller and of a lighter hue. The same differences exactly exist between *Agenia sp. nov,* and *accepta,* the former, the smaller and lighter species, occurring only in the sandy tract above mentioned. While this may be a mere coincidence it is worth stating that most of the individuals which I have observed, were either near or in the midst of a lot of red ants, which they resemble respectively in size and color. Whether this be a real case of mimicry or not, I would not say. But there is no doubt that the protection afforded is considerable as the sting of the red ants is very formidable and a thing to be dreaded, while that of *Agenia* is weak and can scarcely pierce one's skin. The resemblance to the ant is moreover very much heightened by the transparency of the wings, by which these are rendered almost invisible. In fact, the first specimen I saw I at first did not distinguish from the dozens of ants in whose company it was running over the ground. My eye was attracted by a peculiar object lying on the ground, which proved to be a legless spider, and with so many ants running around, I knew that the spider could not have been lying there very long. Presently indeed, the wasp disclosed her identity by making several of her characteristic leaps of a foot or more from side to side, as she approached the spider. She grasped it by an anterior coxa and was about to make off with it, when, for lack of time to follow I captured her. The spider not only had all of the legs removed, but one of the palps as well. It was a large Epeirid, an immense load for the little wasp.

The second specimen of this *Agenia* which came my way was the most skilful acrobatic performer I ever saw. She was carrying an Attid as long and much heavier than herself; but the load seemed a feather's weight, for she carried it along so swiftly, so gracefully and with so little apparent exertion. She was carrying this spider in her mandibles and using her legs entirely for running up stems and over leaves. It was her method of progressing to climb the branches of weeds and bushes to their very tips, and then fly either across to another branch or onto the ground as far as she could. In this she resembled certain species of *Pompilus,* which, however, differ in climbing up stems and running on the ground backwards instead of forward. Every movement of *Agenia* was as certain as it was swift, for she never missed her aim in flying from branch to branch. Her descent even was easy and graceful and she came to the ground as lightly as a feather. Thus for a time she chased on from bush to bush, climbing up the stems and descending to the other side. Suddenly our pleasure came to naught by the interposition of the suspending thread of an Agelina web. In these the two were caught, the Attid sticking fast and the wasp escaping. Nor did the wasp ever return, for I left the spider over night and during the next morning finding it still on the same spot the following noon. The spider had all the legs cut off except the anterior right; the palpi were present.

I have seen this species out hunting on several occasions and have found her to be a most thorough hunter. All her motions betokened the greatest excitement. In her quick flight from place to place, she strikingly reminds one of *Agenia accepta,* the second species, which darts around like her lighter cousin of the post-oak woods. I saw the first specimen on October 21st. Walking along the street, I chanced upon her as she dropped a large Attid among a stream of ants passing back and forth. She flew up as I drew near and I used the interval of her absence to examine the spider, which had all the legs amputated, though it was allowed to retain its palps.

Soon the wasp returned, grasped the spider by a coxal joint and carried it several feet further to the edge of a crevice in the ground. She then backed in, took hold of the spider and drew it down after her. Now came a test of patience which I failed to stand. After waiting three and three-fourths hours, I concluded that the wasp had escaped me, for I was used to quicker work of digging and storing a nest in sandy soil. I therefore dug down and found the crevice two inches deep, from the bottom of which the wasp had dug, almost vertically down, a nest one-fourth inch in diameter and three inches deep. Here I caught her, but failed to find the spider, which had possibly been left somewhere in the crevice.

The other specimen I saw was again advancing with its spider where foraging ants were numerous. In fact, as I followed her, she suddenly disappeared with her victim in a deserted entrance to the ant-nest. In this case the spider, as far as I could make out, had lost but one of its appendages.

It has not been my own good fortune to witness the amputation of a spider's legs by an *Agenia* but I here report the observation of my friends Messrs. Julius Eggling and E. Jaeger on this operation as it was related to me. *A. accepta* and her spider were the centre of the quarter hour's excitement. The spider, a large gray Attid, was resting on a fence post when the wasp flew at it and administered the sting. To tell just how this was done was asking the observers too much. In an instant the victim was limp and helpless and the wasp immediately cut off one of the spider's legs, the shreddy bark of the cedar post affording the wasp a pretty firm foothold. The spider thereupon fell to the ground but the wasp soon found it again and proceeded to carry it off. The spider's legs, however, interfered with her walking, for, as I have observed above, *Agenia* straddles her victim and advances forwards. The wasp dropped her burden and set to work to cut off with her mandibles two more of the spider's legs. This was done very quickly; after one, two or three trials the leg snapped off like the end of a wire snaps off when a pair of nippers is applied. The spider was then taken up a second time but again set down owing to the interference of the remaining legs. A few more legs were again nipped off and this process repeated a number of times until the legs were finally cut off all around, only the palpi of all the appendages being left.

(b) AGENIA SUBCORTICALIS (WALSH), AND AGENIA MELLIPES (SAY).

In contrast to *A. accepta* and her ally just considered, *A. mellipes* and *subcorticalis* have a sombre hue in perfect accord with the dark recesses where they build their adobe cells in secret. *Mellipes* is metallic blue, almost black in color and measures about three-eighths of an inch in length; *subcorticales* is somewhat larger and is distinguished by her red hind femora.

My only acquaintance among the members of the species *mellipes* betrayed the location of her home by the directness of her advance toward it. Under a leaf on the ground in the angle formed by two roots of a large elm tree was the wasp's nesting place and thither she was making trip after trip carrying pellets of mud for the construction of her nest. Like *Alyson melleus, mellipes* has the habit of alighting on the ground a little distance from the nest and covering this latter part of her journey on foot. She enters the archway that conceals her nest without hesitation but is more cautious on departure, looking out on the world and waving her long antennæ before darting away on her errand. The wasp paid no attention to me; I was nothing to her, nor were, apparently, any of the other objects of her environment. For I took away some stems of poison ivy that obstructed my view and endangered my health; I even pushed back the leaf that covered the nest in order to observe her work—all this, without affecting her comings and goings in the least. *Agenia* was building her third cell; and since thirty to forty more trips are needed to complete each one, her familiarity with the surroundings finds an easy explanation. From 4:30 to 5:15, July 31, *mellipes* made fifteen trips requiring from one to five minutes each. The little round pellets of mud which she carried home in her mandibles were added to the cylindrical wall until it had been built out to about the length of the wasp's body. Fifteen to twenty seconds was sufficient time for the wasp to apply each load of mortar carried home. After the required length of the cell, which now looked a good deal like a barrel lying on its side, had been reached, the inside was carefully plastered and calcimined with a number of pellets of mud, the wasp reaching in for her whole length and at times working upside down. Possibly the wasp was adding an extra amount of saliva to this last work thereby manufacturing a kind of varnish with which to increase the durability of the structure. At any rate the interior presents a smooth surface while the exterior is very rough, each elevation representing the amount of mud brought in by a single load.

At 5:15 the cell was ready to receive the spider with which it was to be stored. *Mellipes,* however, does not have good luck in finding the spiders she wants. On this occasion it took her twenty-four hours to store the cell, on another forty-six hours elapsed between the completion and the storing. At 6:30 p. m., August 1, the wasp was just putting the finishing touches on the disc-shaped lid with which she closed the cell. I failed to catch the wasp at this time though I succeeded ten days later while she was at work under another leaf in the same angle of the elm tree roots.

The wasp had built three barrel-shaped cells tapering slightly at both ends, each cell about eight mm. long and four in greatest diameter. One cell was independent of the other two which were built together at an angle of about 120 degrees. The angle seems to depend on the conditions under which the cells are built, for I once found in a narrow crease of a wagon cloth five cells of *mellipes* attached one to the other in a straight line. Having reached home with my trophy I could not resist opening at least the cell last made to ascertain the condition of the spider and the position of the egg. Both are well shown in Fig. 20. The spider, it will be seen, had lost all its legs but the front pair and the egg was placed across the ventral surface of its abdomen. The spider was stuffed into the cell head first.

But egg and spider were not the only occupants of the cell. To my great astonishment I became aware of a tiny parasitic wasp, no larger than *Agenia's* egg itself, resting on the egg. The parasite *(Ophelinus florifrons, Ashm.)* had been imprisoned and when I found it, was evidently about to infect the egg of its host. It had not yet laid its own eggs into that of *melipes,* however, for the latter developed normally. It hatched and the larva in due time devoured every trace of the spider. August 8 it spun a fine white cocoon, which, it might be added, never changed its color. This is also true of the cocoons of *A. subcorticalis.* The larva succeeded in spinning its cocoon with support only from the low sides of the broken cell. It is also significant that the larva and pupa both developed quite as well in the light and without the protection of the mud cell, also in the dry atmosphere of the laboratory, as they would have done in their natural haunt on the banks of Waller

Creek. The adult, a female, emerged August 23, just twenty-two days less three hours after the egg was laid. The adult from cell No. 2, also a female, emerged by a small round hole in the side of the cell on August 22 and the total length of its development was twenty-three days. On August 16, nineteen and one-half days after it was stored and closed, the oldest cell brought forth thirty to thirty-five parasitic wasps of the species mentioned above. *Agenia's* cocoon was present but its contents had been devoured by the larvae of the nefarious swarm which darted around on the inside of my collecting bottle clamoring for exit.

My first acquaintance of the species *A. subcorticalis* was running along in a hop-step-and-jump fashion carrying in her mandibles a large legless Attid. She ran up a tree for a foot and dropped her burden to the ground. Before she could recover it another *subcorticalis* was on the scene and a struggle for the spider ensued. The intruder caught it up and ran with it into a crevice in a tree as if to hide there. But the rightful owner recovered her quarry and made away with it in all haste, mounting a slender sapling to the height of twenty feet, and was lost to view. The other wasp continued her search for a while but she too soon disappeared.

Spiders are not the only creatures that will occupy the abandoned cells of an old mud-dauber's nest. *Trypoxylon* finds them a very convenient abode (Fig. 23) and even the graceful and handsome *Agenia subcorticalis* will not disdain to build her little cells and rear her young where an inferior *Pelopoeus* has been born. *Trypoxylon* uses the whole lumen of the empty cell as it is, merely closing the opening after the cell is stored. But *Agenia* uses the cells merely as cavities in which to build her own small cells of the ancestral type. Thus she may have as many as five of her own mud cells inside a single chamber of the big mud-dauber's nest. Indeed *subcorticalis* goes a step farther and not only closes each one of her own individual cells but builds a plug over the opening to the large chamber just as the original proprietor would have done, thus offering an additional rampart to her enemies.

The dirt which *Agenia* uses is taken from the very nest in which she is building her own. This makes it very convenient for her, of course. She gnaws off her pellets, moistening the dirt as she works. As I have observed in the case of *Trypoxylon* the supply of water necessary for moistening so large an amount of dry dirt must soon give out. So after a number of trips *Agenia,* like *Trypoxylon,* flies away to get a drink of water and then returns to resume her work. She wisely economizes in her use of water by returning each time to the same spot, moistened by the previous visit, for each successive load.

A considerable number of dirt-dauber's nests were thus occupied by the new tenants. Owing to the lateness of the season many contained pupæ waiting in their clean white cocoons for the advent of spring. Of the five spiders examined one remained in possession of all its appendages, one had the left hind one cut off, another had missing three hind legs on the right side, a fourth had only its front pair left and a fifth had lost all its legs. All the spiders were Attids of the same species.

In each of the above cases of spiders deprived of legs, death had ensued even before the storing of the victim. I have, however, found mud cells containing mutilated spiders that were very much alive when found. In the spring of 1903, I found under the bark of an elm, a single cylindrical mud cell containing a young legless Attid that snugly filled the cell. This spider was alive and remained alive for at least a week. On October 21st, I found two cells under a stone, one of which contained a Clubionid, that lacked the hind pair of legs and the two anterior ones on the right side. It was not only alive, but would cling to a pencil held close to it and would bite at it. The spider remained alive until the larva began feeding. The egg was attached to the right side of the abdomen near the pedicil and there the larva on hatching attached itself and began eating. The pupa was spun November 5th.

The amputation habits of Agenia are interesting not only because of the rareness of the habit among wasps, but because it seemed to have developed in this genus as the regular method of procedure.

VII. SOME OTHER SPIDER RAVISHERS.

(a) Pompilus Marginatus, Say.

This species of Pompilus has had its story well told by previous admirers. The single specimen, whose ways are here described, while agreeing in mental traits with her northern sisters, still, in my opinion, deserves a mention among her southern relatives to which these pages are devoted.

August 2d was a fine, hot day and my early expectations of some interesting performances by my insect entertainers were fully realized during the day. At 9:45, I came across a small *Pompilus marginatus.* The sprightly little spider ravisher alighted on the ground and hopped about in great agitation. I had often seen the species on the hunt and was anxious to see one in a duel with the eight-legged enemy of her race, or at work digging and storing the nest. She was at this time much more excited than when on the hunt; and she soon began to dig at a number of places only a few inches apart, showing that she was looking for a suitable place to dig her nest. After eight minutes of trial, she finally settled upon a place that seemed to suit her, little realizing, however, that she had chosen for the home of her offspring, the middle of a much used path through the sandy woods. Here she began to dig with vim and in a few minutes had dug a hole an inch or more in depth and was bringing out the sand at regular intervals, which increased in length with the increase in depth of the nest. The sand was pushed up in loads with the hind legs and the end of the abdomen. The wasp did not appear with a load each time, but often five or six loads would be allowed to accumulate at the entrance, when the whole pile would be pushed out and scattered away from the entrance more or less carefully. All the work was done in feverish haste. While busy on the surface, the furious little worker held her wings straight up in the air, at times vibrating them and making them flash in the sunlight.

Marginatus is a species that catches her prey before digging her nest and she did not delay long to make known where the spider was located. At 9:56, i. e., after the wasp had been digging but a minute, she left her nest and ran off among the grass and weeds growing sparsely along the path. While running, the tiny worker betokened even more feverish excitement than when digging, for she ran swiftly with her wings standing out obliquely and in continuous vibration, giving her a most comical appearance. Three feet from the nest the spider lay on top of a pinnatifid leaf of Achillia, excellently adapted to hold the spider and keep it out of reach of the many ants everywhere running around in great numbers. (Fig. 5.) During the hour and eight minutes that it took to dig the nest (from 9:56 to 11:04), the wasp made six visits to the spider after intervals of one, five, nine, thirteen, thirteen, and thirteen minutes, each time returning to the nest in the same excited manner. The visit was sometimes made partly on the wing, the wasp flying from one of the intervening plants to another. Her sense of direction was, however, not absolutely true, for only once did I see her go straight to the spider. Usually she passed it several times before coming upon it. On the way back, the nest was found without much difficulty.

At 11:04 the nest was apparently finished, for at this time the wasp ran over to the spider again, grasped it by one of the coxae and advanced with it to within fifteen inches of the nest, where she dropped it to reconnoitre the ground and re-examine the nest. The next advance was to within one and one-half inches of the entrance, when another survey had to be undertaken. The next spot was within an inch of the nest which was again examined. Assured that all was right, the spider was once more picked up, and this time taken in. In being taken in, the spider first took a position with its long axis across the entrance; but the wasp, which had backed in, got hold of the posterior end of the spider and pulled it inside. It seemed to go in smoothly, though two of the legs were directed backwards. The wasp remained inside for fifteen minutes and finally appeared scratching in sand and stepping it down into the nest. When this was nearly full, she pulled down the dry sand from above the entrance, biting it loose with her mandibles. After a few minutes rest in the shady corner of a human foot-print, she returned, smoothed over the entrance for a moment or two in a wider circle than before and flew away.

I immediately dug for the spider that had been just entombed and came across it four inches from the opening of the nest and three inches below the surface. It was lying in a chamber large enough to hold it with outstretched legs.

The egg, one mm. in length, was placed on the dorsolateral side of the abdomen near the pedicil, as shown in figure 12, which is natural size. The spider had been stung to death since it never responded to stimulation and was soon overtaken by mould. The egg never hatched.

(b) Pompilogaster Fuscipennis (Lepel).

This wasp with black legs and thorax and bright red abdomen is a furious hunter, flying from plant to plant in a whirlwind. No wonder therefore that I lost sight of a specimen so suddenly one afternoon as she was carrying off her prey. A flash of red and green is all I saw as wasp and spider tumbled down a hole in the sand and disappeared. The hole lead into a burrow that had been dug by some rodent and extended for many feet just beneath the surface of the sand. I have noticed other spider ravishers choose such a place to hide their spider and to dig their nest. Solid black soil, which cracks in dry weather, offers more opportunities in this way than does the sandy land where most of my observations were made.

The wasp remained inside the burrow one hour and twenty minutes. Thinking that the wasp had by that time escaped at another point along the burrow, I dug this up and came upon the wasp, that had buried the spider in a shallow hole which it had dug in the side of the burrow. The spider, which was dead, was a large green "cotton spider" belonging to the genus Dolomedes. The wasp remained in the vicinity for half an hour, when I caught her.

(c) Pompilid That Does Not Bury its Prey.

In the Cambridge Natural History, vol. VI, p. 106, Sharp makes mention of Emery's account of "some Pompilids that do not bury their prey but, after stinging it and depositing an egg, simply leave the spider on the spot." Such an one came flying about our veranda with businesslike airs one fine July day. She was of a brilliant metallic blue, somewhat lighter than *Pelopaeus coeruleus*. She looked into every nook and cranny of the walls that struck her fancy. Finally she remained some little time behind a detached piece of wallpaper from which the edge of a spider's web protruded. Looking down I saw the wasp tugging away at a spider; but this had its claws so thoroughly entangled in its web that the wasp was forced to desist.

After stinging this spider the wasp spent five or six minutes flying about, resting on the rafters or running up and down the walls. At the end this time she disappeared behind the head-casing of a door where another spider had sperad its web. Presently the wasp came forth dragging the spider backwards over its own web with her mandibles fastened to one of its front coxae. The spider was deposited a few inches below the edge of the casing on the margin of its own web and the egg laid upon it. At 3:07 the wasp was out and flew airily about and in a minute was off and away. At 3:20 she *returned to the first spider* on which, after removing it, I found an egg. I can not say whether she laid the egg at the first or at the second visit. In either case it is certain that two eggs were laid in less than fifteen minutes.

The first spider never showed any signs of life but soon withered. The egg died from an injury received in the handling. The second spider lived till half consumed by the larva. This spun its light cream-colored cocoon (which turned yellow in a few weeks) ten days after the egg was laid. Late in August the adult emerged by cutting and lifting a circular cap from one end of the cocoon after the manner of Ichneumon flies. This specimen was a male and it was therefore impossible to identify the species.

