BULLETIN

OF THE

Wisconsin Natural History Society

VOLUME X
(NEW SERIES)

PUBLISHED WITH THE COÖPERATION

OF THE

Public Museum of the City of Milwaukee

EDITOR:
RICHARD A. MUTTKOWSKI

ASSOCIATE EDITORS:
P. H. DERNEHL HOWLAND RUSSEL EDGAR E. TELLER

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MILWAUKEE, WISCONSIN.
THE EDW. KEOGH PRESS.

The Wisconsin Natural History Society,

MILWAUKEE, WISCONSIN.

ORGANIZED MAY 6. 1857.

OFFICERS AND DIRECTORS.

PUBLICATION.

The "Bulletin of the Wisconsin Natural History Society."

Matter intended for publication should be sent to the editor of the Bulletin, who will transmit it to the associate editor of the proper department for consideration.

EDITORS.

MEETINGS.

Regular meetings are held on the last Thursday of each month, except July and August, in the trustees' room at the Public Museum Building, Milwaukee, and meetings of the combined sections on the second Thursday of each month, at the same place.

MEMBERSHIP DUES.

Active Members, $3.00 per annum; Junior Members, $1.00 per annum; Corresponding Members, $2.00 per annum; Life Members, one payment of fifty dollars.

BULLETIN

OF THE

WISCONSIN NATURAL HISTORY SOCIETY.

Vol. 10. JUNE, 1912. Nos. 1 and 2

PROCEEDINGS.

Milwaukee, Wis., September 28, 1911.

Regular meeting of the society.

President Barth in the chair. Fifteen members present. Minutes of the last regular meeting read and approved.

President Barth, in outlining the work for the ensuing year, said that the section meetings would be devoted to detailed scientific discussions, reserving the subjects of a more popular nature for the regular meetings.

The application of Mr. O. H. Bossert, 719 Franklin Place, was received and referred to the Board of Directors.

Dr. P. H. McGovern gave a detailed talk on the "Structure and Chemistry of the Animal Cell," laying special stress on the nuclear structure and functions.

Mr. Muttkowski called the attention of the society to a bill recently introduced in Congress, providing for the inspection and regulation of the importation of nursery stock into this country, aiming at the prevention of the introduction of various insect pests and plant diseases. This bill is being opposed by some of the influential men.

Mr. Muttkowski moved that a committee of three be appointed to draft a resolution to be presented at the next meeting of the society requesting the Wisconsin Congressmen and Senators to support this bill. Seconded and carried.

The president appointed as members of this committee Mr. Muttkowski, Chairman; Dr. Dernehl and Mr. Teller.

The meeting then adjourned.

Milwaukee, Wis., October 12, 1911.

Meeting of the combined sections.

President Barth in the chair. Twenty-one members present. Minutes of the last section meeting read and approved.

The application of Mr. Adolph Biersach was received and referred to the Board of Directors. Resignations were received from Mr. A. C. Katze-Miller and Mr. R. M. Phillip.

Dr. Barth gave an informal talk on certain habits of the solitary wasps. He outlined some observations made during the past summer, relative to the ability of certain species to recognize its prey after the prey has been taken away from the wasp.

He had observed that nests of the digger wasps are not so numerous and not so deep in wet weather as in dry.

Messrs. Peckham, Monroe, Graenicher and Dernehl took part in the discussion.

Mr. Russel read an article by Theodore Roosevelt on Protective Coloration, this article being a summary of a book by Thayer.

Messrs. Monroe, Peckham, Graenicher, Dernehl and Barth discussed the subject.

Mr. Monroe demonstrated a hybrid aster which had arisen from the crossing of two very widely different plants.

The meeting then adjourned.

Milwaukee, Wis., October 26, 1911.

Regular meeting of the society.

President Barth in the chair.

16 members present.

Minutes of the last regular meeting read and approved.

The following applications for membership were received: Mrs. A. F. John, 635 Shepard Avenue, Dr. W. J. Brinckley, Public Museum and Miss Ellen Torelle, Public Museum. These applications were referred to the Board of Directors.

Mr. Muttkowski presented the following resolution for adoption by the society:

Resolution recommending the passage of bill S. 2870 and H. R. 12311, regulating the importation of nursery stock.