(d) MISCOPHUS SP?

Nearly all kinds and sizes of spiders have their wasp enemies, from the giant tarantula, which is hunted by the powerful *Pepsis*, down to the young spiderlings captured by *Miscophus*. This species is a tiny black wasp hardly four mm. in length but very active for her size and just as "bright" as any of her big sisters.

She digs her nest with mandibles and forefeet like most digger-wasps. She is not particular about cleaning away the sand from in front of her nest for any great distance while she is busy digging it, with the result that the sand kicked out collects in a semicircle in front of the nest. When the nest is completed and ready for occupancy and, indeed, when it is left temporarily, it is usually carefully closed with sand and the surface in a radius of several inches is often smoothed over in a neat and tidy manner. She is extremely sensitive to one's presence. When she is carrying a spider, a slight motion on my part will make her drop her burden and fly away for a minute or two.

Miscophus catches for her prey young Epeirids of convenient size. These are carried home on the wing if very minute; medium-sized ones are carried in small jumps like the crickets of *Larra*, the length of the jump depending on the weight of the burden; larger spiders are carried on foot. I have seen no Pompilid carry her spider quite like *Miscophus*. This wasp grasps the paralyzed spider with her mandibles by two or more of its legs, "slings it on her back" and marches off with it, walking forward, the spider hanging rather to one side in an uncomfortable and awkward looking manner.

Arrived at the nest, the wasp opens it, enters and drags her prey after her. After the nest has been stored and the egg laid, the tunnel is closed with sand and the surface smoothed over with fastidious care.

I opened two nests each of which contained six spiderlings, the largest in each nest having attached to its abdomen near the pedicle a minute egg. I did not succeed in rearing any adults for each of the two larvae died after having lived a larval life of five days and spun an incomplete cocoon.

The nests were astonishingly small. The first had a tube two mm. in diameter leading slantingly downwards for a distance of three centimeters to a pocket measuring five mm. across. The other nest was dug in a small clump of dirt which was itself hardly three centimeters in greatest length. The nest measured but fifteen mm. (5/8 inch) in length *including* the round pocket, five mm. in diameter, which harbored the spiders.

Miscophus, though the smallest in size among the spider hunters, is not least in interest nor does she hold a place in my esteem proportionate to her size.

VIII. TRYPOXYLON TEXENSE (SOUSS), A PET OF THE HOUSEHOLD.

Several species of *Trypoxylon* have been admirably described by Mr. and Mrs. Peckham in their delightful book already frequently referred to. I would not presume to attempt to improve in any way on their account of this so well "domesticated" genus; yet I hope that the few new observations here presented on the Texas species may be of interest to the reader.

The many scattered notes I have made on the doings of *T. texense* agree in essentials with the observations set forth in the work just cited. In disposition the southern species is also amiable and good tempered and is most tolerant of the actions which curiosity prompts the observer to take, up to the point of destroying the nest itself. The male of *texense,* when present, remains faithfully on guard in the nest during the absence of the female. I have found a large proportion of the nests without males; in such cases the female went on with her household duties as well as when joined by her vespine consort. In one case a male remained alternately on guard in two contiguous nests; when both females returned at once the male exhibited more than the usual amount of excitement in spite of the fact that neither female paid any attention to him. On the presence of the male in the nest of these wasps I shall perhaps in a later paper have more to say, for I believe the subject worthy of further investigation.

In the selection of a nidus *texense* exhibits the same habits as *rubrocinctum,* occupying almost any small crevices in wooden or stone walls. Beetle burrows in the cedar posts of log cabins along the Colorado River are nearly all occupied by *T. texense.* Fig. 23 represents a pair of these wasps occupying a cell of an old mud-dauber's nest. I have found it very convenient to attract the wasps by setting out for them blocks of wood with holes bored in them. The wasps will make use of borings one-half inch in diameter but prefer tubes of smaller calibre. It does not seem to make much difference whether the tube is horizontal or vertical, both conditions being acceptable. I have found several two-story nests in empty shot-gun shells standing upright. In these the partition and the plug were each in two layers, an inner of white and an outer of yellow clay, each layer being a millimeter in thickness.

In getting the nest ready the only thing I have seen *texense* do is to plaster a few pellets of mud against the bottom of the tube. Thus the cap hole of the shot-gun shell was tightly closed with it. The length of the chambers depends on their calibre and varies from three-fourth inch to one and one-half inches. When a nest is composed of several cells in horizontal series, the partition is built from the bottom up and is therefore thickest at the bottom. In closing the last chamber an extra amount of mud is plastered on and the plug is brought flush with the surface. In about half the cases the final closure was made with two plugs from one-fourth to one-half inch apart leaving an empty space or false chamber between them. This must certainly be an effective means of deceiving such parasitic enemies (should they have any) as lay their eggs by means of boring ovipositors into the nests of their aculeate hosts.

T. texense has a way, as I have already pointed out above, in connection with *Agenia subcorticalis*, of economizing time in the matter of getting mortar for the nest. I had always thought that this was gotten from the moist banks of the creek or river, whither *Pelopaeus* pilgrimizes for her building material. But it is certain that many do not get mud from that source but instead take it from the nearest place obtainable, namely those great pyramids of the world of wasps, the abandoned mud-dauber's nests just at hand. Soon after I had begun inducing *texense* to make her home with us and build her nests on the gallery of the Lucksinger country home, the old mud-dauber nests began to decrease perceptibly in size, their material being used again in similar architectural enterprises. *Trypoxylon* flies from her nest to a suitable place on a mud-dauber's nests and begins to gnaw off a piece of the dirt with her mandibles moistening it with saliva as she works. Pelopaeus' old house is hard and one can hear the grating and clicking of *Trypoxylon's* mandibles upon it as well as the hum of her wings under the strain of her work. Finally a pellet as large as her head is loosened and the wasp, just as the pellet is ready to drop, catches it "under her chin," as it were, and takes it to her nest. The dirt is moist when plastered on and one can see the moist spot from which a wad of it has just been taken. To this same spot the wasp returns for successive loads, thus economizing in the expenditure of saliva necessary to wet the dirt. This requires, of course, more moisture, even for a single partition, than the wasp's body can well hold and it becomes necessary to replenish the stock at intervals. So I have noticed that after every four or five loads the wasp flies away in the direction of the creek, seventy-five yards distant, presumably for a drink, and returns to continue her work where she left off.

Like *T. rubrocinctum* a day's work with *texense* consists of at least storing and closing one cell, though two cells a day is not unusual for her. Of those individuals on which I have detailed notes one stored two cells in one day and one cell the next forenoon, two others each two cells in one day, one stored nine Attids, one Thomisid and three Epeireds and closed the nest all in three and one-half hours; another stored and partitioned off one cell in eight hours and stored and plugged up the second cell in ten hours. Thus *texense* is more industrious than *rubrocinctum,* which shows that a semi-tropical climate is not enervating to the wasp race at least.

The development of the young wasp is more rapid in the Texas species than in the northern. The period required for the egg and larval stages of *texense* together varies from six and one-fourth to seven days and averages nearly seven days. One larva spun its cocoon in five and one-half days but never reached the imago stage. The length of the pupal period is a little more or less than thirty days.

T. texense captures eight to twenty-five spiders for a single cell, the average being about fifteen. When a nest is composed of two superposed or adjoining cells the deeper one or the one first stored has invariably the greater number of spiders; the difference is specially noticeable when both cells have been stored the same day. The wasps seem to have a decided sense of fatigue, which is quite natural. The great majority of the spiders are alive when brought in; the majority of these live to about the third day. This accords with the findings of the Milwaukee students in the case of *T. rubrocinctum.*

T. texense begins work early in the year and is on the crest of her prosperity at the time *rubrocinctum,* her northern cousin, is "losing interest in the family affairs and taking a well-earned holiday on the blossoms of the aster and the goldenrod." *Texense* is our most common solitary wasp next to the red Pelopaeus, among which she may be seen at work, the former decorating(?) the wall with her edifices, the latter modestly occupying the out-of-the-way crannies and crevices that might otherwise be used by spiders as their retreats.

IX. SOME ENEMIES OF THE ORTHOPTERA.

(a) Larra Americana (Fox), and Her Crickets.

The first specimen of this species which I chanced upon was digging her nest on the edge of a small precipice at the bottom of which lay three crickets, all kicking violently, one even almost able to crawl away. Her manner of digging was peculiar among the solitary wasps I have seen. While she proceeded in part by scratching the dirt back under her much like *Pompilus* and with equal vigor and nervousness, she pushed out the loads she accumulated in a different manner. Other wasps use chiefly their hind legs and abdomen; but this specimen used her head and front legs, improvising of these a kind of scraper. To take on a load of sand the wasp stretched out her legs, lay down flat and pushed her head in the sand and backed out. On account of this method of digging, the burrow resulting was wide and low, so as to make room for the outstretched legs.

There was something wrong with this individual of *L. Americana.* She soon lost interest in her work, ran around looking into other nests and other holes in the ground. She acted in a most demented manner. Her visits to her old nests and to her crickets became fewer and fewer and she finally remained away altogether.

My second specimen I followed to her nest on the nearly vertical bank of a creek near Austin. She was carrying a large cricket in her mandibles and was moving along in jumps of a yard or more. She alighted at the bottom of the embankment and walked up its steep side entering a large hole, from the further end of which she had dug her nest. In this way I saw her carry in four crickets of various sizes. Two days later I found the nest closed with earth, though not quite to its mouth. I dug up this nest as well as another close by and found both to have been of about the same shape and dimensions. A tunnel five-sixteenths inch in diameter ran into the embankment at a slight inclination downward for a distance of four inches. It ended in a dilatation, one of the pockets of the nest. Just in front of this the tunnel branched off for a slight distance and lead into another pocket which was the larger as well as the one first made. In this six crickets had been stored, all of which but one (which was dead) were not only alive but positively lively. One, indeed, after I had dug out the nest, very nearly got away from me. The smaller pocket contained but one large and one small cricket, both very much alive. The larva in each case had attached itself to the prosternum of the most active cricket and curved around the body of its host, thus embracing it for better protection. Larval *americana* does not eat any of the hard parts of its viand, but reaches into the thorax, abdomen, head and legs to procure the meat and suck the juices. After five days the older larva (ca. six days old) had devoured its store of food while the other had eaten but one large cricket. Both spun an imperfect cocoon and soon died.

Tachytes abductus (Fox), var.? is a rather common Larrid in this locality. The wasp is black and in the sunlight there is a shimmer of bronze between the segments of the abdomen. The species catches nymphal short horned grasshoppers, carrying them closely pressed to her venter with her legs. She is to be admired for the reluctance with which she betrays the whereabouts of her nest.

(b) PRIONONYX THOMAE (FABRE), THE LOCUST KILLER.

As late as October 9th, after her northern cousins had begun to lose interest in the affairs of life, *Priononyx Thomae* was as busy as ever. My only specimen of this interesting wasp flew up from her nest as I came down the well-worn path where she was at work. A flash of red was all I saw at first; from this and from the shape of the nest on which she was engaged, being a round hole leading straight down, I was led to believe that the creature I had disturbed was none other than *Ammophila*. *Priononyx* soon returned, however, and proved that she was an entirely new acquaintance, though her subsequent actions clearly showed that both she and Ammophila had inherited mental traits from the same not very distant ancestors. She is more stoutly built than *A. procera*, is smaller and is black with the exception of her abdomen which is bright red in color.

A faster worker never lived than *P. Tomae.* But her speed is due to a deliberate haste and not to the insane, wasteful hurry that seems to characterize the actions of many species of *Pompilus.* At 1:30 she returned to her burrow which she had dug down to the length of her body. After working at it for a minute she abandoned the nest for some reason, filled it with sand to the top and started a new one near by. Although digging in a well-worn gravelly pathway she made astonishing progress. Biting the pebbles and smaller sand grains loose with her powerful jaws she scratched the loose material out with her fore-feet or carried the larger pieces out with her mandibles. Her movements had almost machine-like regularity, entering the nest forwards and invariably backing out. Back and forth she went, darting in and out so quickly and smoothly that I can best compare her movements to those of a rubber ball attached to the end of an elastic band. After thus working for nineteen minutes, *Priononyx* flew away to a distance of twenty feet where she pulled forth a large green locust. Straddling her prey like *Ammophila* and grasping one of the short antennae she ran swiftly down the path. Within two feet of her nest she carried the grasshopper into a tuft of grass, which she easily mounted with her burden thanks to the length and the strength of her legs. After then digging at her nest for five minutes more she took up her victim as before and carried it over to her nest, laying it down with its head near the entrance. She then, like Ammophila again, backed down the tunnel and pulled the locust after her. In a minute she reappeared and immediately began to close the tunnel. Scratching in pebbles and dust, she tamped them down with her head. I now placed a net over her but she worked complacently on. I could see her every action through the thin net, for she worked but a foot below my eyes. After the net was full flush with the surface good sized pebbles were carried over it. Time and again these were tightly grasped in her mandibles and pressed down with might and main, the wasp standing the while straight on her head and almost turning a summersault while her busy buzz indicated the exertion which the operation demanded. Then she dug awhile in the abandoned hole she had previously filled in but soon quit digging and filled it in a second time. I slightly raised the net and *Priononyx* flew away.

An hour later she was again at work only a few inches from the scene of her previous operations, digging another nest. Three feet away I found another green locust under a clump of grass—another prey for another nest. Thus it seems certain that *Thomae* first catches her prey and then digs her nest. At this juncture I caught her.

The greatest surprise was, however, yet in store for me. With a pick axe I dug a hole about a foot deep at a safe distance from the nest and with a trowel worked away the hard earth carefully in the direction of the nest so as to lay it open and yet not injure the grasshopper or the egg upon it. To my surprise I came upon a nest sooner than I had expected; to my still greater surprise the grasshopper had not an egg but a good-sized larva upon it. A second nest was then revealed and a third and so on until eight had been opened and I had lying before me a collection of nine caterpillars, including the one not yet stored. All the nests were scattered over a space not larger than half of this page. The chamber was oblong (long axis horizontal), about two inches in length by ½ to ⅞ inch across and two inches below the surface. Some of the chambers were so close that they had but a ¼ inch wall between them. Just at what point the tunnel (which measured ⅜ inch in diameter) entered the chamber, I could not exactly determine but think that it come off of one end, which would make the shape of *Thomae's* nest nearly like that of *Ammophila procera*. (Fig. 22.)

In each case the egg or larva had an exactly similar position on the locust. This was just above the coxa of the hind leg (which in one case was torn away) i. e., between the articulation of the coxa and the locust's "ear." The only variation in this regard was that in four cases the egg or larva was placed on the right and in four on the left side of the locust.

The egg of *P. Thomae* is slender and about 7 mm. in length. It arches from its point of attachment over the coxa of the hind leg, which, though the free end of the egg touches it, cannot easily injure it no matter how much the locust may be kicking. The egg is yellow with the exception of the two hyaline ends. Its anterior third is white and the extreme attached end is a watery hyaline disc. Like the egg of *Ammophila*, that of *Priononyx* does not seem to hatch. The first indication I perceived of larval life was the appearance of tracheal tubes down each side and later the sucking movements on the inside of the translucent larva.

Below I give the data on the condition of the nine locusts found Oct. 9th and the development of the larva:

No. 1.—Locust not yet stored. Dead when found.

No. 2.—Locust kicks violently without stimulation. On touching, it will jump two feet. Egg dead. Locust lived four days.

No. 3.—Locust twitched spontaneously from time to time as long as Oct. 11; legs and mouth parts do not usually twitch simultaneously. Egg was the one most recently laid (Oct. 9). Larva spun cocoon in night of Oct 14-15. Length of larval life 5½ days. Cocoon soon turned dark brown.

No. 4.—Locust a great kicker; jumped three feet with egg upon it; lived till Oct. 11, when wasp grub was nearly half grown. Very young larva showed tracheæ when found (Oct. 9); begun to spin cocoon at noon Oct. 14; cocoon light brown next morning.

No. 5.—Locust kicked violently when irritated as long as Oct. 10 though larva was 7 mm. long and half as thick. (The larva after a few days is shorter, though very much thicker, than the egg when laid). Larva spun cocoon a. m. Oct. 13.

No. 6.—Same as No. 5.

No. 7.—Very small locust was dead when found for larva was itself nearly as large as its victim; locust devoured Oct. 11; very small cocoon spun Oct. 12.

No. 8.—Large locust dead; large larva reaching into thorax. Cocoon spun a. m. Oct. 13.

No. 9.—Locust dead; devoured Oct. 11. Oct. 12 larva tried to spin cocoon but failed and died.

From these data it would seem that there were three sets of grasshoppers according to the age of the eggs or larvæ upon them. The facts go to show that the first three were captured Oct. 9. No. 4 might possibly also have been captured and stored early the same day, though more probably late the day before; Nos. 5 and 6 were certainly stored Oct. 8th. Nos. 7, 8 and 9 were stored Oct. 7. Thus this *P. Thomae* accomplished the feat of digging in hard soil and provisioning three nests a day for three days in succession. It is also significant that all these nests were made in such close proximity. The locusts were all of the same species and were, in all cases but one, I have reason to believe, entombed alive and lived until killed by the wasp-larvae themselves.

In many of her ways *Priononyx Thomae* reminds one of *Ammophila* in her general demeanor; in running in and out of her nest while engaged in its excavation; in the shape of her nest; in the manner of carrying her prey, in laying it down at the entrance and backing inside to pull it after her; in closing the nest and pressing pebbles down upon it as if to add some finishing touches intended to be ornamental as well as useful.

X. EXPERIMENT ON THE SENSE OF DIRECTION OF CERCERIS FUMIPENNUS.

The Sense of Direction of animals, particularly of Ants, Bees, and Wasps, is a subject which has engaged the attention of many naturalists. From my own observations on social and solitary wasps I incline to the opinion that these are guided mainly by sight in which familiar objects in the environment of their nests are important factors.

A rather decisive evidence of the important role played by trees, bushes and other objects in the orientation of insects is afforded by the actions of one of my friends, *Cerceris fumipennis*. On October 24th I discovered her bearing a weevil *(Chonotrachelus neocrataege)* into her nest, which was situated on the edge of a five-foot embankment just under a bush some two feet high. The next day I returned, cut the bush off at the roots and placed it three feet to the right. Soon *fumipennis,* too, returned and flew, not to her nest but to the bush which I had placed to one side. After discovering her mistake she flew away to get another start, came down again from between two trees and flew to the bush. Since she repeated this performance at least a dozen times without finding the nest, it is safe to conclude that it was the bush which directed her flight. Moreover, the wasp always flew down from the same direction, showing that earlier in her course she was directed by other objects, especially trees. This latter observation I have several times made on wasps whose nests I destroyed before the owners had completely stored them.

As a matter of fact, the power of finding their way is not so perfect as one might be led to suppose. Many spider-ravishers have great difficulty in finding the spiders which they hid or hung up while digging their nests. I have seen individuals of *Bembex texanus* and *Monedula carolina* so far lose track of their nests as to fail entirely to find them again.

In view of these and other facts I should agree with the Peckhams in the opinion that wasps have no additional sense, the sense of direction, in the common acception of the term, nor that they find their way by a process of dead reckoning as Darwin suggested, but that they find their way by a detailed familiarity with objects near the nest and by a general acquaintance with the locality in which they pass their lives.

SUMMARY AND CONCLUSIONS.

The present paper comprises more or less detailed observations on some 28 species of Texas Solitary Wasps. It was not written for the purpose of entering the discussion of mooted questions of instinct and intelligence, but rather of describing clearly and accurately the actions of some of these delightful little workers in their natural haunts.

My experiments on the mental faculties of wasps have been few and therefore of little value. The experiment recorded above on the sense of direction I have considered of sufficient value to be put down. It certainly has to commend it an absence of artificiality having been made by merely varying the natural conditions to which the wasp was already accustomed. In general my observations lead me to accord with the opinion held by the Peckhams and others that wasps are guided by sight in finding their way—by sight and the memory of familiar landmarks in the neighborhood.

Of the varibility of instincts within a given species there can in my opinion be no doubt. The variability in mental traits and dispositions as reflected in the wasp's actions, seems moreover to be proportionate to the physicial variability. At any rate, *Bembex belfraegi,* the species of *Bembidula* and *Microbembex monodonta* for example are all very variable species in size and coloration as well as in the demeanor of different individuals.

All the species of solitary wasps either dig holes in the ground for their nests or work with mud in their architectural pursuits. In the case of *Agenia* (Chap. VI) both kinds of nests are found in the same genus, some species digging typical nests in the ground while others build mud cells in protected places. This fact alone, it seems to me, would justify the setting-up of a distinct genus, *Pseudagenia,* as is done by some authorities. Among the wasps that dig their nests we may recognize two methods of excavation: in one the wasp utilizes the forelegs to scrape out the dirt loosened by the mandibles; in the other the wasp employs the mandibles both as pick and as shovel. *Ammophila* (Chap. II) and *Priononyx* (Chap. IX) represent the latter method and their nests are composed of a vertical tunnel leading straight down from the surface (Fig. 8) to a pocket whose long axis lies horizontal (Figs. 18 and 22.) The wasps working by the scratching method and employing their forefeet as rakes in excavation have simple nests consisting of a tube running obliquely down and ending in a dilation or pocket at the lower end of greater or lesser diameter (Figs. 19 and 21.) Among the mud-plastering wasps we may distinguish two methods of work again: Some species build the entire nest of mud, as for example *Agenia, Pelopaeus,* while others occupy convenient crevices, and use the mud-mortar merely to close the mouth of their ready made nests, as obtains in the case of *Trypoxylon.* The same genus may have species some of which practice the one, some the other method *(Odynerus,* Chap. I). And again the same species, as *Agenia subcorticalis* seems to do, may combine the two methods, for she builds complete cells of mud not in the open air like Pelopatus but hidden away in crevices.

Some wasps always carry their prey on the wing and on their return to the nest alight directly in or over its entrance. *Bembex, Monedula, Bembidula, Hoplisoides, Microbembex* carry their prey with their middle pair of legs and press it closely to their venter; *Rhopalum abdominale* and *Notoglossa* use their hind pair; *Odynerus, Trypoxylon* and *Cerceris* carry theirs with their mandibles as does also *Alyson,* which alights some distance from the west and completes her journey on foot. *Larra americana* and *Microbembex* prefer flying to walking; but when the weight is great the advance is in jumps or short flights, the distance of each advance being inversely proportionate to the weight of the burden.

Other wasps always drag the victim over the ground regardless of how light this may be and how absurd it may look (to us). *Ammophila's* method, to which that of *Priononyx* corresponds, is shown in Fig. 16. Some spider catchers *(Miscophus, Agenia)* walk forward in dragging their prey; others (some species of *Pompilus* and *Pompilogaster)* always walk backward. *Agenia* and some others combine the flying and the walking means of progression. These drag their victims over the ground, climb up the stems of herbs and bushes in their path and fly off, parachute-fashion, from the highest point obtainable in the direction of their course. The species differ greatly, too, in the ease or reluctance with which they betray the locality of their nest, *Miscophus* and *Tachytes abductus* being, for example, experts in leading the observer astray.

By the way in which a wasp enters the nest the species may often be recognized. *Bembecids* as a rule, after having opened the nest and on entering it, head foremost, deftly pass their prey back from the middle to the hind pair of legs. *Microbembex,* for example, never fails to do this regardless of the size, weight, or shape of the prey. *Ammophila,* like *Priononyx Thomae,* lays her victim down beside the entrance, backs down and drags it into the nest. *Rhopalum (Crabro) abdominale* and *Thyreopus (Crabro) argus* display great skill and precision in slipping into their nest, the former actually diving into her open door-way without stopping at the entrance.

The manner of entering the nest depends somewhat on whether the nest is open or closed when the wasp arrives. In this particular there is great variation in the species as well as in the individuals. *Microbembex* usually closes her nest on leaving it but sometimes leaves it open; with *Bembex texanus* the exact opposite habit prevails. *Ammophila Procera* closes her nest after each visit in cases where she stores more than one caterpillar. *Monedula carolina* leaves her nest open as often as she closes it, *Bembex belfraegi* and *Bembidula* close their nest more often than they leave it open. *Miscophus* and *Hoplisoides* always carefully close their nests before leaving. *Thyreopus, Alyson* and all solitary wasps that use mud in their architecture never close their nests on leaving on a hunting expedition; the female *Trypoxylon*, however, leaves the male on guard in her absence. Among the spider-ravishers that capture their prey before digging their nests many carry their spider out of reach of predatory enemies until the nest is ready (Fig. 5).

A given species of wasp will usually confine herself to a particular kind of prey: a bug-catcher will always take bugs, a spider-ravisher never anything but spiders, an Ammophila only caterpillars, etc. Sometimes, as in the case of *Priononyx Thomae, Alysonmelleus* and *Rhopalum abdominale* and *Thryeopus argus,* the specialization is so complete that a certain species of grasshopper, leaf-hopper or fly is adhered to, all other grasshoppers, leafhoppers or flies being refused. The opposite habit, a universality of insect-food, obtains with *Microbembex,* which carries to her young any insect dead or alive or any part of an insect which she can find and capture (Chap. III.)

Each species of wasp has learned the life habits of its prey and therefore frequents the latter's haunts. *Bembex texanus* and other fly-catchers hover around the droppings of cows and horses and around these animals themselves; *Bembex belfraegi* makes trees and bushes her hunting grounds; leaf-hopper catchers fly in and out among the grasses in search of food for their young; the cricket-killer *Larra* runs into and out of holes in the ground or under stones; *Microbembex* glides gracefully through the woods satisfied with the first insect or part of an insect that comes to view.

As regards the feeding habits among solitary wasps two types may be recognized: first that in which the growing larva is fed by the mother from day to day until the larval or eating stage has passed and the larva has spun its cocoon and become quiescent; and second, the type in which the store of food is provided once for all, the egg laid among the provisions, the nest closed over the egg and the larva left to its fate.

The Peckhams consider the habit of feeding the larva from day to day as the most primitive. They say: "It may be possible then that all wasps originally fed their young as Bembex now does and that while the instinct of storing the whole supply of food once for all was working itself out among solitary wasps, the instincts of life in a true society developed into those of our wasp communities." From this point of view, *Microbembex* on the one hand and the social wasps on the other show the habit in its most primitive form since they not only feed their larvae until these pupate, but they gather almost any kind of insect food they find. The first step in the development among the Digger-wasps would then be the specialization shown in all other wasps of confining themselves to one kind of prey (flies, bugs, caterpillars, as the case may be). In this *Bembex* and some species of *Monedula* are most primitive, since they continue to feed their larvae from day to day. Finally comes the habit which obtains in nearly all solitary wasps of provisioning the nests once for all. This is shown in its highest form in the *Ammophiles* and *Pompilides,* which paralyze the caterpillars and spiders, store them in the nest and lay the egg upon them. In these cases the nest is closed long before the egg is hatched and the mother wasp never sees the larva. There are however, transitional cases between the habits of *Bembex* and that of *Ammophila.* Thus *Monedula carolina,* the big fly catcher, closes her nest several days before the larva spins its cocoon, after first supplying the larva with a sufficient supply of food. The little bug-catcher *Bembidula parata* shows a somewhat greater difference, for while she stores her nest as fast as she can with very small bugs, the work is not finished until the larva is at least half-grown. Another instance, showing a still greater step in the direction indicated, is shown by an *Ammophila urnaria* described by the Peckhams. This species lays the egg on the first caterpillar brought in and stores the other or others as soon as she can. In one case, the mother wasp on her return with the second caterpillar found a larva a day old feasting on the caterpillar already provided.

It is interesting to note that, parallel with the working out of the instinct to store the nest quickly and close it up over the unhatched egg, runs the development of the stinging instinct, which aims to paralyze the prey to preserve it for the future offspring. Thus *Microbembex,* which is the most generalized in the mode of procuring food, seldom needs to sting her prey, for she nearly always finds it dead. When she stings, it is to kill and from a single observation I judge her to be very awkward in the application of her sting. The five caterpillars I saw her carry into her nest were all dead. The greater part of the caterpillars captured by *Ammophila* or *Odynerus,* wasps that specialize in that kind of prey, are brought into the nest merely paralyzed instead of killed outright.

Bember tex and other fly-catchers sting their flies to death with a single prolonged sting as I observed in Chap. IV. This suggests the idea that the primary purpose of the sting is to overcome the victim.

Among most of the other solitary wasps the tendency to merely paralyze the victim is more or less perfectly developed. Bugs, grass-hoppers, bees, spiders or caterpillars are sometimes brought in stung to death, but often they live from a few days to many. The nearest approach to perfection is reached in the Ammophilae. So nearly perfect is the habit here that Fabre was led to assert that two conditions always obtain with Ammophila's caterpillars and are absolutely essential to the perpetuity of the species: first, that the caterpillar must be sufficiently paralyzed to insure the safety of the egg, yet secondly, it must remain alive sufficiently long to furnish fresh food for the growing larva. Though Fabre has noted a slight variation in the number and order of the stings administered he insists of the necessity of stinging the caterpillar in the middle segments, one of which is to receive the egg, and his observations seem to bear him out. In Chap. II, I have given my own observations on five caterpillars of *Ammophila procera* which fulfilled to a nicety the condition thus laid down by Fabre. In each case the caterpillar lived long after the egg should have hatched, yet in each case the caterpillar was sufficiently stung in the middle segments to insure the proper quiescence. It must be said, however, that the five caterpillars thus observed are not sufficient to yield conclusive results. In this connection we should listen to the Peckhams, whose opinions, diametrically opposed to those of Fabre on the question of the stinging and other instincts of wasps, yet seem to me to be well established. Fabre argues that the wasp's actions are the result of an automatically perfect instinct which allows no variations. The Peckhams combat this view, holding that, in their study of wasps, the "one preeminent unmistakable and everpresent fact is variability; variability in every particular; in the shape of a nest and in the manner of digging it, in the condition of the nest (whether closed or open) when left temporarily, in the method of stinging the prey, in the manner of carrying the victim, in the way of closing the nest and last, and most important of all, in the condition produced in the victims after stinging, some of them dying long before the larva is ready to begin on them, while others live long past the time at which they would be attacked and destroyed if we had not interfered with the natural course of events. And all this variability, we get from a study of nine wasps and fifteen caterpillars."

Fabre's opinion of the instinct of wasps has long been the prevailing one among naturalists. Romanes depended on Fabre for his information. The question would not have been dreaded by Darwin but welcomed with delight had he been aware of the facts as afterward presented by the Peckhams. The central point from which the influences of the older naturalists were drawn, was the assumption that the larvae must be nourished upon fresh food.

The fact is now, however, fully established that the larva thrives quite as well upon dead as upon living food.

The study of the habits of animals is, indeed, a most fascinating branch of zoological work, and the solitary wasps, though so little studied, are among the most interesting objects of study owing to the great variety of their activities. As to the result to be derived from a study of their habits, the solitary wasps may be expected to contribute no small quota toward the solution of the psychological problems concerning the lower animals.

THE EFFECT OF TENSION UPON THE DEVELOPMENT OF MECHANICAL TISSUES OF PLANTS.

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The subject which will be discussed in this paper has been but partially investigated.

In 1893, Hegler,[1] an assistant in the laboratories of Dr. William Pfeffer, at Leipzig, announced the results of certain experiments from which it appeared that when a slight tension is applied in the direction of growth to young seedlings such as the field bean and the sunflower, there occurs first a diminution in the rate of growth and later an acceleration as compared with the normally growing seedling. This matter had already been investigated by Scholz[2] and Baranetzky.[3]

This tension was secured by attaching small weights of 20-30 grams to a thread, passing this over a lightly moving roller and making the free end fast to the plant under investigation, the whole being placed in such position that the tension upon the tissues of the seedling was in the direct vertical line.

This diminution and acceleration of growth was fully confirmed by other investigators. It appears that the slight amount of tension produced by the weight acts as an irritant, at first checking and then stimulating growth. Thus far, these effects are analogous to those produced by certain other irritants such as, at times, sudden changes in temperature, a series of small shocks, or slight wounds, and abrasions of the growing parts.

Hegler investigated the matter further and found that more important and far more complicated results could be obtained by applying tension in the manner described and increasing the strain at intervals. He claimed in this way to be able to develop certain tissues such as the bast and collenchyma to such an extent that the tensile strength of the plant would be vastly increased, and in fact claimed to be able to develop, during the course of a few days, certain mechanical tissues in plants in which these do not normally appear, or at least, as has since appeared,[4]

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[1] Hegler: Cohn's Beitrag Z. Biol. d. Pfanzen, 1893, Bd. 6, p. 383.

[2] Scholz. Idem., 1887. Bd. 4, p. 323.

[3] Baranetzky Angleiche Periodicität d. Längen-Wachs Thums, 1879.

[4] Küster, Flora, 1900, p. 173. Pfeffer, Pflanzen Physiologie. Bd. II, 2 Aufl., 1901, p.148.

which possess these tissues only in traces. For instance, he found that a seedling of the sunflower which at first could support a weight of only 160 grams, after having been weighted for two days with 150 grams, could support 350 grams. Likewise, petioles of Helleborus niger, which at first sustained only 400 grams, would after successively increasing the tension for a few days, sustain a weight of 3500 or more grams. These astonishing results, if true, would afford a most striking example of the power of living organisms to adapt themselves to changes in their environments. According to his results, this power of resistance was acquired through an increase in the number of the cells in the Collenchyma as well as an increase in the thickness of the walls of the collenchyma, schlerenchyma and of the hard bast cells, and in the case of Helleborus, in the development of an entirely new tissue, namely, hard bast, which originated from the phloem elements already present.

It is well known to all that certain parts of plants are at times subjected to greater strains than at others. The fruit-stems of apples, of gourds, oranges, bananas, and such fruits as increase largely in weight while maturing must develop their powers of resistance to the constantly increasing strain of the enlarging fruit. The tissues in the limbs of fruit trees when fully loaded must be subject to far greater strains than during the intervals of fruiting. Boughs of hemlocks, firs and pines of northern climates must in winter often sustain for a great length of time not only their weight, but an added burden of snow and ice. The tendrils of climbing plants are subjected to the constantly increasing weight of their parent stems. Evidently there must be a compensating increase in the tensile strength of the parts subjected to such increasing weights, and certain increases in thickness have been observed in these latter cases, although it is still a matter of question how much of this is due to tension and how much to contact irritation.[5]

While the element of tension apparently plays a very important part in all these cases, it will be observed that the line of action is not the same in all. In fruits and in the side limbs of trees, either when sustaining their own ever increasing weight or an added burden of snow or ice, the weighting force acts, in general, in the line of the direction of gravitation and hence, is one at all times acting under natural conditions, whereas in Hegler's case the force acts directly opposite to gravitation and is, moreover, one which, under no conceivable natural condition, could occur. Bearing this point in mind we see that two questions are to be considered:

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[5] Worgitzky, Vergleichende Anatomie d. Ranken Flora, 1887, p. 69. Von Derschan Einfluss v. contact u. Zug auf Rankende Blattstiele, Leipzig, 1893.

1. What effect is produced by tension acting in the normal vertical direction of growth?

2. What is this effect when applied in any other than the vertical?

The published results of Hegler have a twofold significance—a philosophical and a practical, the first of which has already been indicated. If a new force acting upon an organism, can within a short period of time, produce such marked changes in its tissues, and what is still more remarkable, in some cases call into existence tissues which are normally not present, or at least, normally remain undeveloped, then the accepted theory of evolution, according to which all existing organisms and their parts have reached their present form and acquired their several habits only through a long process of adaptation extending through a wide range of time, is at fault.

On the other hand, such results would indicate the possibility of increasing the tensile strength of timbers to any desired extent by a simple process of applying suitable weights to a young and growing tree and increasing these as fast as the plant had adjusted its mechanical tissues to the new strains put upon them.

Certain other questions as to the behavior of plants, or their parts, when in positions other than the normal, and either subjected to tension or not, at least so far as artificial mechanical strain is concerned, the parts played by gravitation and the effects of difference in light supply, must also be considered. For example, in the cone bearing trees, the woody tissues of the under side, in Dicotyledons, those of the upper, are hypertrophied in the parts which stand in oblique or horizontal position.[6] Adventitious buds appear on the upper and rootlets on the lower side of many plants or their parts when in a more or less horizontal position.[7] These effects have been found to be due in some cases simply to geotropic causes, in others to the influence of one-sided light supply and are probably often the resultant of these two.

A young and growing plant when laid horizontal and unrestricted, curves upwards in order to regain the normal position. This reaction is due to gravitation and is called Geotropism. If this curving be mechanically prevented, a marked thickening of the cell walls of the tissues of the upper side occurs.[8] It must be noted here that, under these conditions, the tissues of the upper side are subject to a certain degree

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[6] Nordlinger Der Holzring als Grundläge des Baumkörpers, 1871, p. 24. Weisner, Ber. d. Deutsch. botan. Gesellsch., 1895, p. 481, and 1896, p. 181.