Whereas, The lack of proper laws for the regulation of the importation of nursery stock has resulted in the repeated introduction of predaceous insect pests and plant diseases into various parts of the United States; and

Whereas, Bill S. 2870 and H. R. 12311 is designed to regulate the importation and interstate transportation of nursery stock and to mitigate and fight existing evils; therefore, be it

Resolved, That the Wisconsin Natural History Society favors the passage of these bills; and

Resolved, That we hereby urge upon the Senators and Representatives of Wisconsin in Congress that they vote for and strive by any legitimate means to secure the passage of these bills; and

Resolved, That the Secretary of this society be instructed to send copies of this resolution to each Wisconsin Senator and Representative in Congress, to James Wilson, Secretary of Agriculture, and to Dr. L. O. Howard, Bureau of Entomology.

The Committee,
R. A. MUTTKOWSKI.
EDGAR E. TELLER.
P. H. DERNEHL.

It was moved and seconded that this resolution be passed.

The motion was carried.

Dr. S. J. Holmes, Prof. of Zoology at the University of Wisconsin, gave a lecture on "Tropisms in Relation to Instinct and Intelligence." This lecture dealt largely with heliotropism as illustrated in some of the lower animals. Dr. Dernehl and Mr. Muttkowski took part in the discussion.

The meeting then adjourned.

Milwaukee, Wis., November 9, 1911.

Meeting of the combined sections.

President Barth in the chair. Fifteen members present. Minutes of the last meeting read and approved.

The president announced to the society the death of the last of its charter members, Mr. C. H. Doerflinger. Mr. Ward moved that the secretary be instructed to write a suitable letter to Mr. Doerflinger's family, expressing their sympathy. An amendment was offered by Mr. Muttkowski that Dr. Dernehl be asked to write an obituary to be published in The Bulletin. The motion was carried as amended.

Mr. Ward moved that the Park Board be requested to label the plants and shrubs in the conservatory at Mitchell park. The motion was seconded and carried.

The meeting was given up to an informal discussion of a variety of topics. Dr. Barrett told of some observations he had made in Arizona on protective coloration among the animals.

Mr. Ward exhibited a specimen of Townsend's Solitaire, a bird that has not hitherto been recorded for Wisconsin.

Dr. Barth made some observations on the subject of the habits of one of the solitary wasps, *Ammophila*, with regard to its manner of handling pebbles in closing its nest.

After informal discussion of these and allied subjects, in which all those present took part, the meeting adjourned.

Milwaukee, Wis., November 23, 1911.

Regular meeting of the society.

Vice-President Dernehl in the chair. Twenty-eight members present.

Minutes of the last regular meeting read and approved.

The application for membership of Mr. Arthur E. Bergmann, 3123 Cedar Street, was received and referred to the Board of Directors.

Mr. M. E. Blystone, of the Weather Bureau, read a paper on the Origin, Activity and Movement of Tornadoes. He told of the freaks played by the recent tornado in Rock County and. by means of an apparatus, demonstrated the manner in which tornadoes originate. After full discussion of tornadoes and storms in general, the meeting adjourned.

Milwaukee, Wis., December 14, 1911.

Meeting of the combined sections. 16 people present.

Dr. Dernehl in the chair. Mr. Muttkowski as secretary pro tem.

Minutes of the last section meeting read and approved.

Dr. Dernehl read a letter which he had received from Dr. Marks of Harvard University, written in behalf of Prof. Kukenthal in regard to a proposed arrangement for a lecture to the society. The letter stated the terms for which he would agree to speak and the time which would be most convenient. The matter was discussed by Drs. Barrett, Graenicher, Dernehl and Russel, who stated that in consideration of the present financial standing of the society it would be inadvisable to expend a large amount for one lecture. Dr. Graenicher also suggested that Dr. Osgood of Chicago had consented to lecture to the society on a former occasion, but had been prevented to do so through the necessity of leaving for the South; at the time he had assured the committee that he would speak at some later date whenever the society chose. The letter was laid on the table until the committee could make another report.

The question of having a meeting during the holidays was then taken up and discussed by Drs. Barrett, Graenicher, and Dernehl and Messrs. Teller, Russel, and Muttkowski. It was finally moved to drop the meeting. Seconded and carried.

Mr. R. A. Muttkowski gave a talk entitled "Observations on Caterpillars." The talk was illustrated by specimens and plates and was a random discussion of various common and some rare types of caterpillars.

Dr. Dernehl, Dr. Graenicher, Miss Elmer, Mr. Pratt and others made various remarks on the topic of caterpillars.

A motion to adjourn was presented and carried.

Milwaukee, January 11, 1912.

Meeting of the combined sections.

Eleven members present. President Barth in the chair.

Minutes of the last section meeting read and approved.

The resignation of Mr. R. A. Muttkowski, as editor of the Bulletin, was received and accepted. The resignation of Mr. G. W. Colles, as a member of the society, was received and accepted.

Mr. Teller read a paper entitled "The Middle Devonic of Wisconsin and the Fishes thereof." This paper was illustrated by charts and drawings and a number of fossil specimens obtained at the Milwaukee cement quarries and belonging to Mr. Teller's collection. The paper was discussed by Dr. Graenicher and Mr. Ward.

Dr. Graenicher spoke of a brush he had seen mentioned in an agricultural periodical which could be used in fertilizing clover and thus take the place of the bee. Some experiments with this instrument had shown it to be even more efficient than bees in pollenization.

Mr. Ward called attention to an elephant skeleton in the possession of the Museum, which had recently been proven to be that of a mammoth.

After an informal discussion, the meeting adjourned.

Milwaukee, Wis., January 25, 1912.

Regular meeting of the society.

President Barth in the chair. Forty-five people present.

Minutes of the last regular meeting read and approved. The resignation of Miss Florence M. Olcott, 205 Twenty-second Street, was received and referred to the Board of Directors.

Dr. S. A. Barrett of the Public Museum gave an illustrated lecture on "The Klamath Lake and Modoc Indians of Northern California and Southern Oregon." This lecture was illustrated by numerous lantern slides. The culture of these Indians in its relation to their life in a lake region was especially emphasized.

After a full discussion, the meeting adjourned.

Milwaukee, Wis., February 8, 1912.

Meeting of the combined sections.

Nine members present. Vice-President Dernehl in the chair.

Minutes of the last section meeting read and approved.

An invitation to the society to be present at the centennial anniversary of the Academy of Natural Sciences of Philadelphia was received and placed on file.

Dr. P. H. Dernehl read a paper on "Some Recent Advances in Cell Study." He exhibited some microphotographs taken of living animal cells in the course of indirect cell divisions. These pictures were taken by means of the ultra violet rays.

On motion, the meeting then adjourned.

Milwaukee, Wis., February 29, 1912.

Regular meeting.

Vice-President Dernehl in the chair. Ninety members present.

Minutes of the last regular meeting read and approved.

Prof. R. H. Denniston of the University of Wisconsin delivered the evening's lecture on "Wisconsin Trees." This lecture was illustrated by numerous lantern slides. Prof. Denniston confined his remarks to the native trees of the state. After discussion by Drs. Graenicher and Bartlett, the meeting adjourned.

Milwaukee, Wis., March 14, 1912.

Meeting of the combined sections.

Nine members present. President Barth in the chair.

Minutes of the last section meeting read and approved.

The secretary read a paper on "Trematode Parasites of Man and the Lower Animals." Some specimens of the liver fluke, *Distomum Hepaticum*, were shown. Special stress was laid on the morphology of these animals. After a discussion, in which all those present took part, the meeting adjourned.

Milwaukee, Wis., Maren 29, 1912.

Regular meeting.

President Barth in the chair. Seventy-five persons present.

Minutes of the last regular meeting read and approved.

The president called the attention of the society to the joint meeting of the Wisconsin Archeological Society, Wisconsin Mycological Society, Wisconsin Natural History Society and the Wisconsin Academy of Sciences, Arts and Letters to be held at Madison April 4th and 5th.

The application for membership of Mr. J. E. Mellish of Cottage Grove, Wisconsin, was received and referred to the Board of Directors.

Prof. M. F. Guyer of the University of Wisconsin delivered the evenings' lecture on "Eugenics." Prof. Guyer urged that some legislation be enacted in Wisconsin similar to that in force in Indiana and California for the prevention of the multiplication of those physically, mentally and morally unfit for parenthood.

The meeting then adjourned.

Milwaukee, Wis., April 11, 1912.

Section meeting.

President Barth in the chair. Twenty-four members present.

Minutes of the last sectional meeting read and approved.

A bid on the printing of the Bulletin was received from the Democratic Printing Company of Madison. This bid was referred to the executive committee.

Dr. S. Graenicher of the Public Museum gave an illustrated talk on the "Supposed Relation between Ants and the Myrmecophilous Plants." The discussion of this paper brought out many interesting points in the behavior of ants and their relation to man. Mr. Ward made a few remarks relative to the occurence of the Cardinal in Wisconsin and introduced a short discussion on migratory habits of birds in general.