[7] Vochting, Organ-Bildung im Pflanzenreich, 1868, pp. 148, 164. Sachs, Arbeit. d. Botan. d. Inst. in Würsburg, 1880, Bd. 2, p. 474. Wiesner, l. c. See Pfeffer, Pflanzen physiologie, 1901, pp. 107, 125 and the literature there cited.

[8] Wortman, Zur, Kenntniss d. Reisbewegung, Botan. Zeitung, 1887, p. 819.

of strain. The observed thickening has been attributed by some investigators to this tension, and by others to an observed increase in the amount of protoplasm in the cells of the upper side of plants so treated.

A new series of investigations was begun in order to answer definitely the questions involved and if possible to bring the known facts into correlation.

Experiments on many hundreds of plants were made in order to determine if tension in the vertical direction causes a change in the tensile strength of stems or any alteration in their tissues. Young seedlings of the sunflower, field bean, castor bean, *Vicia faba Helleborus niger, Mirabilis jalap,* and others were used. It is not necessary to enter into the minutiae of these experiments. In general, a sling of softest kid or chamois skin was devised as a holdfast for the string that supported the weights since it was found that the old method of a slip knot in the thread very often caused choking of the plant or bruises and abrasions of the skin, that would very materially affect the value of the results.[9] Weights of sizes varying from 2-1000 grams were provided with hooks to facilitate attachment to the cord and thus prevent any great shock during change. Experiments were made both upon normal and etiolated plants. In no case was an increase in the tensile strength of the plant thus put under stress other than that which would normally result from increase in strength through growth. Seedlings of the bean and the leaf stems of Helleborus niger after having been weighted with amounts varying from 500 to 3500 grams through periods of four to five months, showed no observable abnormal increase in tensile strength nor any change in, nor in any case, any appearance of new tissues.

Thus far the results are purely negative. Not so, however, when the plants are in an abnormal position. Proceeding on the hypothesis that tension causes the observed thickenings of cell walls when normal geotropic curving is prevented, the demonstration of the fact was attempted.

A series of experiments were made in which the effects of the two forces were studied, when acting alone, by excluding the one, and also when both coincided in their action.

I. As has already been mentioned, gravitation is known to be the cause of hypertrophy in the cell walls of tissues on the upper side of stems and limbs of Dicotyledons which stand in an ascending or horizontal position. In order to eliminate the action of this force, and to observe that of stress alone, Elfving, a Sweedish investigator, placed young plants upon the klinostat and allowed them to rotate, after having bent

[9] Townsend, Annals of Botany, 1897, Vol. II, p. 509 ff. shows that small wounds act as an irritant, causing more rapid growth in plants.

them in such manner as to produce a strain on the tissues of the outer curve. On the klinostat, gravitation no longer acts continuously upon the tissues of one side of the stem, but. by means of the rotation, its effects are equally distributed on all sides. Evidently if proper care be taken, the effects of one sided light supply may also be obviated either by working in diffuse light or in the dark room where all light is excluded. Elfving concluded that as tension was the only known agency at work, it must be the cause of the thickenings which occur under these conditions, both in light and in the dark room.

Elfving's experiments were carefully repeated and his results in every case sustained. However, though tension is the only known factor at work, it is not safe to ascribe definitely these results to its action, since other and unseen forces may also take a part.

II. In order to exclude tension, but still to allow full play to the action of gravitation, portions of the stems of the plants named were enclosed in plaster of Paris casts and the whole laid horizontal. The portion so enclosed can not curve under geotropic influences. This geotropic curving is immediately produced by the more rapid growth in length of the cells of the lower or earthwards side of the stem, while those of the upper grow normally. Hence there is a stress exerted upon the tissues of the latter side. Since all growth in length is inhibited by the cast, there can obviously be no stress due to the cause named. The portion of the stem behind the cast was prevented from curving by the weight of the gypsum, while that part in front could curve freely. Sections taken from all parts of the stem showed a general thickening of cell walls of the upper side, though this was not so marked in the parts enclosed in the plaster, as was to be expected, since growth was necessarily restricted there and the stem suffered more or less etiolation.

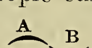
III. Young stems of the bean were now forcibly bent in the lower portion and fastened by threads in a nearly horizontal position. After geotropic curving of the free part had taken place, the plants presented an 

figure in which the curve A was due to the mechanical stress applied, and that of B to normal geotropic curving. At A the strain upon the tissues must have been considerable. After about ten days sections were cut and showed thickened walls of the bast, collenchyma and epidermis of the upper side. In the bast, however, the number of cells whose walls underwent thickening was always less than in the normal plant. This fact was observed in all cases of thickening and is especially noticeable in Ricinus.

IV. When the plant has reached an age such that the stems are no longer pliable and do not curve under geotropic influences, no mechanical means are required to hold them in a horizontal position. Here also the usual thickenings of cell walls was found after a few days. This epitrophy is not counterbalanced by a later hypertrophy, at least, not during the time of observation, which was four weeks.

V. Again, plants were laid horizontal and at a distance of four or five inches from the base, sharply bent downwards over a glass rod, and held in this position by means of thread and weights for four or five weeks. Here also a great stress must have been at work upon the tissues of the curved portion, as well as gravitation. Hypertrophy occurred in the horizontal part on the upper side but not to any marked extent at the curve. Again the number of bast cells undergoing thickening was less than in the normal plant, the groups of thick walled cells being separated by rays of parenchymatous tissue. Figs. 4 and 5 show a cross section of a castor bean plant 28 days old, which was bent in the manner described for 21 days. Fig. 4 is the upper, 5 the lower side. Fig. 3 shows a normal of same age.

At the point of curvature on the concave side a sharply defined line often appeared. This line stained with chlor-zinc-iodine exactly like wood fibres and apparently consisted of compressed disorganized rows of cells. Occasionally, small thick walled cells could be detected in it. In addition to this, active cell proliferation occurred just without and contiguous to the bast. These cells were very thin walled and strongly resembled those of the phellogen of bark.

VI. Seedlings were laid horizontal and bent around a rod as before but this time in the horizon. Thus, gravitation acted upon the upper side while the outer flank of the stem was strongly stretched. No thickening whatever occured on the flank but the usual state of affairs was always found in the upper side.

VII. Young bean plants were bent at a height of 3 to 4 inches at right angles, the upper part being confined to the horizontal position, again allowing both tension and gravitation to coincide in their action. Sections made at intervals of ¼ inch from the base to the leaflets showed that hypertrophy began at a distance of about ¼ inch from the point of greatest curvature and increased in amount on and over the curve, reaching its highest development however in the horizontal part at some distance from the curve. At the point where both factors were at work the effect was not so great as where only one was active. At the inner curve, as in the other cases, the cell walls of all tissues directly under the contact surface, were very poorly developed and resembled parenchyma cells, the tissues being thrown into calluslike ridges and folds.

VIII. Well advanced seedlings of *Phaseolus* and *Ricinus* were now inversely placed and then bent in to the horizon and secured. After geotropic action was well advanced, the whole plant presents a figure like the three sides of a rectangle, of which the angle, or rather curve, at A was artificially produced by bending and tieing, at B by the normal geotropic curving. After two or three weeks of this position, the cell walls of the entire upper side showed marked thickenings, even those at the inner curve A, which, whenever the curve opened in any other direction, remained very thin.

IX. Helleborus niger was subjected to all the experimentation described without in any manner altering the character of the phloem elements or the production of new elements, though at all times the usual changes occurred in the collenchyma.

X. In order further to investigate the extent to which tension enters into this thickening of tissues, an apparatus which may be called a "rocking machine" was employed. This is simply a large clock work with a long pendulum, driven by a weight of several hundred pounds. A vertical iron rod working upon a bolt through its middle is connected by a cross bar to the lower part of the pendulum. The upper end of the rod bears a cup for the reception of the flower pot. When the pendulum is in motion, the cup and flower pot swing to and fro, the length of the arc being readily adjusted by changing the position of the pivot of the rod. When now the plant is fastened by means of a thread to a point in the plane of the pendulum in such manner that when the plant is upright, the thread is tightly stretched, at every second beat of the pendulum, the plant will be sharply bent out of the vertical. In the meantime the plant rights itself by its own elasticity. If the stem be made fast to two points on opposite sides, there results an alternate bending from the one side to the other. In this way, the effects of the wind may be to some extent reproduced. The tissues on opposite sides are thus alternately strongly drawn and compressed.

At first, seedlings of the plants named were put upon the machine without being fastened. These underwent very little bending, even when swung through a relatively wide arc. Such plants showed no alteration of tissues whatever after having been thus "rocked" for seven or eight days. When, however, the stem was fastened, so that a periodical bending resulted, there appeared in every case on the outer or stretched side, a hypertrophy of the tissues, bast, as well as collenchyma. It must be noted, however, that not only is tension at play here, but at every beat the plant assumes a more or less horizontal position, according to the length of the arc through which it is swung. During one-half of the time, then, it is subject to the influence of gravitation. The cells of the side which becomes concave remain thin walled. In many plants there appeared the same phellogenlike proliferation of the parenchyma cells as already been described. See Fig. 8. Fig. 9 shows a normal. This occurred always on the convex side at the point of greatest curvature

(Fig. 8). It is worthy of mention that when this cell division occurs, the starch sheath which surrounds the bast bundle disappears.

If the thread be fastened close to the cotyledons and the plant be bent towards one side only, there follows always a curving of the younger upper part in a direction opposite to the mechanical bending. This is apparently a geotropic curving, since at every beat the plant is subjected to gravitational influences. When the plant is bent in both directions there follows a thickening of tissues on both sides, but no difference could be seen in the flanks, all portions being alike affected.

Knight,[10] an English investigator, working in 1801-02, fastened young apple trees in such manner that the wind could bend them only in the N.-S. direction. After about two years years he found that the diameter of the wood in the N.-S. direction to that of the E.-W. was as 13 to 11.

However, Hartig,[11] observed an eccentric thickening of the yearly rings of pines which had been subjected to a constant West wind. The cells were also thicker walled on the East side.

On the other hand, Wiesner has shown that on the side limbs of plants gravitation sometimes causes an epitrophy, sometimes a hypertrophy.

XI. In order to observe the effect of one sided light, young plants were placed in a dark chamber into which light was admitted through a narrow slit. As is known to all, plants in such position will bend towards the source of light. If this heliotropic curving be prevented, e. g., by weighting the upper end with just enough force to prevent the curving and not to exercise any great degree of tension, hypertrophy of the tissues on the side exposed to the light will be found to occur. When one takes into account the partial etiolation that must result in this case the thickening is as noteworthy as in the other cases.

Here, however, there is no geotropic force at work, although a degree of tension exists among the tissues as is shown from the fact that when the plant is released there follows an instant curving toward the source of light.

DISCUSSION OF THE RESULTS.

From the facts given it follows that simple tension applied in the line of growth will not produce alterations in the tensile strength of plants nor any changes in their tissues. A general increase of the strength of the plant occurred during the time of investigation as a natural result of thickening of cell walls or of growth in cross section, or of both factors combined.

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[10] Knight, Phil. Trans., 1803, II, p. 280; 1811, p. 217.

[11] Hartig, Wachtumsunter suchungen an Fichten. Forstl. Naturwiss. Zeitschr. z. Haft., 1896.

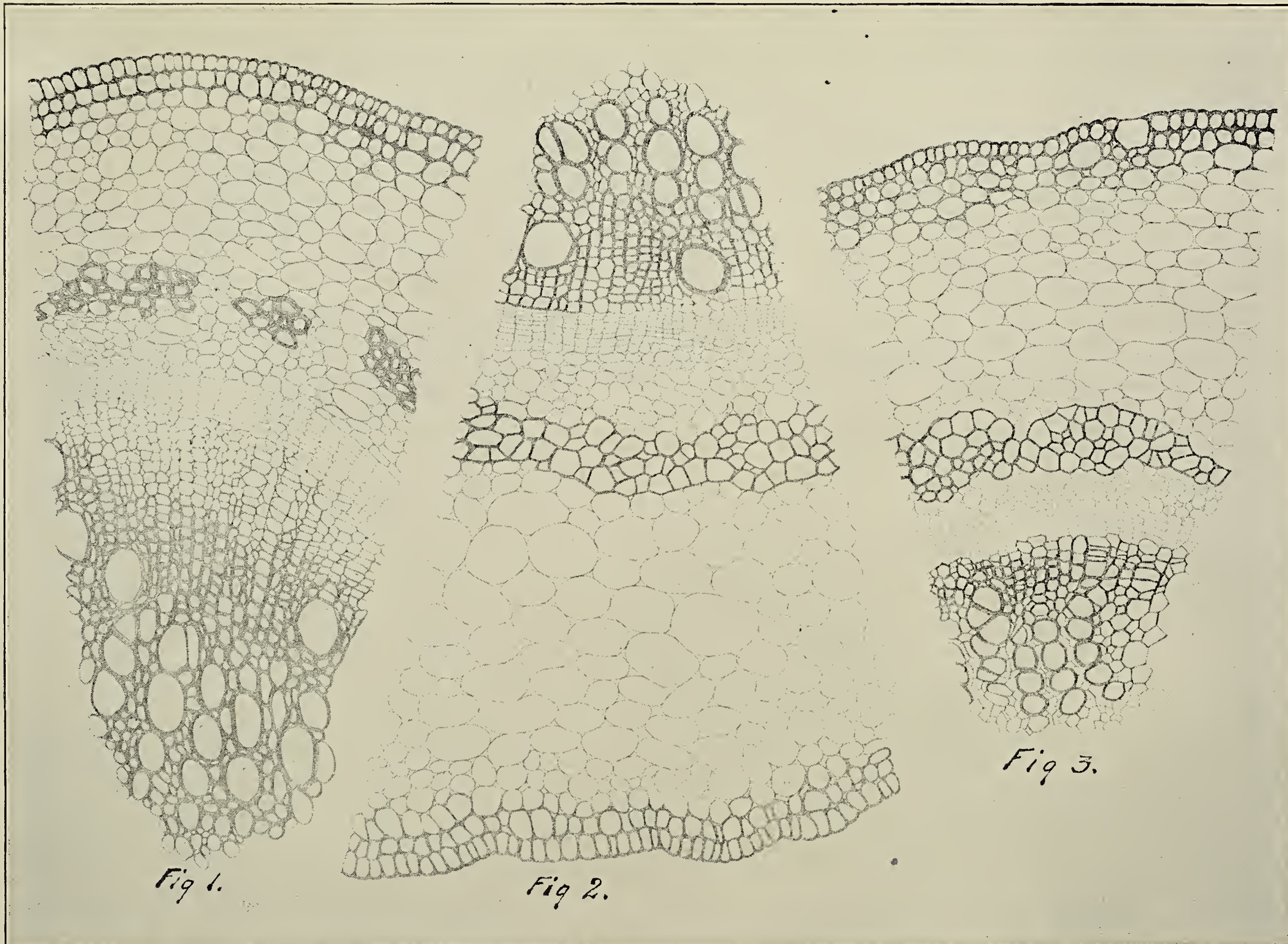
Fig 1.
Fig 2.
Fig 3.

On the other hand, it can not be denied that in certain cases, a mechanical force may cause an increase in tensile strength. Worgitzky[12] found that tendrils which had twined about a support were, in Passiflora quadrangularis, twice, and in Cucurbita pepo, thirteen times as strong as those which had found no support. Nevertheless, he has not definitely shown how much of this was due to mechanical tension and how much to contact irritation. The latter plays the chief role in the often very marked thickening of the petioles of leaf climbing plants. This appears, according to von Derschau, to a certain extent even when contact irritation is not present and when the weights were fixed to the leaves instead of to the petiole direct. However, these results are not altogether free from objection, especially as the matter was not fully investigated. In those cases where tension and contact irritation were simultaneously increased, it is still a matter of doubt how much of the observed effect was due to tension and how much to contact.

However, it can not be doubted that, in general, a similar complicated correlative interaction exists, as is everywhere the case when a gradual development of an organ which stands in the closest mutual relationship to the whole occurs. This is especially applicable to the development of the stems of fruits which stand in close correlative relation to the ripening fruit. It is indeed possible that the simple increase in weight of an apple or a gourd acts as a stimulant, and in a regulatory manner, causes a greater tensile strength in the fruit stem.

That there are stimuli which can aid in the development of mechanical tissues will be seen from the results of Wortman[13] and Elfving,[14] which we have sustained, according to which prevention of geotropic curving and forcible bending cause a tolerably well defined development of collenchyma, bast fibres, etc. Nevertheless no new tissues were formed, but only tissues normally present were strengthened and which would of themeslves, have been, in time, fully developed. Since this difference was a one-sided one, there results an actual difference between the convex and the concave sides which, in the case of Ricinus and Phaseolus, continued for from three to four weeks. If this difference decreased with increasing age or was finally equalized, it was not investigated. We have already seen that neither through forcible bending nor through prevention of geotropic curving could fibres of hard bast be developed in Helleborus niger.

In those objects which, as the result of the prevention of geotropic curving, a one-sided thickening occurred, there was no increase in tensile

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[12] Worgitzky. Vergleichende Anatomie der Ranken, Flora, 1887, p. 46.

[13] Wortman l. c.

[14] Elfding, l. c.

strength to be observed; this would suggest that there was no development in the opposite side, which is an observed fact. Perhaps an artificial thickening of the tissues on both sides would cause an increase in the tensile strength.

As has already been shown, one-sided thickening may be produced by different causes. In the one case, this occurs through mechanical bending when gravitational influences have been eliminated, as upon the klinostat, as Elfving has already shown. Again, it occurs when geotropic curving is prevented by tension or mechanical obstruction; in this case, on the upper side. The same result is attained when a heliotropic curving is prevented and also when the object was immovably fixed in a plaster of Paris cast and subject only to the action of gravitation. It is possible that the prevention of any tropistic curving will produce like results.

In view of the fact that longitudinal stress, without curving, has no effect, we may infer that the tension of mechanical bending can not of itself act as a stimulant through which cell thickenings on the convex side are produced. This does not exclude the possibility, however, that differences in tension between the opposed flanks may act as a stimulus. Irritations are also produced by differences of light supply which can not be measured by the results of the action of diffuse light. Likewise, it is also possible that in some way affecting the supply of food products, or other like changes may act as stimuli.