The meeting then adjourned.

Milwaukee, Wis., April 25, 1912.

Regular meeting.

Mr. Teller in the chair. Twenty-five persons present.

Minutes of the last meeting read and approved.

Prof. E. A. Birge of the University of Wisconsin delivered the evening's lecture on "An Inland Lake." This lecture was illustrated by numerous lantern slides, showing the various forms of plant and animal life. Prof. Birge called especial attention to the difference in the abundance of life in the deep and shallow lakes. In shallow lakes, the water circulates much more freely and consequently there is a better distribution of the food materials. As a result of this fact, the shallower lakes support a much richer flora and fauna than do the deeper lakes of the same area.

After a brief discussion, the meeting adjourned.

Milwaukee, Wis., May 9, 1912.

Combined sections meeting.

President Barth in the chair. Thirteen members present.

The president appointed Mr. Ward as secretary pro tem.

Minutes of the previous meeting were read and approved.

President Barth announced that the next meeting of the society would be the annual meeting, at which would occur an election of officers, and appointed a nominating committee consisting of Dr. S. Graenicher, chairman; Howland Russell and E. E. Teller, to present the proposed list of officers before that meeting.

Mr. J. R. Heddle then addressed the society on "Some Diseases of Plants caused by Parasitic Fungi," this paper being illustrated by lantern slides and drawings.

The meeting then adjourned.

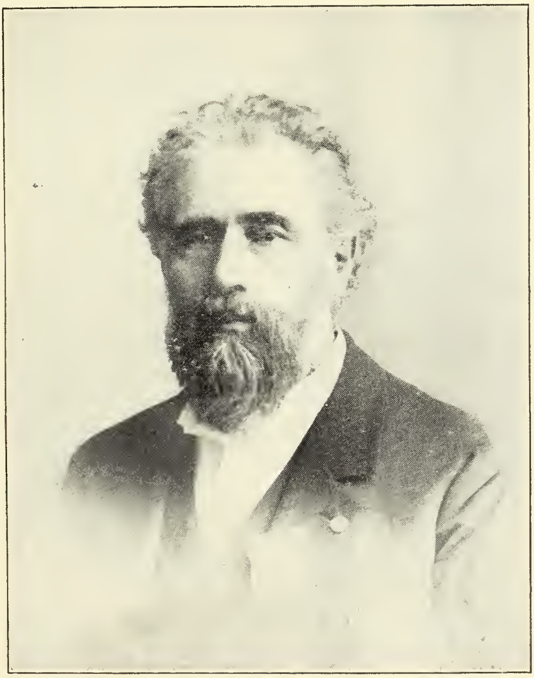
HENRY L. WARD,
Sec'y pro tem.

IN MEMORIAM.

By the death of Karl Herman Doerflinger in Bradentown, Florida, November 9th, 1911, the Wisconsin Natural History Society lost one of its earliest and in some regards one of its most notable members.

Karl Herman Doerflinger was born in 1843 in the small town of Ettenheim in Baden, Germany. His father, Karl Doerflinger, a political refugee of the revolutionary period of 1848, came to America with his family in 1850. Attracted by the large colony of his fellow refugees at Milwaukee he brought his family here. Young Doerflinger was then in his sixth year. At this age he made his first acquaintance with the three R's, under the guidance of private tutors and of his parents. When ten years of age he entered the German English Academy. (founded in 1851). Here he continued an adept pupil for four years. These and later years spent under the influence of and in intimate association with that thorough, efficient and stimulating teacher, Peter Engelman, left upon young Doerflinger a deep and lasting impression and did much in moulding his future career.

Thrown upon his own resources at the conclusion of his school years, he started his battle thus early in life. Fates seemed to be against him, and after shifting about for a time and driven by want and pecuniary distress, he sought the then "Golden West," hoping there to make his fortune. His stay was terminated by the call for volunteers at the opening of the Civil war. Then eighteen years of age, he returned and enlisted in the Twenty-



KARL HERMAN DOERFLINGER.

sixth Wisconsin Volunteers, a company composed almost entirely of Germans, and of the division under command of Carl Schurz.

During the brief period of his active service, he met with rapid promotion, reaching the rank of first lieutenant. At the battle of Chancelorsville he received a gun shot wound, which necessitated the amputation of his left leg. Faulty surgery made several subsequent operations necessary, and as a result of this he suffered almost constant, at times agonizing pain, until his death. Following the war he engaged in various undertakings, as a means for support. Private tutoring, teaching at the German English Academy, farming, holding public office,[1] printing and mercantile enterprises. Possessing a distaste for mercenary pursuits and imbued with strong idealistic tendencies, his successes in business were but commensurate with these traits.

From earliest youth he entertained an absorbing love for nature, his interest in it embraced many fields, and while not strictly scientific, his scientific knowledge was in a degree sufficient to stamp what he said with the force of one who speaks with authority. His labors in the field of natural history and the results therefrom went largely to the Wisconsin Natural History society.[2] One of its earliest members, he was active in all its doings and served for many years as its secretary. Devoted to its progress he labored for its welfare with untiring love and enthusiasm. To the development of the society's museum in particular he gave his best and constant efforts, often, at the expense of the fulfillment of other duties.

When in 1883 the Wisconsin Natural History Society donated its museum to the City of Milwaukee,[3] Doerflinger was made its first custodian—a deserving and well earned recognition of his former labors in its behalf. Pressure being brought upon him by many friends to accept the custodianship, he gave up his farm near

1) Secretary City Civil Service Commission 1896-1900.
2) From 1857-1879 Naturhistorischer Verein von Wisconsin.
3) Doerflinger suggested such a transfer as early as 1875. See report of Society that year.

Burlington, Wis., and reluctantly assumed charge. (At a salary of $800 per year). In his letter of acceptance, kindly placed at my disposal by his family, he frankly exposes his own deficiencies in scientific training and expresses his conviction that, only a man of thorough scientific training ought to be intrusted with the care of the institution, and modestly affirms that his prime motives in accepting were his love for and attachment to the museum and his desire to further its growth along the lines laid down by the Wisconsin Natural History Society, namely to "conduct the museum and increase its collections with special reference to the main purposes of the society, i. e., public instruction and the provision of materials and helps for scientific investigation."

True to and possessed of these principles he entered upon his duties as custodian. The trials and difficulties he had to face were manifold, and to a man of less determination might have appeared insurmountable. The society's large collections, vaued at $30,000 had to be reinstalled in new quarters. There was a lack of sufficient funds, a very inadequate working library, he was without trained or skilled assistants to aid him in the classification and care of the material; these deficiencies, and his own lack of scientific training in the special branches of science made his labors as custodian extremely trying and taxing. Yet by an indomitable will, by relentless energy and by an untiring love for his work, he laid the firm and enduring foundation of our Milwaukee Public Museum, upon which his successors, unhampered by finances and aided by men scientifically and specially trained in their respective lines of work, were enabled to erect the present grand superstructure. The burden he had shouldered proved too much for him and after nearly five years of uninterrupted active service, broken down in health from overwork, and suffering from the constant agony of his leg, he resigned in 1887, in order to seek mental, and physical rest and to regain his lost health. A prolonged stay in Germany, Switzerland and France brought the needed recovery. During his stay abroad he was by no means idle, new work of a more recreative nature absorbed his time and attention.

While in Switzerland he made a large collection of Alpine plants, and in association with Professor Messikomer, he devoted much of his time in studying and unearthing the remains of the Pile-dwellers at the upper end of the Zürich Lake. In France he undertook in company with Dr. Francis Daleau, for the purpose of study and collecting, the excavation of the Cave-dweler caves in the neighborhood of Bourg sur Girande near Bordeaux. Of this collected material he donated a large portion to the Musée Prehistorique et Ethnographique of Bordeaux. His own extensive and valuable collection of this material and that secured in Switzerland was later acquired by the Milwaukee Public Museum.

In 1894 he undertook an extended tour through Mexico, numerous specimens collected there are now placed among the Mexican material in our Museum.

On his return from Mexico in December, 1895, he engaged in business, The Doerflinger Artificial Limb Company, with which he remained associated up to the time of his death.

Always interested in probems of education he devoted the later years of his life, almost entirely to them. With his characteristic energy he undertook to advocate a revision of the American public school system[1], believing that by his proposed methods of education, "an improved education, broader and better in quality and power, ethical and aesthetic as well as intellectual and physical, for the whole people," might be attained. Whatever may be the merits or demerits of this proposed "New Education," time will tell. It remains that its conception rests upon careful thought and deliberation and that it is fostered by high ideals. To it some of the leading educators of the day have subscribed.