On the other hand, one-sided thickening of the cell walls are produced by gravitation, and indeed, most noticeably when no geotropic curving occurs. If the latter takes place, there follows a reduction of the one-sided hypertrophy, which appears, at least to a certain extent, upon the upper or concave side, while the cell walls of the under or convex side may undergo a certain reduction.

Although in the case of the negatively geotropic curving portion, a mechanical tension is exercised upon the antagonistic upper side by prevention of curving in the lower, which strives constantly to increase in length, it must, from the same considerations which were developed in the discussion of the mechanical curving, appear doubtful if tension is the active agent. Directly supporting this view is the fact that in well grown objects, in which any such strain on the part of the lower side must be at a minimum, a thickening occurred on the upper, and further that this effect was also produced in stems which had been enclosed in plaster of Paris casts where all stress from the under side was excluded.

A satisfactory causal explanation is, for the time being, as with other irritation processes, impossible. This is likewise true for the epitrophic and hypertrophic stimulations of growth in many plants which are due to the stimulus of gravitation.

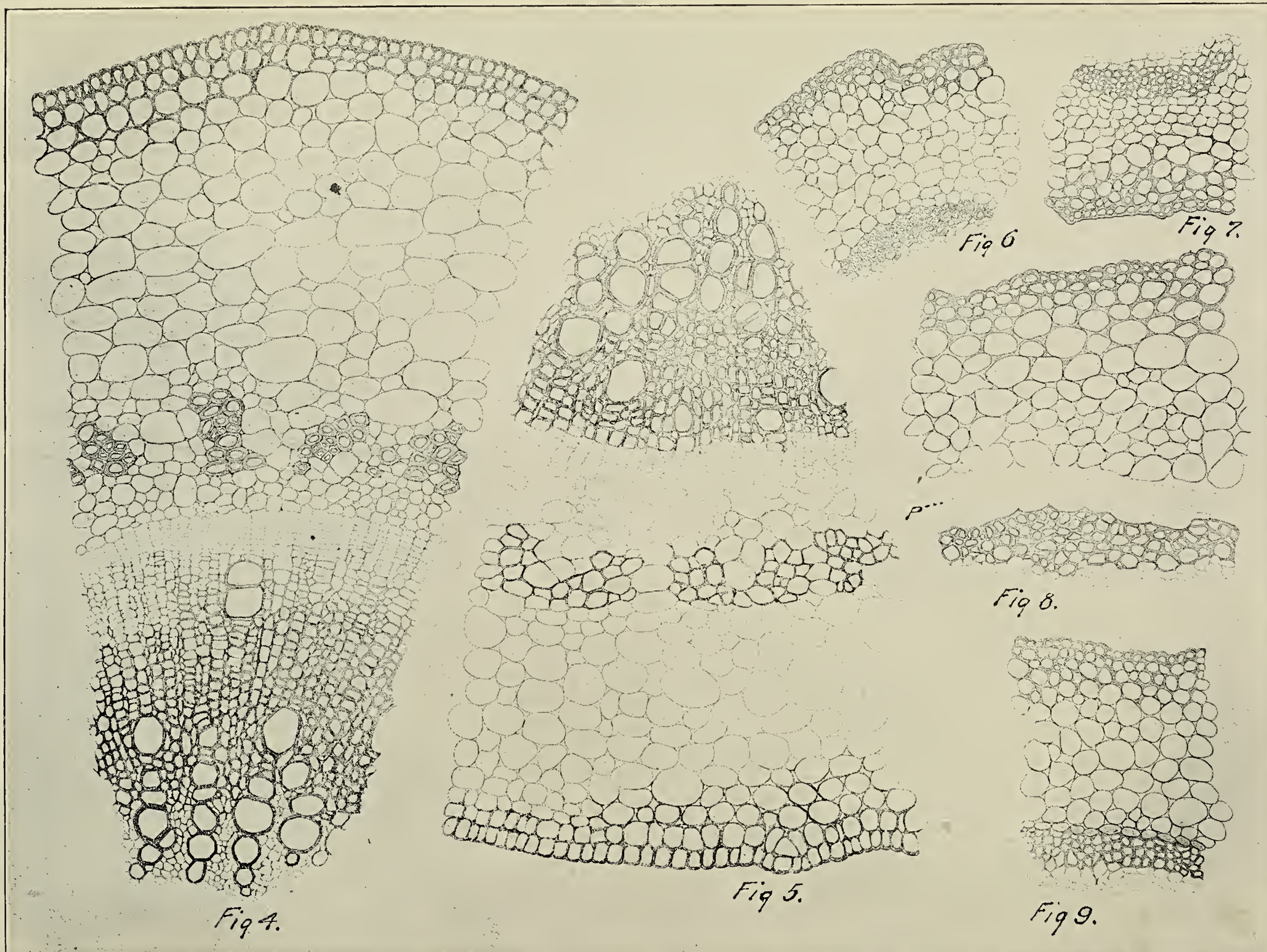
Fig 4.
Fig 5.
Fig 6
Fig 7.
p
Fig 8.
Fig 9.

We have thus to deal with two different stimuli, which produce analogous results, and which may combine in their actions.

In this manner are the results to be explained which appear when a forcibly bent stem is so placed that the plane of the curve is horizontal. Under these conditions it appears that the action of gravitation predominates, since only the zenithward side underwent thickening of the cell walls. Such a result is very well possible, since in physiological processes, the resultants do not correspond to a simple summation of the isolated individual factors, but rather, as experience shows, the different factors, working among themselves, may influence and modify each other. Dislocations and modifications appeared in the rythmical bending of stems in two directions, in so far as the thickening of cell walls was not confined to the two flanks but extended to the sides so that a continuous cell wall thickening appeared. Whether the tensile strength was also increased in this case was not investigated.

EXPLANATION OF FIGURES.

All figures were drawn with the Abbe camera and reduced to four-fifths by the engraver. Mag. 150.

Fig. 1. Upper side of a section through a stem of Ricinus com. 28 days old and 21 days horizontal and stretched. 5 cm. from ground.

Fig. 2. Under side of the same section.

Fig. 3. Section of a normal Ricinus of the same age and at the same distance.

Fig. 4. Upper side of a cross section of a stem of Ricinus of the same age which was horizontal and forcibly bent over a glass rod for 21 days. About 5 cm. from ground and 2 cm. from the point of contact with the rod, toward the root.

Fig. 5. Lower side of the same section.

Fig. 6. Bast, collenchyma and bark from the upper side of a 15-day old epicotly of Phasaeolus multiflorus which was enclosed in a plaster of Paris cast and laid horizontal for 7 days.

Fig. 7. The same tissues from the under side of the same section.

Fig. 8. Cross section through a 21-day old stem of Phaseolus mult. which was bent in two directions for 7 days on the "rocking machine." Taken from the point of strongest bending. P—cambium-like cell proliferation in the parenchyma.

Fig. 9. Section from a normal Phaseolus of same age as the preceding and taken at the same height.

VEGETATION

OF

THE SOTOL COUNTRY IN TEXAS*

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THE VEGETATION OF THE SOTOL COUNTRY OF TEXAS.

WILLIAM L. BRAY, PH. D.

There is a very striking and interesting type of vegetation identified with cerain physiographic features of our arid Southwest, which seems to be aptly characterized as to its strongest feature by the briefly descriptive name sotol country. The vegetation abounds in plants of the Cactus, Yucca and Agave type, having besides, many of the most characteristic desert shrubs or chaparral species. The most conspicuously abundant of all the species is the sotol or bear grass—Dasylerion texanum—whose occurrence is well shown in plates I to V. It is advisable to say "conspicuously abundant" with reference to sotol, for it has a strong competitor for the honor of characterizing the country in the dagger-point leafed lechuguilla —Agave lechuguilla which, although a less conspicuous plant in the vegetation landscape, must cover almost as much of the territory, is certainly numerically as abundant and withal a more extreme type of the desert plant whose sharp, dagger-point leaf armature is less likely to be forgotten by the experienced than the long gracefully spreading grass like leaves of the sotol.

The physiographic feature which—climatic conditions remaining approximately desert—determines the occurrence of the sotol formation, is a rolling or hilly or mountain slope area whose surface is covered by loose, coarser or finer, stony debris accumulated by the gradual disintegration of the plateau and mountain masses of the arid Southwest. Typical occurrences of such country would be the eastern foothills and mountain slopes of the continental axis from Southern New Mexico through Texas and far down into Mexico. Such areas occur also throughout the region reaching to the Colorado desert and the Gulf of California. In general, one may say that the type of vegetation under consideration is characteristic of the greater part of the Lower Sonoran Zone where the above named physiographic conditions prevail.

In Texas, the main body of the sotol country is embraced in the rough limestone region lying between the breaks of the Devil's River and the front ranges of the Cordilleras near Marathon over 150 miles west, extending thence southwestward over the region of the Great Bend of the Rio Grande. Northward, tongues of the sotol formation reach out along the divides of the drainage area of the Devil's River into the Edwards Plateau and of the Pecos River into the Stockton Plateau, and farther westward the formation follows the foothills and eastern front of the mountains into Southern New Mexico. Westward to the Rio Grande at Presidio and El Paso the sotol formation occurs wherever the physiographic features with which it is identified are repeated, viz., debris covered mountain slopes and rolling or hilly areas representing the progress of dissection of the plateau.

An adequate conception of the extent and character of the sotol country may be gained by crossing it along the line of the Southern Pacific railway, where, going westward, the sotol vegetation begins near the Devil's River crossing and continues more or less constantly to and beyond Maxon, a distance of more than one hundred and fifty miles.

Mr. Vernon Bailey, who has spent a portion of several seasons in making a biological survey of Trans-Pecos Texas, estimates that the area covered by lechuguilla in Texas would exceed twenty thousand square miles.

The sotol country, as here defined, marks the entrance into the desert areas of the arid Southwest. It is, as stated, a part of the Lower Sonoran Life Zone. The North American deserts lie chiefly within this zone and some of the sotol country is of extremely desert character, although it would be misleading to characterize the whole of it as such, especially in view of the importance of some of it as grazing country. The region of the Great Bend is certainly a desert, excepting, of course, watered canyons and the upper mountain slopes. The Devil's River area approximates more closely that of the Great Plains and differs rather in physiographic than in climatic conditions. Indeed the Great Plains really penetrate the sotol country, for the grassy plateau of the Alpine, Marfa and Fort Davis regions is in its vegetation essentially like the Staked Plains.

The plant life of the sotol country claims a large measure of interest for the biologist from the fact that in such inhospitable regions life phenomena are accentuated by being expressed in terms so different from those to which most observers are accustomed. In the desert, living things are embodied in unusual and unique forms. These forms express something of the nature and force of desert environment. If we examine the characters of plants which make them seem unusual and unique, they will be found to be, in the main, just those which best adapt the organism to the rigorous environment of the desert.

But this vegetation is also of interest from an economic standpoint. It forms, in the first place, a part of the southwestern cattle country, which with its mild winter climate is an ideal land for rearing herds and wintering them, its capacity limited, of course, by the lack of available water and sometimes of suitable forage, though as a matter of fact there is a great deal of forage—the sotol itself yielding vast quantities especially for sheep and goats—and after seasons of generous rainfall the grasses and annuals form almost a continuous covering of the soil in the open formation of sotol or lechuguilla or chaparral shrubs. In the second place, there is an economic interest in the possible yield of commercial products from certain species in the vegetation. For example the fibre of the lechuguilla has a well established reputation though the production of it is yet upon a rather meager and primitive basis.

TRANSITION FROM LUXURIANT FOREST VEGETATION IN EAST TEXAS TO THE SONORAN DESERT REGION.

In its temperature relations, the region considered in this paper is part of a transcontinental belt of warm temperate climate designated as the Lower Austral Life Zone. The zone embraces the South Atlantic and Gulf States and those of the Mexican boundary on both sides of the line. Because of the great difference in rainfall and conditions incident thereto, the former group of States comprising the eastern humid division, is designated as the Austro-riparian, the latter, comprising the arid division, as the Lower Sonoran Life Zone as previously stated. The differences in the plant life of these two zones are fairly proportional to the difference in the moisture relations of the two, in which the rainfall extremes are from more than 60 inches at the east to less than 5 inches at the west.

The State of Texas occupies the interesting position of lying in the zone of transition between these two extremes of the Lower Austral Zone. Within this State the extremes, briefly stated, range from the luxuriant forests of the Sabine border where the rainfall reaches nearly 50 inches annually and the air is moisture laden, to the desert mesas of the El Paso border where the annual rainfall is less than ten inches and the air is parched and dry during the season of growth.

The more apparent phenomena of this transition are very familiar to tourists who have crossed the State on the line of the Southern Pacific railway, and perhaps no section would show the transition more faithfully than that made by this line. Going westward, successive changes unfold themselves in panorama somewhat as follows:

	Miles west of the Sabine.	Elevation in feet.	Approximate annual rainfall in inches	Physiography and Soils.	Character of the Vegetation.
Orange on the Sabine..	0	12	ca. 50	Flat Coast Plain; low sandy ridges; river bottom; bayous.	Coast prairie with wet-soil grasses, etc.; cane and reed swamps; dense cypress and tupelo swamp forest; heavy pine forest; mixed forest of "Big Thicket" type.
Houston	106	40	ca. 45	Flat Coast Plain; higher sandy knolls and ridges cut into by drainage channels, e. g. Buffalo Bayou.	Western border of Atlantic type of continuous forest; western limit of southern pine; coast prairie with wet-soil grasses, rushes, sedges and many prairie annuals; prairie marshes with spider lily, Sesban, etc.
Luling	260	416	ca. 33	Rolling country, sandy loams, gravelly clay ridges, rich, alluvial bottom land.	Grass land with many prairie annuals—composites, labiates, mallows; open savanna-like occurrence of live and post oak and heavier post oak timber; numerous sand and gravelly soil species, including several cacti.
San Antonio..	316	686	ca. 29	Inner border of the Rio Grande Plain, slightly rolling; deep porous soils; southern margin of Plains Region; roughly eroded escarpment of Edwards Plateau; limestone.	On Rio Grande Plain, Sonoran species — mesquite. huisache, Opuntia sp., Zizyphus, Acacia sp., brasil; dry soil grasses and annuals. On limestone hills, characteristic hill timber—cedar, mountain live oak, shin-oak, cedar-elm, etc.
Spofford (Ft. Clark)..	449	1015	ca. 24	Northern border of Rio Grande plain; rolling; ridges covered with gravel, flats with finer soils.	Typical chaparral, more open formation, average height of woody growth much reduced; much Leucophyllum, Parkinsonia texana and Microrhamnus; mesquite and Acacias as eastward.
Del Rio..............	486	956	ca. 20	Alluvial valley of Rio Grande River; rough margin off Edward's Plateau; ridges with coarser limestone fragments, flats with calcareous clay and alluvial soils.	Chaparral, two to three feet tall in more open formation; huajillo, Leucophyllum, Parkinsonia texana; more cacti; grass cover broken, scattered bunches.

PLATE I.

Typical Sotol vegetation near Langtry, Texas; plants larger than the average because more moisture is present in the lower ground.

	Miles west of the Sabine.	Elevation in feet.	Approximate annual rainfall in inches.	Physiography and Soils.	Character of the Vegetation.
Langtry	550	1321	ca. 15	Rio Grande canyon and branches; high gracefully sloping hills, wide draws, broad divides, coarser or finer limestone derbis everywhere.	Typical sotol country; large areas of lechuguilla; chapearral; Covillaea, Flourensia, Koeberlinia, Microrhamnus, Ephedra; many species of cacti; Yucca, Hesperaloe, Selaginella; bunch grasses.
Haymond	668	3883	ca. 15	High, level or gently rolling plateau with isolated mountains; deep covering of fine, loose wind-swept soils; coarser debris on mountain slopes.	Western border of main sotol belt; edge of grassy plateau; cylindrical Opuntias common.
Marfa	743	4692	ca. 18	Level plateau with fine loose soils; isolated mountain masses.	Typical short grass country like staked plains; rich in prairie annuals; flat areas with Yucca radiosa and Koeberlinia.
El Paso	939	3713	ca. 9	Rio Grande valley; high arid gravelly mesas.	On mesas, Covillaea, Sarcobatus, Fouquiera, Croton; many cacti, shrubby composites, scattered grasses, desert vegetation.

SUMMARY OF TRANSITION PHENOMENA.

1. From heavy rainfall and humid atmosphere to almost rainless desert.

2. Gradual disappearance of Austro-riparian species and substitution of Lower Sonoran.

3. At the east, vegetation makes dense earth cover; at the west, it is very open, and the earth everywhere exposed.

4. Gradual dwarfing of woody vegetation.

5. Western limit of cultural zones indicated by the character of the native vegetation.

6. Eastern vegetation broad leafed, foliaceous; westward, vegetation non foliaceous, leaves variously modified or wanting.

7. Eastward, the contrast between summer and winter phases is strong; westward, the differences are much less noticeable in the dominant vegetation.

THE HABITAT.

The fact most emphasized in the foregoing east-west section, is the radical change in the conditions which determine the physiological adjustment of the vegetation. The rainfall diminishes to a bare 9 inches annually; the air loses its moisture; the dry winds bear away every meager supply of moisture from the earth's surface and from the surfaces of transpiring plants; the sunlight becomes more intense and more constant by reason of cloudless skies and vaporless air; the temperature variations of air and soil reach the daily extremes of burning heat by day and chilling cold by night and the seasonal variations are proportionately extreme; the elevation increases from nearly sea level at the Sabine to a maximum of five thousand feet (the highest point reached by the railway; of course mountain peaks exceed this by over 3000 feet), and a level earth covered by a deep, rich moist soil is succeeded by a rolling, hilly, canyon fissured region, the fragmented debris of whose rock strata lie loose and uncovered or only imbedded in the closely packed adobe soil derived itself from the limestone.

It is evident that the chief cause of this desert condition lies in the reduction of the moisture supply. This would more or less directly influence the temperature variations, the light intensity and even more the decomposition of the native rock and consequently the soil texture and of course its water supply.

That the factor of moisture alone would be insufficient to bring about the desert aspect of the vegetation is, however, clearly shown by the presence of a continuous grass vegetation on areas which, like the plateau about Alpine and Marfa, have a rich covering of deep, porous soil. The fierceness of the desert is manifest where the physiographic conditions present dissected areas of naked rock as in the lower Pecos and Devil's River country and along the Rio Grande canyon.

The general statement will probably be accepted that the vegetation of the region is, in its physiological relations, the product of this particular combination of environmental factors, i. e., that its chief characteristics consist in its methods of adaptation to the environment. This paper does not attempt to discuss the question as to the origin of the peculiar forms of plants—the so-called vegetation forms or ecological forms—which make up much of the sotol formation. That—as others have previously pointed out—could be solved only after exact measurement of the ecological factors on the one hand and by a detailed study of the physiological processes through the life cycle of the ecological forms on the other.

Sotol vegetation on the high divide between the lower Pecos canyon and the Rio Grande six miles northeast of Langtry, Texas.

Presumably the phenomena of adaptation are now in play as perceptibly as at any previous period, just as, in general, we assume that species are originating to-day as perceptibly as in previous ages under equally stimulating environments. Thus the peculiar fitness of cactus types, of Yucca, of Covilliaea, etc., as desert forms, and the cause of their being what they are structurally, might be discovered after measuring exactly the moisture conditions of soil and air confronting a given plant during the course of its development; also the temperatures and temperature variations in air and soil, the intensity and duration of illumination and variations in these; the chemical content of the soil and physical structure as affecting aeration, moisture, temperature, etc., and the response of the plant to these as expressed in its activity or passivity with respect to the absorption of water and mineral salts, and its disposition of these elements; with respect to Carbon assimilation and subsequent metabolic processes; its behavior as to growth and reproduction. All this means that valuable contributions to the life of desert plants can be made only after the application of as fine technique and as fine instruments and as much well directed study as is given in modern laboratories to other phases of plant life.

Without attempting, therefore, to present exact measurements of the environmental factors in this connection, a general statement of them is here presented, applicable especially to the region lying between Devil's River and Sanderson.

Rainfall. Within the belt just referred to, the average annual rainfall appears to be from 12 to 15 inches. The annual fall at Sanderson for 1901 was 7.30 inches and for 1902, 6.24 inches. It appears not to be exceptional for the entire year's rainfall to fall below 6 inches. For the most part, the rain comes in sudden rather local storms so that the off-flow carries away the greater part of it. The seasonal distribution of rainfall is of special moment in this case. The usual season for the renewal of vegetation,—March and April—is apt to be quite rainless, the greater part of the season's fall coming between June and October—especially in August and September, so that the coming of warm spring weather is not necessarily attended with luxuriant vegetative growth. It is said that more cattle die from weakness and starvation in March and April than in January and February because forage and water are scarce.

Humidity. The normal annual relative humidity of the atmosphere decreases from 80.4 per cent at Galveston to about 55 per cent at Sanderson and 38.4 per cent at El Paso, at practically equal annual mean temperatures. The air, therefore, becomes exceedingly parched and dry in Trans-Pecos Texas, and during the hot summer months, the dry superheated air currents bear away every meager vestige of moisture from the surface soil and draw with withering persistency upon the moisture resources of transpiring vegetation. Naturally, much of the vegetation has ceased vital activity by that time, and the remainder exhibits effective measures for resisting the dessicating power of the air.

Temperature. The temperature relations of the two extremes—Orange and Sanderson—differ but little. Both have an annual mean of about 70°. The monthly means coincide closely and range (at Sanderson) from about 50° during December and January to 85° in June, July and August. Minimum temperatures in winter are lower at Sanderson than at Orange, but the summer maxima are several degrees higher at Orange. Growing temperatures uninterruped by frost, may be expected from about March 1 to November 20. Vegetation in the arid west is less visibly altered by winter freezes owing to the early disappearance of herbaceous annuals and the non foliaceous character of the other forms. Also the warmer weather of early spring is more quickly felt and responded to by vegetation in the sotol country than at the east, probably because less moisture is present in the soil and because the soil itself is susceptible to rapid heating—being uncovered by a close vegetation. The daily variations in temperature in summer are greater at Sanderson than at Orange. The uncovered, rocky soil, the absence of vapor from the air, the greater altitude are factors which favor intense heating of the earth's surface and the stratum of air immediately above during the day and proportionately rapid and extreme cooling at night.

Illumination. This factor must be of special moment in its relation to vegetation in the sotol country. In a general way, the intensity of illumination has been recorded in the experience of various persons who have attempted to photograph objects and landscapes in the West Texas region. The almost vertical sun, the altitude, the vaporless air and prevailingly cloudless sky on the one hand and the white reflecting surface of rock on the other, conspire to make a glare of blinding intensity.

Physiography. At the beginning of this paper, it was mentioned that the sotol formation is characteristic of certain physiographic features of the arid southwest. It is most strikingly an edaphic formation. One may expect to find this formation in one phase or another of its associations, on every foot hill and mountain side where fragmented rocky debris covers the surface; on the border-

PLATE III.

Sotol vegetation on coarse, bare rock substratum near Terlingua, Texas, in the Great Bend of the Rio Grande. (From photo. by R. T. Hill, U. S. Geol. Survey.)

ing terraces of gravel or coarser debris about the flat basins or bolsons, and on points jutting out into these, and finally upon all of that part of the South Plateau where the Cretaceous formation has been dissected into an area of high, round topped hills and deep canyon fissures, of broad divides and proportionately wide, shallow draws, and of narrow ridges and deeper valleys—everywhere, that is, where there is unlevel territory covered by the fragmented debris of the disintegrating strata. While this debris is mostly from the disintegrating limestone the sotol formation is by no means limited to limestone but occurs upon other kinds of debris where these offer substantially the same physical conditions.

THE FLORISTIC CONTENT AND RELATIONSHIPS.

A complete collection and determination of the flora has not been made from the sotol formation at any point. The vicinity of Langtry on the Rio Grande not far from the Pecos canyon, and points east and west of this have furnished most of the writer's notes and collections. These collections, together with excursions to other points in Trans-Pecos Texas where the formation is entered, and the collections of previous explorers have yielded a sufficiently representative list to satisfy the objects of the present paper. No consideration is given here to species of the canyons or other moisture favored situations.

In the following list, those plants which form the permanent and distinctive features of the vegetation are starred (*).

Elionurus barbiculmis
Elionurus ciliaris
Hilaria cenchroides
Hilaria jamesii
Hilaria mutica
Eriochloa punctata
Aristida bromoides
Aristida dispersa
Aristida pupurea
  and others.
Stipa species.
Sporobolus confusus
  and others.
Muhlenbergia arenicola
Muhlenbergia berlandieri
Muhlenbergia monticola
Muhlenbergia texana
Bouteloua aristidoides
Bouteloua breviseta
Bouteloua eriopoda
Bouteloua havardi
Bouteloua hirta
Bouteloua oligostachya
Bouteloua uniflora
Papphorum wrightii
Cathestecum erectum
Tricuspis acuminata
Poa bigelovii
Selaginella lepidophylla
*Ephedra antisyphilitica
*Ephedra nevadensis
*Ephedra torreyana
*Hechtia texensis
*Yucca constricta
*Yucca macrocarpa
*Yucca radiosa
*Yucca treculeana
*Samuela faxoniana
*Hesperaloe parviflora
*Nolina erumpens
*Nolina lindheimeriana
*Nolina texana

*Dasylerion texanum
*Dasylerion graminifolium
*Agave lechuguilla
Eriogonum havardii
Eriogonum suffruticosum
Atriplex acanthocarpa
Atriplex canescens
Cladothrix suffruticosa
Allionia oxybaphoides
Allionia aggregata
Allionia albida
Abronia fragrans
Abronia turbinata
Selinocarpus angustifolius
Selinocarpus chenopodioides
Selinocarpus diffusus
Acleisanthes wrightii
Boerhaavia decumbens
Boerhaavia eriosolena
Boerhaavia wrightii
Talinopsis frutescens
*Berberis trifoliata
Lesquerella (2 or 3 species)
Greggia camporum
Greggia linearifolia
*Fallugia paradoxa
*Cowania ericaefolia
*Acacia berlandieri
*Acacia constricta
*Acacia greggii
*Leucaena retusa
*Leucaena pulverulenta
Acuan velutina
*Calliandra conferta
*Mimosa biuncifera
*Mimosa borealis
*Mimosa fragrans
*Prosopis glandulosa
*Prosopis pubescens
Cassia bauhinioides
Cassia pumilio
Hoffmannseggia brachycarpa
Hoffmannseggia drepanocarpa
Hoffmannseggia jamesii
Hoffmannseggia oxycarpa
*Cercidium texanum
*Krameria canescens
*Krameria parvifolia
*Krameria ramosissima
Krameria secundiflora
*Eysenhardtia amorphoides
Dalea argyroea
*Dalea formosa
*Dalea frutescens and several other species
Oxalis dichondraefolia
*Covillaea tridentata
Tribulus grandiflorus
*Porliera angustifolia
*Koeberlinia spinosa
Thamnosma texana
*Helietta parviflora
*Castela nicholsoni
*Euphorbia antisyphilitica
*Jatropha spathulata
*Bernardia myricaefolia
Croton—several species
*Rhus microphylla
*Rhus virens
*Schaefferia cuneifolia
*Mortonia scabrella
*Condalia obovata
*Condalia spathulata
*Zizyphus obtusifolius
*Microrhamnus ericoides
*Karwinskia humboldtiana
Malvastrum coccineum
Sida filipes
Sida hederacea
Sida neo-mexicana
Abutilon crispum
Abutilon newberryi
Hermannia texana
Ayenia microphylla
Ayenia pusilla
Galphimia angustifolia
Aspicarpa longipes
*Fonquiera splendens
Amoreuxia wrightii
Mentzelia albicaulis
Mentzelia multiflora
Eucnida bartonioides
Cevallia sinuata
*Echinocactus brevihamatus[1]
*Echinocactus horizonthalonius
*Echinocactus longihamatus
*Echinocactus setispinus
*Echinocactus texensis

[1]This list comprises only the cacti collected about Langtry.

PLATE IV.

Sotol on the margin of Tornillo Desert in the Great Bend of the Rio Grande. (From photo. by R. T. Hill, U. S. Geol. Survey.)

*Echinocactus williamsii
*Cactus conimamma
*Cactus heyderi
*Cactus micromeris
*Cactus pectinatus
*Cactus pusillus
*Cactus scolymoides
*Cactus viviparus
*Cactus williamsii
*Cereus dubius
*Cereus emoryi
*Cereus greggii
*Cereus longispinus
*Cereus stramineus
*Echinocereus caespitosus
*Echinocereus dasyacanthus
*Echinocereus paucispinus
*Ecinocereus pectinatus
*Opuntia arborescens
*Opuntia arenaria
*Opuntia engelmannia
*Opuntia leptocaulis
*Ariocarpus fissuratus
Gaura species
Macrosiphonia berlandieri
Menodora heterophylla
*Lycium pallidum
Nama hispidum
Gilia havardi and several others
Physalis lobata
Coldenia canescens
Coldenia greggii
Coldenia hispidissima
*Lippia ligustrina
Bouchea spathulata
*Salvia ballotaeflora
*Leucophyllum texanum
*Leucophyllum minus
Cucurbita foetidissima
Zexmenia brevifolia
Grindelia squarrosa
Eriocarpum rubiginosum
*Flourensia cernua
Psilostrophe arachnoides
Psilostrophe tagetina
Baileya multiradiata
Laphamia angustifolia and others
Perityle species
Bahia species
Actinella scaposa
Sartwellia flaveriae
Porophyllum species
Chrysactina mexicana
Hymenatherum acerosum
Hymenatherum greggii and others
Pectis angustifolia
Pectis longipes
Pectis papposa
Perezia nana
Perezia wrightii
Trixis angustifolia

From this list it is to be noted first of all that the dominant species have a very general distribution throughout the arid rocky plateau embracing Trans-Pecos Texas, Southern New Mexico, Arizona, Southeastern California and the Mexican States of Sonora, Chihuahua, Coahuila, Nueva Leon and several others immediately to the southward, and that as a rule these species are not found elsewhere outside of this region. Species of the Great Plains and of the Rocky Mountains are scarcely represented in the formation, although the level plateau above Alpine, Marfa, etc., has a characteristic Great Plains flora and the elevated mountain peaks possess islands of Rocky Mountain flora. Still less is there any representation of the Austro-riparian flora, and comparatively little of what is called the Gulf Neotropical (except, perhaps, Porliera, Helietta, Amyris, Amoreuxia).

One the whole, the flora of this arid region is little shared with similar regions of other continents, there being more exceptions to this in the case of South America[1] as would be expected where the cacti reach a very noteworthy development and where Prosopis, several zygophyllaceous genera and Mentzelias are more numerously represented in the deserts of Chila and Argentine than in the region here discussed. Perhaps it would not be inaccurate to say that this formation contains a larger percentage of species peculiarly North American than any other that could be selected. Here are many Nyctages, Mallows and the very interesting composite group of Tubuliflorae-Helenieae which is strikingly a Lower Sonoran group and many of the genera quite limited to rocky plateaus of the arid Southwest. But more important floristically, of course, are the groups which embrace the more striking ecological types of the formation,—dwarf shrubs like Krameria, Microrhamus, Parkinsonia; the wandlike Fouquiera, and the "all thorn" Koeberlinia; the dracenoid lilies embracing Yuccas, Nolina, Dasylerion and Hesperaloe, the Agaves, and finally, the most unique group of the cacti. On the basis of its floral and ecological distinctness, one gains the impression that this southwestern plateau desert has had a more effective barrier about it than has the continent as a whole and the statement is justified that it is to be regarded as a distinct floral province and an originative or creative center for ecological forms like those in other deserts but from quite distinct floristic groups.

ECOLOGICAL FORMS AND THEIR OCCURRENCE IN THE VEGETATION.

The plant forms in the sotol vegetation are constructed upon a relatively few general types not unlike those which have been formed by similar environment in other arid regions of the earth, but for the most part floristically distinct. The dominant factor in shaping these adaptation forms has been the water supply. In some plants it has led to abnormal storage of water and other products and the whole plant structure has been subordinated to this. In others, quite the contrary course has been followed and plants of this type are strikingly devoid of succulent tissue—i. e., Chaparral shrubs. Other plants meet the emergency of insufficient water supply by virtual encystment of their living substance and consequent drying and shrinking or folding of their mechanical parts, and yet others exist the greater part of the time as resistent seed capable of germinating and completing a vegetative cycle

[1] See Relation of Flora of Lower Sonoran Zone to Arid Regions of South America, Bot. Gaz. XXVI, 1898, pp. 121-147.

PLATE V.

Sotol vegetation on stony hillsides and smooth talur slopes at Longfellow, Texas; far down on the flat the bunches are Nolina Sp.

back to the seed condition in the brief season following copious rains while the surface soils are supplied with moisture. These are well known adaptation devices.

A systematic presentation of these types will be instructive:

A. Ecological forms distinguished by marked development of storage tissue in one or more of the regions—root, stem, leaf—which results in abnormal forms of plants and in special habits with respect to the performance of the vital functions.

I. Storage tissue—for water, reserve foodstuff, mucilage, excretion products—chiefly in thick, fleshy, spine protected leafless stems; leaves wanting; assimilation tissues in superficial area of stem.

Cactus types.

1. Stems flat jointed; Plat-Opuntias.
2. Stems spherical or flattened, disk shape. Echinocactus texensis, horizonthalonius, longihamatus, etc.; cactus heyderi, micromeris, pectinatus, etc.; Ariocarpus fissuratus.
3. Stems cylindrical, fluted. Cereus stramineus, longispinus and greggii; Opuntia leptocaulis and arborescens.

II. Storage tissue—for reserve food, saponin, mucilage, crystals—in more or less enlarged and succulent, bayonet shaped leaves arranged in rosette or close spiral with armed tips presenting an abattis-like defense. Roots commonly fleshy, much branched and wide spreading. Tendency to develop palm-like caudex with food storage in a leaf base region. Agave lechuguilla, Yucca radiosa, treculeana, macrocarpa, baccata, etc.; Hesperaloe parviflora.

IIa. As in II but storage tissue chiefly in roots and short caudex; leaves narrow, long and grass like; Dasylerion texanum; Nolina texana, erumpens, and lindheimeriana.

III. Storage tissue in more or less woody but fleshy stems or roots.

1. Leaves normal, quickly falling. Jatropha spathulata.
2. Leafless, juncoid stems. Euphorbia antisyphilitica.

IV. Storage tissue developed in well protected perennial, sclerenchymatic roots or in bulbs; aerial parts evanescent, coming out soon after rainfall and disappearing with dry weather.[1] Jatropha berlandieri and macrorhiza; Alliona,

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[1]In reality, a large number of species generally thought of as constituting the herbaceous annual vegetation fall in this class.

Selinocarpus, Acleisanthes, Cucurbita foetidissima, Asclepiadora decumbens; Cooperia, Zephyranthes.

B. Ecological forms marked by absence of storage or succulent tissue: mechanical tissues in excess, very compact and hard; stems and branches dwarfed, rigid and often spine tipped; leaves much reduced in size or early falling or permanent and leathery and otherwise variously protected; tender, leafy shoots appear after sufficient rainfall during the growing season—March to November; roots generally much branched and far reaching.

I. Foliage leaves wanting; young shoots develop sappy cortex and assimilation tissue; enlarged woody root axis. (Compare A. IV.) Ephedra.

II. Leaves wanting or very ephemeral.

1. Shoots green (except older trunks) tapering to hard pointed thorns. Koeberlinia spinosa.
2. Stem wandlike, armed with stout thorns and thereby furrowed. Fonquiera splendens.

III. Reduced leaves of various forms and variously protected.

1. Compound leaves, dissected into many leaflets—Acacia berlanderi, constricta, greggii; Prosopis glandulosa and pubescens; Leucaena retusa and pulverulenta; Calliandra conferta, Mimosa fragrans, borealis, biuncifera.
2. Compound leaves especially reduced as to the number of small leaflets. Krameria canescens and ramosissima. Parkinsonia texana. Dalea formosa and frutescens.
3. Leaves protected by glandular secretion. Covillaea tridentata. Flourensia cernua.
4. Leaves minute, ericoid, appressed. Mortonia scabrella and sempervirens. Microrhamnus ericoides.
5. Leaves with protective hairy covering. Leucophyllum minus and texana. Crotons. Eurotia lanata.
6. Leaves simple, small, without notable protective devices. Condalia obovata and spathulata. Zizyphus obtusifolia. Celtis pallida.

C. Ecological forms designated as short lived annuals. More or less protected by various types of pubescence: Not capable of enduring long continued drought and therefore develop only after copious rains and mature seed quickly, which then lie in the dormant condition until a subsequent rainy season.

PLATE VI.

Fig. 1. Typical lechuguilla on arid, stony hill slope near Langtry, Texas.