Doerflinger early recognized the educational worth of the kindergarten and in association with a few of Milwaukee's forceful men, established the first private Fröbel Kindergarten in Milwaukee, which also was one of the first to be established in the west.[2] He also aided materially in introducing into our school system, physical culture and manual training. A sincere patriot, he at all times took a keen interest in all matters relating to public welfare.

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1) For the principles involved: See Doerflinger: Synopsis of Plan for the Reorganization of the American Public School System, etc., National New Education League, Milwaukee.

2) The First Fröbel Kindergarten in America, was founded by the wife of Carl Schurz at Watertown, Wis., in 1855.

In 1872 stimuated by the endeavors of Carl Schurz to inaugurate national legislation against the ruthless destruction of our forests, he[1] and his friend Peter Engelman[2] labored for this cause in Wisconsin. The apathy of the public mind, in this matter, at the time, made all progress hopeless, and the arguments for re-forestation, for rational forestry were labeled as ridiculous, our forests were believed indestrucable; today we deplore the destruction of our *indestructable* forests. Had the admonitions of these men been heeded, what would be the added wealth to Wisconsin!

Doerflinger's chief claims to distinction were his lofty character and his uncompromising devotion to principle. Austere in appearance, serious and strenuous in thinking, and in his life, sincere, frank and conscientious in the highest degree, an idealist, a lover of nature, a warm and true friend, and an untiring worker for the broadening of human life and the refining of human nature.

P. H. DERNEHL.

1) Bericht des Naturhistorischen Vereins von Wisconsin, 1872.

2). Among the first papers read before the Wisconsin Academy of Arts, Science and Letters, were those of Peter Engelman on the importance of the conservation of our forests.—Trans. Vol. XV, pt. 2.

THE TROPISMS AND THEIR RELATION TO MORE COMPLEX MODES OF BEHAVIOR[1]

S. J. Holmes.

The subject of animal behavior has been of interest to human beings from the earliest times, but it has not been taken very seriously until a comparatively recent date. The ways of animals were considered curious, interesting and in many ways useful things to know about, but the great theoretical import of animal psychology was unsuspected until it came to be recognized that our own minds are the outgrowth of the animal mind, and that to obtain a truly scientific human psychology it is necessary to have a clear insight into the psychology of the lower animal from which we are descended. Near the middle of the nineteenth century Herbert Spencer enunciated the principal that, "If the doctrine of evolution be true the inevitable implication is that mind can be understood only by observing how mind is evolved," and he boldly plunged forward upon an undertaking to remodel the science of psychology from the genetic standpoint. The result was the publication in 1856, three years before the appearance of the Origin of Species, of the Principles of Psychology, a work which for sheer originality, independence of treatment and profound grasp of the subject stands almost without a rival in the history of science.

Notwithstanding the work of Spencer, genetic psychology was given perhaps its greatest impetus by Darwin, not only through his influence in establishing the general doctrine of organic evolution, but also through his careful work on and illuminating treatment of the mental life of animals. The admirable and original chapter on Instinct in the Origin of Species, the chapters on the comparison of the mental powers of man and the lower animals in the Descent of Man, and the work on Expression of the Emotions in Man and Animals were all substantial contributions to the science which were very influential in stimulating further work.

It is not my intention to treat of studies of animal behavior undertaken from the standpoint of evolution, but to discuss another and in many respects complimentary aspect of the subject, that of analysis, or the effort to discover the causal mechanism of animal activities by resolving them into their com-

1) Adapted from a lecture before the Wisconsin Natural History Society, at Milwaukee, Oct. 26, '11.

ponent factors. The analytical study of behavior is simply a consequence of extending to animal psychology the methods of experimental investigation so largely employed in the physical sciences and which are coming more and more to be employed in biology and in the laboratory investigations of the psychology of man. The results thus far won may be meagre, but judging from the increasing number of trained investigators who are devoting themselves to the work, we may look forward to a rapid increase in our knowledge and insight.

From the standpoint of analysis the subject of tropisms is one of great import. Certain stimuli exercise a direct effect upon the movements of animals, causing them to go toward or away from the source of stimulation. The moth flies toward a candle; infusorians gather in regions of dilute acids and avoid regions of too great heat or cold; certain caterpillars tend to crawl opposite the direction of the force of gravity. These directed movements are commonly called tropisms but there is a variety of opinions regarding the kinds of behavior to which the term tropism may be applied and usage has not settled authoritatively upon any rigid definition of the word. We shall therefore use the word in a somewhat broad and indefinite sense.