Fig. 2. Very thick and uniform covering of sotol on high slopes looking toward the Pecos canyon near its mouth.

Boerhaavia decumbens and Wrightii; Lesquerella species; Cevallia sinuata; Gilia species, Krynitzkia species, Nama hispidum; Baileya multiradiata, Sartwellia flaveriae, Perezia nana.

D. Ecological forms which have the capacity of becoming dormant by virtual encystment of their living substance, accompanied by the rolling together of the leaves of the entire plant.

Typical and most common is Selaginalla lepidophylla. S. rupestris also, and several Cyanophyceae, lichens belong here. One or more thallose liverworts and perhaps a dozen species of ferns found on rock ledges in the canyons possess the capacity to dry out and roll up most completely—e. g., Cheilanthes and Notholaena.

E. The Grass Type: Annuals or perennials, the latter probably predominating but with no special food storage. During rainless periods the stems and leaves die and become thoroughly cured standing. After rainfall, new shoots quickly appear from dormant buds of perennials and from seed of annuals. See list of grasses, pp. 9, 10.

The sotol formation of the West Texas region is thus found to be composed of a flora varying with the locality from one hundred to a few hundred species falling into a small number of adaptation forms. These several forms do not all play an equal part in the vegetation in the sense of being equally numerous or equally conspicuous. Thus the cactus type which is popularly supposed to represent the ideal desert plant, is by no means so abundant or so conspicuous as it is in the vegetation of many parts of the Rio Grande Plain although there are many more species of cacti in the sotol formation. It must be said, however, that the species of cacti represented in the sotol formation are not conspicuous plants and that their numerical representation in the flora is really much greater than seems apparent. In general, the very types that would be selected as the fittest adaptations to arid habitats—with the exception of lechuguilla—are those of relatively infrequent occurrence—e. g., Fouquiera, Koeberlinia, Ariocarpus, Ephedra. Preference is also shown by different types for different conditions of soil and topography, and consequently their part in the whole vegetation would vary with the extent of the particular feature with which they are identified. Thus the broad divides or long slopes are the most extensive physiographic feature and sotol which selects such areas is also the most abundant single type. The round topped points or sharply sloping rock-strewn hillsides afford abundant areas for lechuguilla and the flats covered with fine sediment give Covillaea opportunity for its conspicuous occurrence.

With regard to the formation as a whole; it strikes one as being notably a nonfoliaceous vegetation. The soil is not shaded and shade loving plants are wanting. This condition is of course due to the very large extent to which the foliage functions of leaves are subordinated to other purposes or to their great reduction in size or to their entire absence. Another striking characteristic of the formation is the fact that it almost never hides the ground upon which it stands—a circumstance due partly to the lack of foliage just mentioned, but especially to the actually unoccupied space. In this respect, the formation presents two phases, first that due to the presence of perennial species whose aspect varies only with the presence or absence of young vegetation or flower shoots, and second that due to the addition of the short lived annual species or herbaceous perennials whose presence is dependent upon copious rainfall. These appear on the whole more regularly in the spring, although the rainfall upon which they are dependent may come in September or October as in the season of 1904. The coming of the annuals tends to close up the formation by claiming unoccupied space between the perennial species and together with the young growths upon these latter approximate a closed formation after an unusual amount of well distributed rainfall. This may be called the vernal aspect of the vegetation even though its coming be delayed until June or late September. Even at such times of relatively luxuriant growth, the vegetation is not sufficient to hide the white background of disintegrating limestone (or of other geological formations where these occur, e. g., in the Great Bend) while in the drought of midsummer and in winter the vegetation cover seems meager indeed. In any event, the arrival of the favorable temperature conditions of February and March results in the formation especially of flower shoots on the part of some of those species which have abundant storage tissues or those whose roots penetrate deeply enough to find a constant, if meager supply of moisture. Thus, Yucca treculeana, Hesperaloe parviflora, Cereus species, Microrhamnus ericoides, most Mimosae, Dalea frutescens, Covillaea and others were in blossom in early March of 1903 and 1904 although it was then too dry for a general bursting forth of the vegetation: Other species require a higher temperature to induce the formation of flower shoots—e. g., most cacti, lechuguilla and sotol itself—and so do not blossom until June or later.

Certain of the phenomena of association of species in the vegeta-

PLATE VII.

Typical occurrence of Ocotillo (Fonquiera splendens), in the sotol country near Langtry, Texas.

tion of humid climates are absent or unnoticeable in the sotol formation as also in other arid regions. In the first place, since the plants do not stand in close order, they do not influence the growth one of another, nor is there that co-operative or mutually dependent phase which results in establishing special conditions such as are found in a forest with its characteristic soil, light, air, temperature, and strata of vegetation. There is scarcely a question of shade loving plants here, nor is there evident that phase of dependence exhibited by clambering or climbing and twining plants. There are few parasites or saprophytes, in short, it is a vegetation of independent members.

But while the various members of the formation are independent of each other, there is by no means a uniform aspect of the vegetation at all points. Differences in soil texture, soil moisture, relief, etc., are responded to as in other formations and one finds a division of territory as if by common agreement. In some situations, the formation involves an association of a majority of all its species, in others, a single species is dominant, but in view of their being always unoccupied ground a general association may be the ultimate condition. The more prominent types of association are the following:

Sotol Association: Sotol becomes the dominant species on upland divides and on the even gentle slopes of isolated cones and ridges in the more eroded areas. As previously mentioned it is the one conspicuous, dominant form which seems worthy of characterizing the whole formation. There is variation both in the closeness or frequence of plants in this association and in the height. On the more arid divides, the sotol cover is uniformly close but not exceeding two feet in height, while at the head of draws where there is more soil and moisture the plants are luxuriant and broad and three to five feet tall.[1] See plates I to IV.

Lechuguilla Association: This species rivals the sotol in the actual extent of territory covered, but in the Langtry district at least, it occupies the lower round topped points and ridges where the stony debris is coarser and the conditions more arid than where sotol prevails. Mr. Vernon Baily has estimated that the lechuguilla association covers twenty thousand square miles in Texas. The plants of lechuguilla stand more thickly upon the ground than in the case of sotol, but the pike formed leaves are not so conspicu-

[1] Mr. James H. Gaut of the United States Biological Survey reports having seen sotol in Southern New Mexico with a distinct caudex several feet tall, such as some of the Yuccas develop.

ous as the gracefully spreading grass like leaves of sotol nor does the lechuguilla growth attain as great height as the sotol, averaging perhaps less than one foot, though in the Great Bend region—slope of the Chisos Mountains—the growth is taller, which is a matter of consequence in connection with the yield of fibre. See plate III and pl. IV, fig. 1.

Covillaea Association: This is the Mexican greasewood vegetation which is a mark of the Lower Sonoran desert almost throughout. Its characteristic occurrence is upon fine soil covered flats where it forms a symmetrical open growth two and one-half to three feet tall not unlike a young orchard plantation. Covillaea forms a characteristic feature of the bolson desert vegetation in West Texas—regions not comprised in the sotol formation.

Mixed Association of Chaparral, Yucca, Cacti, etc.: The sotol formation seems to be tending in the direction of becoming a more general mixture of associated species. The openness of the formation in general seems always to invite invasion of most species not already on the ground and the chaparral of far Western Texas seems to be almost as aggressively spreading as in the Rio Grande Plain and Central Texas. This mixed association is at present confined more to the depressions and the level divides where moisture conditions are better than on the sharper slopes and ridges. The drainage courses which in their lower stretches cut deep canyons, are, on the upland, broad shallow depressions or valleys. In these depressions the mixed association has attained a characteristic development. Along the railway from Langtry to Sanderson this is especially illustrated. Yucca treculeana becomes an emphatic feature in the landscape here.

In a minor way Nolina, Fouquiera, Selaginella lepidophylla, Flourensia, Mimoseae, Leucophyllum and others become in turn the dominant species, and on the eastern border of the sotol country—e. g., about Del Rio—haujillo and Parkinsonia texana give the vegetation aspect in places where one would expect the sotol and lechuguilla. See pl. VII, IX, X.

The Occurrence of Cacti in the Vegetation: The part played by cacti in the sotol formation in Texas is relatively inconspicuous. It is well known, however, how completely they dominate the formation in the Mexican Plateau. In the region between the lower Devil's River and Pecos canyons there are probably fifty species of cacti. At no point do these constitute a dominant element in the formation (except for small areas of a few square yards) but they would be designated as of frequent or abundant occurrence.

PLATE VIII.

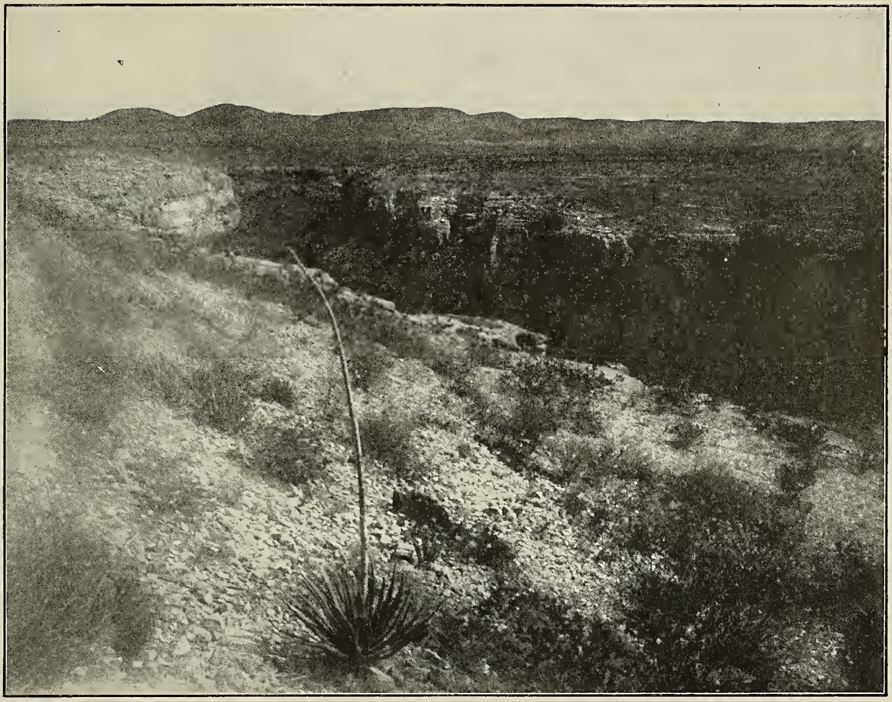
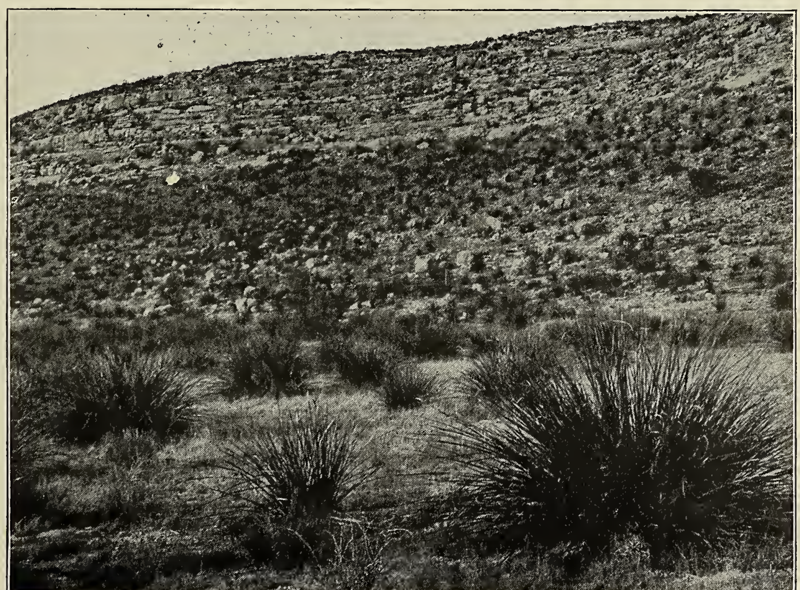


Fig. 1. The sotol vegetation at Longfellow, Texas; in foreground is Nolina Sp.; higher up is mostly sotol.



[Fig. 2. Typical erosion canyon and contours in the sotol country; cretaceous limestone; pump canyon, Langtry, Texas.

PLATE IX.

Fig. 1. Abundant occurrence of resurrection plant (Selaginella lepidophylla) on stony hillsides, Langtry, Texas. The dark shadows are curled bunches of the plant.

Fig. 2. Single unfolded plant of the resurrection plant.

At El Paso the cacti are more conspicuous in the vegetation, and in the Great Bend of the Rio Grande they are still more so. Manifestly the main sotol belt from Devil's River to Sanderson is only on the northern border of the cactus area. It is noteworthy that numerous species of cacti which on the Mexican Plateau are large sized, prominent plants, are habitually small and inconspicuous north of the Rio Grande. See pl. XI.

ECONOMIC IMPORTANCE OF THE VEGETATION OF THE SOTOL COUNTRY.

In the introduction to the paper, attention was called to this subject. With regard to the use of the vegetation as food and beverage or for medicinal or minor domestic purposes, there has long been a rather intimate knowledge of the various species, since in the arid Southwest the native population has always held the plant life in special regard.

The methods taken in adapting the species to their rigid environment have been the source of what the plants have had to yield to mankind. There was, first, the possibility of securing water to quench thirst from plants which had developed the capacity to store up reserves of this essential fluid. As a means of retaining this water within the plant—i. e., against evaporation—were developed the saponin found in numerous soap yielding species (amole plants) and the mucilage, giving the cooling lotions and poultices. Along with the storage of water in succulent stems went also the storage of assimilation products (starches, sugars) which by fermentive process yield the numerous beverages. The mescal from sotol, the drink yielding Peyote—Star Cactus—which may also be chewed after fermentation of the succulent body, resulting in a delirious exhilaration.

In shrubby and herbaccous plants, desert conditions induce the secretion of aromatic oils, gums and resins and of strongly scented and dyed secretions in bark or stem or root, which are a source of protection to the plant and yield various extracts of value in medicine or arts. Shrubby desert vegetation, especially, is apt to abound in strong flavors or bitter taste.

The two connections, however, in which the sotol vegetation has extensive economic possibilities, are in the line of fibre yielding and forage plants. Its value in the latter connection has, of course, been quite thoroughly tested.

There are several genera embracing numerous species which habitually produce much bast fibre in the leaves. These are the

Yuccas, Nolina, Dasylerion, Hesperaloe and the Agaves. Thus far practical experience in attempts to utilize various species, have resulted in choosing out only the Agava lechuguilla as of superior excellence. As shown in Dr. Rose's report—Contr. U. S. Nat. Herb., vol. V, No. 4, p. 242—the fibre industry in lechuguilla is well developed in Northern Mexico. It is practically nil north of the Rio Grande or limited only to the manufacturing of a few articles for local use. The presence of such a vast area of lechuguilla in Trans-Pecos Texas—estimated at 20,000 square miles—would seem to suggest large possibilities in the development of the fibre industry at least of the kind carried on in Mexico.

In the matter of forage value, the region faces the need of husbanding its resources rather than of developing them. After having seen the sotol country between Devil's River and Sanderson in winter or in dry midsummer, or from what has been said in this paper hitherto, it will surprise one to know that its forage value is actually superior to some regions in Western Central Texas or in the upper Rio Grande Plain—not naturally, of course, but because the better ranges have been so reduced by over-pasturage. A cattleman of experience maintains that within a radius of 100 miles of Langtry the forage value is equal to the support of one cow to each fifteen acres or one sheep to each four acres. Among the forage resources counted upon are the grasses and the short-lived herbaceous annuals which of course are as variable in their occurrence as the rainfall itself, but which come more or less regularly with the spring and not infrequently appear in great abundance in the fall and thus carry stock well through the winter. It is just the uncertainty of having enough rainfall in March and April to start this vegetation that makes the early spring months the time of starved weakness and danger for stock. At this season permanent vegetation, the young shoots and leaves of shrubs and the succulent buds and sometimes the leaves of the Yucca and sotol type are the forage standby.

If the succulent parts of the cacti, Yucca, Agaves and the like could be obtained by stock unaided, naturally these water and nutriment yielding forms would cease to exist so plentifully. As a matter of fact the Yuccas are attacked when the large, succulent and nutritious flower bud is well formed. This, for Yucca treculeana, happens early in March, and at that time one may observe a most amusing behavior on the part of cattle which consist of an eager procession of these animals fairly running from plant to plant of the Yucca, impatiently thrusting their heads among the

PLATE X.

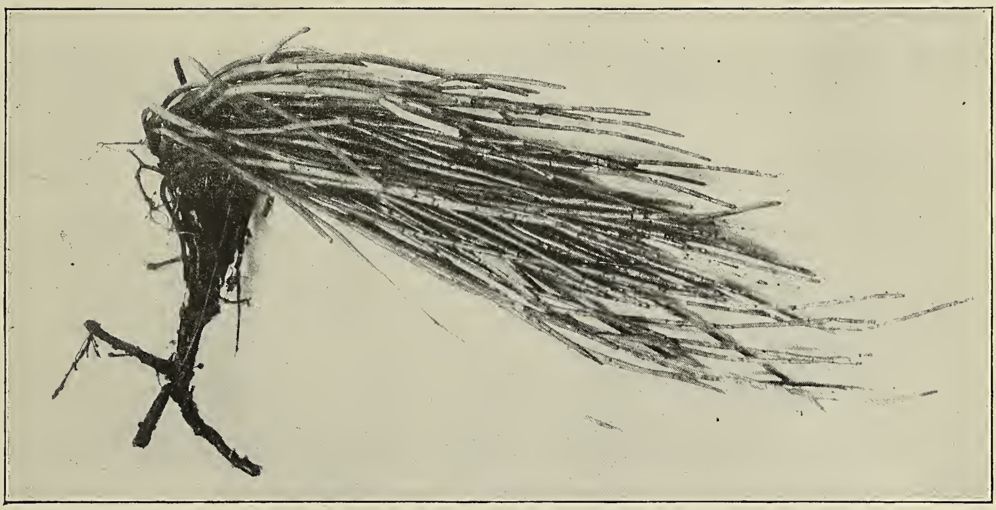


Fig. 1. An instance where chaparral constitutes the vegetation of sotol country; the even, close cropped bunches are Ephedra antisyphilitica.

Fig. 2. A single clump of Euphorbia antisyphilitica; occurs at Langtry, Texas, but is very abundant and characteristic in the Terlingua district in the Great Bend of the Rio Grande.

PLATE XI.