Tropisms have long been recognized in plants. The familiar phenomenon of the turning of plants to the sun was termed heliotropism by De Candolle in 1835, and he, in common with several other botanists in the early and middle parts of the nineteenth century, regarded this turning as a direct and more or less mechanical effect of sunlight upon the tissues of the plant. Sachs on the other hand emphasized the aspect of irritability in tropisms, and maintained that it is the direction in which the rays of light penetrate the tissues of the plant and not merely the different degrees of illumination on the two sides, that determines the direction of turning. The work of Sachs on plants directed the attention of Loeb to the phenomena of tropisms in animals, and also furnished him with some of the fundamental conceptions of his own celebrated theory. Loeb's first paper on tropisms of any considerable length was entitled The Heliotropism of Animals and its Agreement with the Heliotropism of Plants. The publication of this paper marked an epoch in the analytical study of animal behavior. Previous to this time the tropic responses of animals were interpreted as the expression of the predilections or conscious choice of animals for certain kinds of stimulation. Graber, Sir John Lubbock and Paul Bert had studied the effect of colored lights upon animals and discovered that certain species congregated most abundantly under light of a certain color, while other species would gather in greater numbers under light of a different color. These aggregations were therefore considered as an index of the kind of color most pleasing to the aesthetic or other sensibilities of the animals. Similarly with the movements toward or away from lights. Earwigs and cockroaches were supposed to crawl away in secluded places because they like the dark and butterflies were supposed to congregate in sunny spots because they enjoyed the sensation afforded by the sunshine. A somewhat more anthropomorphic interpretation of a tropism was suggested by Romanes in discussing why the moth flies into the flame of a candle. The conclusion arrived at was that the moth was drawn to the fatal flame out of curiosity, or the desire of investigating what manner of strange object a candle flame might be.

The theory developed in Loeb's Heliotropisms stands in a sharp contrast to the anthropomorphic views of his predecessors. Orientation of animals to light is supposed to take place in a more or less mechanical fashion like the orientation of plants. "These tropisms," he says, "are identical for animals and plants. The explanation of them depends first upon the specific irritability of certain elements of the body surface, and second, upon the relations of symmetry of the body. Symmetrical elements at the surface of the body have the same irritability; unsymmetrical elements have a different irritability. Those nearer the oral pole possess an irritability greater than that of those near the aboral pole. These circumtances force an animal to orient itself toward a source of stimulation in such a way that symmetrical points on the surface of the body are stimulated equally. In this way the animals are led without will of their own either toward the source of the stimulus or away from it." The moth flies into the flame, not out of curiosity or any other conscious motive, but simply because it cannot help it.

In a very instructive series of experiments Loeb showed that heliotropism in animals obeys the same laws as heliotropism in plants. In both plants and animals it is the direction of the rays that controls the direction of movement. In both plants and animals it is the rays nearer the violet spectrum that are the more potent in evoking the heliotropic response. In both plants and animals temperature, previous exposure to light and other external factors influence reactions to light in much the same way. Back of all the differences of form and function of plants and animals, and notwithstanding the higher organization of the animal world with its specialized sense organs and complex nervous systems, the living substance of organisms possesses certain fundamental common properties of irritability upon which the common and fundamental features of behavior which we call tropisms depend.

The theory of Loeb would sweep away all higher psychic factors in the realm of tropisms, and reduce the phenomena to comparatively simple manifestations of reflex irritability. Further he would explain much of the so-called instincts of animals as a result of these tropisms. Since the prospect of finding a mechanical or causal explanation of any feature of behavior is always an alluring one, it will be of interest to pass in review some of these cases of tropisms with the end of determining how far the reflex theory will carry us. And then we shall consider the relation of these tropisms to more complex forms of behavior.