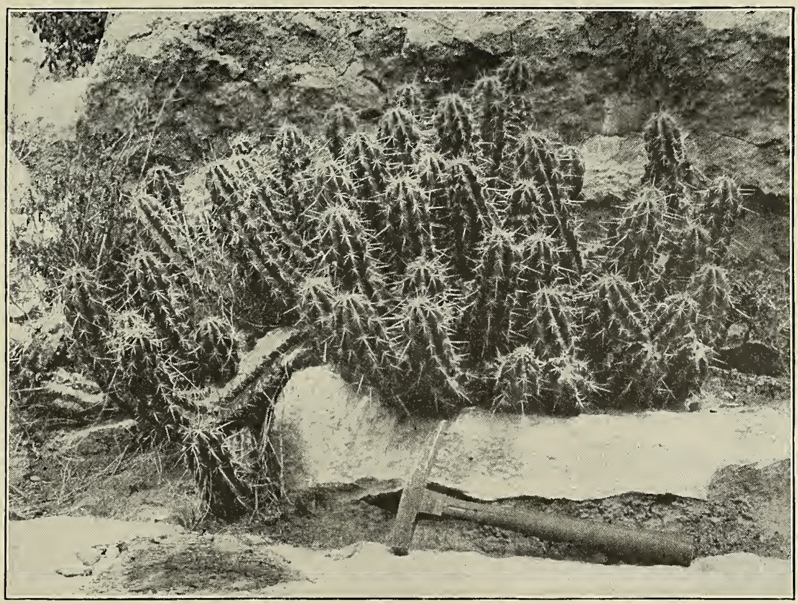


Fig. 1. A typical specimen of a clump forming Cereus (Cereus longispinus?); this and two other species are common about Langtry, Texas.

Fig. 2. The star cactus (Ariophorum fissuratum) which is often abundant at the foot of steep, arid, stony slopes from the Pecos river southwestward.

bayonet leaves and rifling the plant of its flower bud, leaving it broken and disfigured. This procedure is so common on the range about Langtry and the plants of Yucca treculeana are so disfigured —all, that is, except such as are too tall for the cattle to reach— that apparently the species is in a fair way to be exterminated in that region. Probably the sotol plants are similarly robbed of their young flower buds, which would seem to account for the absence of the tall flowering stalks on easily accessible range, whereas on steep, rocky cliffs and unpastured corners these flower stalks are very conspicuous. See pl. v. The writer does not recall having noted a single flower stalk upon thousands of acres of close growing sotol on the divide between Comstock and the Pecos Canyon, or upon the open range about Langtry.

It was not determined whether sotol sends up a flowering shoot periodically or whether only once in the lifetime of the plant as maintained by a very competent local observer. These flowering buds and shoots would, like Yucca, be a source of food of much consequence and easily available for stock. But the resource is at least temporarily multiplied many fold when the sotol plant is cut and fed to stock. This renders available the nutritious cabbage-like terminal bud which is naturally very closely covered by the dense tuft of saw-edged, tough leaves. Sotol cutting is a prominent part of the duties of the sheep and goat herders nowadays— a process very suggestive of the old custom of cutting green corn from the field for fall feeding of cattle and hogs. It is very largely practiced also for cattle feeding, not on the range merely, but for shipping to other points. The most striking example of this known to the writer is the case where a cattle feeder in Eagle Pass shipped to that point 100 carloads of sotol for his cattle during the winter of 1903-04.

For so important an item of forage, too little is known about the habits and qualities of the sotol. That it is rich in nutriments has been demonstrated in general by its use as a food, and as a source of beverage and by experience in feeding stock, but more quantitative determinations do not seem to have been made. Its habits and rate of growth are not well known. The conditions and frequency of flowering and other means of reproduction, the vitality of the plant and its capacity to sprout up after the bud has been cut out are matters of importance to be determined in view of the great drain its popularity is making upon the supplies. Whence came the great invasion of sotol and when it began are questions of much speculative interest, but not sufficient data are at hand to render this speculation valuable. It seems tolerably certain that the plant is, in general, losing, rather than gaining ground, which is of course quite contrary to the history of its shrubby associates.

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*Elected in place of Dr. E. Dwight Sanderson, resigned.

PAPERS PRESENTED AT REGULAR MEETINGS.

January 1, 1904 (Evening Session).

1. "Some Experiments in Color."—An illustrated lecture.—N. H. Brown, Ph. D., Professor of Physics and Electrical Engineering, Agricultural and Mechanical College, College Station, Texas.

2. "The Boll Weevil."—An illustrated lecture.—E. Dwight Sanderson, B. S. A., Professor of Entomology, Agricultural and Mechanical College, College Station, Texas.

January 2, 1904 (Morning Session).

1. "The Cellular Basis of Heredity," Thomas H. Montgomery, Jr., Ph. D., Profesor of Zoölogy in the University of Texas, Austin.

2. "A Design for a Rice Irrigation Plant," W. E. Anderson, Member American Society Mechanical Engineers, Houston.

3. "The Causes of the Great Ice Age," C. W. Hutson, M. A., Professor of History, Agricultural and Mechanical College of Texas, College Station.

4. "Avoidance of Infinite Series in an Elementary Study of Taylor's Theorem," H. Y. Benedict, Ph. D., Associate Professor of Mathematics in the University of Texas.

5. "Pseudo-Organic Structures of Colloidal Silicates," Dr. Alfonso L. Herrera, Museo Nacional, City of Mexico.

January 2, 1904 (Afternoon Session).

1. "The Composition of Texas Cottonseed Meal," H. H. Harrington, M. S., and G. S. Fraps, Ph. D., Department of Chemistry, Agricultural and Mechanical College, College Station.

2. "Composition of Rice By-Products," G. S. Fraps, Ph. D., Department of Chemistry, Agricultural and Mechanical College, College Station.

3. "Scientific Hypotheses," M. B. Porter, Ph. D., Professor of Mathematics in the University of Texas.

4. "The Cuban Insurrection," Capt. H. H. Sargent, Second Cavalry, U. S. A., Professor of Military Science, Agricultural and Mechanical College, College Station.

5. "The Effect of Tension on the Development of Mechanical Tissues in Plants," O. M. Ball, Ph. D., Professor of Botany and Mycology, Agricultural and Mechanical College, College Station.

MARCH 24, 1904.

Herbert Spencer Memorial Meeting. Addresses by Drs. Henry Winston Harper, Thos. H. Montgomery, Jr., Warner Fite, and Professor W. S. Sutton.

FORMAL MEETING JUNE 8, 1904.

1. Two new lecture experiments:
   (1) "Dependence of Chemical Equilibrium and Velocity of Reaction Upon the Relative Concentration of the Components (Influence of Mass) Shown With Acidified Solution Mixtures of Potassium Iodine, Iodine, Potassium Ferrocyanide and Potassium Ferricyanide."
   (2) "Demonstration of the Measurement of Single Potential Difference," Dr. Eugene P. Schoch, Instructor in Chemistry in the University of Texas.

2. "Instincts and Habits Illustrated by Solitary Wasps," Carl G. Hartman, M. A., Tutor in Zoölogy in the University of Texas.

3. "Character and Growth of Population in Texas," Judge Z. T. Fulmore, Austin.

4. "Representative Lists of the Vertebrate Fauna of Texas," (By Title), Frederic William Simonds, Ph. D., D. Sc., Professor of Geology in the University of Texas, Austin.

OCTOBER 21, 1904.

Presidential Address: "The Social Sciences," Dr. Milton Brockett Porter, Profesor of Mathematics in the University of Texas, Austin.

DECEMBER 2, 1904.

"What Should Be Done By the University for the Professional Education of Teachers?" William S. Sutton, M. A., Professor of the Science and Art of Education in the University of Texas, Austin.

LIST OF PATRONS, FELLOWS, AND MEMBERS.

PATRONS.

Brackenridge, Geo. W., Chairman Board of Regents, University of Texas, San Antonio, Texas.

Halsted, Mrs. Geo. Bruce, Gambier, Ohio.

Total 2.

FELLOWS.

Askew, H. G., Auditor, Railroad Commission, Austin.

Bailey, Dr. James R., Adjunct Professor of Chemistry, University of Texas, Austin.

Ball, Dr. O. M., Professor of Botany and Mycology, Agricultural and Mechanical College, College Station.

Bantel, Edw. C. H., Instructor in Civil Engineering, University of Texas, Austin.

Battle, Dr. W. J., Professor of Greek, University of Texas, Austin.

Benedict, Dr. H. Y., Associate Professor of Mathematics and Astronomy, University of Texas, Austin.

Bray, Dr. Wm. L., Associate Professor of Botany, University of Texas, Austin.

Bruce, Dr. W. H., Professor of Mathematics, North Texas State Normal School, Denton.

Calloway, Dr. Morgan, Jr., Professor of English, University of Texas, Austin.

Carter, Dr. W. S., Dean of the Department of Medicine and Professor of Physlology and Hygiene, University of Texas, Galveston.

Charlton, Prof. O. C., Professor of Science, Kalamazoo College, Kalamazoo, Michigan.

Curtis, Geo. W., Manager Burrus Mill and Elevator Company, Fort Worth.

Dumble, E. T., Consulting Geologist, Southern Pacific Company, Houston.

Ellis, Dr. A. Caswell, Associate Professor of Science and Art of Education, University of Texas, Austin.

Ferguson, Prof. A. M., Instructor in Botany, University of Texas, Austin.

Fite, Dr. Warner, Instructor in Philosophy, University of Texas, Austin.

Fraps, Dr. Geo. S., Professor of Chemistry, Agricultural and Mechanical College, College Station.

Garrison, Dr. Geo. P., Professor of History, University of Texas, Austin.

Halley, R. B., Professor of Science, Sam Houston Normal Institute, Huntsville.

Halsted, Dr. Geo. Bruce, Professor of Mathematics, Kenyon College, Gambier, Ohio.

Harper, Dr. H. W., Professor of Chemistry, University of Texas, Austin.

Harrington, Dr. H. H., Professor of Chemistry, Agricultural and Mechanical College, College Station.

Herff, Dr. Ferdinand, San Antonio.

Herrera, Dr. Alphonse L., Comision de Parisitolgia, Museo Nacional, City of Mexico.

Hilgartner, Dr. H. L., Austin.

Hill, Dr. Robert T., Consulting Geologist, 25 Broad Street, New York City.

Howard, Dr. Wm. R., Professor of Medicine,. Fort Worth University, Fort Worth.
Johnson, J. B., Professor of Mathematics, Baylor University, Waco.
Keiller, Dr. Wm., Professor of Anatomy, University of Texas, Galveston.
Lefevre, Arthur, Dallas.
McDaniel, Dr. A. C., 119 Alamo Plaza, San Antonio.
McFarlane, Dr. Alexander, Gowrie Grove, Chatham, Ontario, Canada.
McRae, Dr. A. L., Professor of Electrical Engineering, School of Mines, Rolla, Missouri.
Mally, F. W., Garrison.
Mather, Dr. Wm. T., Associate Professor of Physics, University of Texas, Austin.
Mezes, Dr. S. E., Dean of Faculty, Main University, and Professor of Philosophy, University of Texas, Austin.
Mitchell, J. D., Victoria.
Montgomery, Dr. Edmund, Hempstead.
Montgomery, Dr. T. H., Professor of Zoology, University of Texas, Austin.
Nagle, Jas. C., Professor of Civil Engineering, Agricultural and Mechanical College, College Station.
Paine, Dr. J. F. Y., Professor of Obstetrics and Gynecology, University of Texas, Galveston.
Pearce, Jas. E., Principal Austin High School, Austin.
Porter, Dr. M. B., Professor of Mathematics, University of Texas, Austin.
Prather, Jno. K., Waco.
Puryear, Charles, Professor of Mathematics, Agricultural and Mechanical College, College Station.
Reichman, Dr. Fritz, Designer of Instruments, with W. & L. E. Gurley, Troy, New York.
Rucker, Miss Augusta, Instructor in Zoology, University of Texas, Austin.
Sanderson, Dr. E. Dwight.
Schoch, Dr. E. P., Instructor in Chesimtry, University of Texas, Austin.
Simonds, Dr. F. W., Professor of Geology, University of Texas, Austin.
Smith, Dr. A. J., Professor of Pathology, University of Pennsylvania, Philadelphia, Pa.
Smith, Dr. M. M., Austin.
Spence, D. W., Associate Professor of Engineering, Agricultural and Mechanical College, College Station.
Sutton, W. S., Professor of Science and Art of Education, University of Texas, Austin.
Taylor, Thomas U., Professor of Civil Engineering, University of Texas, Austin.
Thompson, Dr. Jas. E., Professor of Surgery, University of Texas, Galveston.
Thompson, R. A., Chief Engineer Railroad Commission of Texas, Austin.
Windsor, Phineas L., Librarian, University of Texas, Austin.

MEMBERS.

Total 58.

Aden, Dr. C. N., New York City.
Anderson, E. A., Fellow in Chemistry, University of Texas, Austin.
Bell, Spurgeon, Professor, John Tarleton College, Stephenville.
Beville, Dr. A. J., Waco.
Black, Dr. H. C., Waco.

Brown, J. S., Professor of Mathematics, Southwest Texas Normal School, San Marcos.
Brown, R. L., Austin.
Burgoon, C. E., Student Cornell University, Ithaca, New York.
Capps, Dr. E. D., Fort Worth.
Clark, Jas. B., Proctor, University of Texas, Austin.
Cline, Dr. J. L. United States Weather Bureau, Corpus Christi.
Cooke, Dr. H. P., Galveston.
Corrigan, C. S., Assistant Engineer, Gulf, Colorado & Santa Fe Railway, Galveston.
Daniel, Dr. F. E., Austin.
Decherd, Miss M. E., Tutor in Mathematics, University of Texas, Austin.
Deussen, Alex., Tutor in Geology, University of Texas, Austin.
Dohmen, Dr. Franz J., Austin.
Duggan, Dr. Malone, Quarantine Inspector, Eagle Pass.
Duval, E. P. R., Baltimore, Md.
Endress, Geo. A., Instructor in Drawing, University of Texas, Austin.
Evans, Major I. H., Austin.
Freshney, Alfred, Professor of Science, Southwest Texas Normal School, San Marcos.
Giesecke, F. E., Professor of Drawing, Agricultural and Mechanical College, College Station.
Glasscock, B. L., Fellow in Chemistry, University of Texas, Austin.
Gregory, T. W., Member Board of Regents, University of Texas, Austin.
Hanszen, O. A., Director Manual Training, Public Schools, Dallas.
Hargis, O. D., Assistant in Chemistry, Agricultural and Mechanical College, College Station.
Harper, Dr. W. A., Austin.
Hartman, Carl, Superintendent Public Instruction, Travis County, Austin.
Hexter, J. K., Victoria.
Hill, Benj. F., Instructor in Mineralogy, University of Texas, Austin.
Hill, Dr. Homer, Austin.
Hitt, Prof. J. R.
Hixson, W. C., Editor Texas School Journal, Dallas.
House, E. M., Austin.
Howard, E. E., Resident Engineer, Kaw River Viaduct, Kansas City, Missouri.
Howe, J. M., Civil Engineer, Houston.
Hudson, Dr. S. E., Austin.
Hutson, C. W., Professor of History, Agricultural and Mechanical College, College Station.
Hunnicutt, W. H. P., Draughtsman, Land Office, Austin.
Jones, W. Goodrich, Temple.
Junkin, T. P., Instructor in Mathematics, Agricultural and Mechanical College, College Station.
Kuehne, J. M., Instructor in Physics, University of Texas, Austin.
Long, W. H., Jr., Professor of Science, North Texas State Normal, Denton.
Mackenson, B., Professor of Science, San Antonio High School, San Antonio.
Maxcy, Jno. W., Civil Engineer, Houston.
McClendon, J. Y., Fellow in Zoology, University of Pennsylvania, Philadelphia, Pa.
McLaughlin, Dr. J. W., Austin.

Miller, C. H., Dean of Law Department and Professor of Law, University of Texas, Austin.

Miller, Thos. D., New Orleans Lighting Co., New Orleans, La.

Miller, T. S., General Attorney, Missouri, Kansas & Texas Railway, Dallas.

Moore, Dr. John T., Galveston.

Neville, W. R., Jr., Austin

Oppikofer, F., United States Engineer, Department of Texas, Galveston.

Palm, O. H., Chemist, Austin

Pantermuehl, R C., Teacher of Science, High School, Denison

Parker, R. D, Resident Engineer, Houston East & West Texas Railway, Houston.

Pittuck, B. C., Professor Louisiana State University, Baton Rouge, La.

Potts, C. S., Instructor in History, Agricultural and Mechanical College, College Station.

Prather, Dr. Wm. L., President University of Texas, Austin.

Primer, Dr. Sylvester, Associate Professor Germanic Languages, University of Texas, Austin.

Reese, Hon. T. S., Assistant Attorney-General, Austin.

Reid, Dr. E. Emmett, Professor of Chemistry, Baylor University, Waco.

Reynolds, H. P., Texarkana.

Rice, C. D., Instructor in Mathematics, University of Texas, Austin.

Sargent, Capt. H. H., Professor of Military Science and Commandant of Cadets, Agricultural and Mechanical College, College Station.

Seltzer, H. K., Resident Engineer International & Great Northern Railroad Bridge Construction, Austin.

Smith, Noyes D., Austin.

Smith, Dr. Q. C., Austin.

Smith, R. F., Associate Professor of Mathematics, Agricultural and Mechanical College, College Station.

Stanfield, S. W., Professor of Science, Southwest Texas Normal School, San Marcos.

Sublette, G. W., City Engineer, Minneapolis, Minn.

Sublette, Mrs. W. J., Kirksville, Mo.

Swenson, J. R., Fellow in Chemistry, University of Texas, Austin.

Tompkins, Stonewall, with Weld & Neville, Houston.

Warfield, Dr. Clarence, San Antonio.

Weller, Wm. L., 10 Strada Lipscani, Bucarest, Roumania.

Wells, Dr. E. H., Professor of Natural Science, Baylor Female College, Belton.

Whitten, Miss Harriet V., Teacher of Science, Girls' Industrial College, Denton.

Wilkinson, A. E., Supreme Court Reporter, Austin.

Williams, Mason, Attorney at Law, San Antonio.

Wipprecht, Walter, Bryan.

Wooldridge, A. P., President City National Bank, Austin.

Work, Cree T., President Girls' Industrial College, Denton.

Worrell, S. H., Instructor in Chemistry, School of Mines, Boulder, Colorado.

Total 85.

Grand Total 145.