An excellent illustration of tropism is afforded by the light reactions of the larvæ of the marine worm *Arenicola*. These larvæ are oblong in shape with two eye spots at the anterior end. Near either extremity there is a band of cilia by means of which the larvæ swim through the water. The larvæ are positive in their reactions to light, and will follow a light around in various directions. Orientation to light is brought about by bending the body to the stimulated side. If the larvæ is between two sources of light from which the rays intercept one another as they fall on the animal at an angle of ninety degrees, the larva will take a course midway between the two lights. If one light is turned off the larva bends immediately to the other one. By arranging a mirror so as to throw a small spot of light on different parts of the body Mast has shown that when light is thrown into one eye there is a strong bend of the body toward the stimulated side. The parts behind the eye spot show no definite reaction. It is evident that orientation in this form is due to different intensities of illumination on two sides of the body. So far as can be ascertained orientation takes place directly and automatically, without any conscious decision on the part of the animal. The movements of the larva appear little more voluntary than the precise movements of certain protozoa or the swarm spores of algæ. Let us pass to animals somewhat higher in the scale of life.

Some years ago when on the Atlantic coast at Woods Hole, Mass., I studied the behavior of various amphipod crustacea of that region and particularly the reactions of the terrestrial species commonly called sand fleas. It is a somewhat curious circumstance that the aquatic amphipods are negative to light and tend to keep in the darkest part of their environment while the terrestrial ones are usually positive. Positive phototaxis is the most pronounced in the most terrestrial of the species, the large *Talorchestia longicornis* which lives in holes in the sand high up on the beach. When dug out of the sand these crustaceans usually lie curled up in a death feint, but when they become active they manifest a very strong tendency to hop toward the light. When brought into a room they may keep hopping toward a window with intervals of rest during the entire day. If they are placed in a dish one half of which is shaded while the other half is exposed to the direct sunlight they will keep hopping toward the light until they are overcome by the heat of the sun's rays.

The smaller *Orchestia agilis* which lives nearer the water's edge and frequently manifests a negative reaction to light shows the same fatal degree of positive phototaxis when exposed for some time to strong sunlight. Does light orient these forms automatically and involuntarily as is apparently the case with the larvæ of *Arenicola?* There are several facts which favor such an interpretation. The persistent and apparently unreasonable nature of the response, its sudden reversal by certain external agents, and especially the fact that the witless creatures continue to go toward the light even when they are brought thereby into a region where the light proves fatal to them, seem to bear out the conclusion that the phototaxis of these animals is in the nature of an involuntary or "forced" response. This view is strengthened by the results of certain experiments on individuals which were blinded on one side. These experiments were undertaken with the view of ascertaining something of the mechanism of orientation. The amphipods do not become oriented by bending the body toward the light, but by the unequal activity of the appendages on the two sides of the body. In forms with positive phototaxis it was found that blackening over one eye caused the amphipod to perform circus movements toward the normal side. In negatively phototactic species it was found that the same treatment caused circus movements in the reverse direction. It is probable therefore that impulses received by the eyes cross in the central nervous system and becomes carried to the appendages on the opposite side of the body causing them to act with greater vigor, thus bringing the animal into a position of orientation. This supposition led to the experiment of cutting the brain lengthwise through the center in several species of arthropods and it was found that, although sensitiveness to light could be shown to remain, all power of orientation to light was entirely destroyed.

It will be of interest in this connection to consider the light reactions of a somewhat more highly organized arthropod; the water scorpion *Ranatra.* This insect lives near the banks of ponds and streams with the tip of its long breathing tube at the surface of the water and its raptorial fore legs held in a position for rapidly seizing any small passing creature which may be utilized for food. When *Ranatra* is taken out of the water it generally feigns death, assuming a perfectly rigid attitude which it retains through all sorts of maltreatment, even suffering its legs to be cut off or its body cut in pieces without betraying any signs of animation. By moving a light over the motionless insect it may gradually be brought out of its feint. The first noticeable signs of awakening are very slight movements of the head in response to the movements of the light. When the light is passed to one side of the body the head is rolled over ever so little toward that side. Move the light to the other side and the head tilts over slightly in that direction. Place the light in front of the body and the head bows down in front, and when the light is behind the insect the front of the head is pointed slightly upward. These movements occur with perfect regularity in response to the movements of the light, and gradually increase in vigor and extent. After following the movements of the light with these definite movements of the head the insect slowly and awkardly raises itself up and begins to follow the light with equally definite swaying movements of the body. If the light is to one side the legs on that side are flexed and the opposite legs extended. Passing the light over the body causes the reverse attitude. Hold the light in front of the body and the insect bows down in front in an attitude of abject submission, while if the light is carried behind it the insect elevates the anteror part of its body and holds its head high in the air. These bodily attitudes are assumed with almost machine-like regularity. For each position of the light there is a corresponding position of the head and body.

After a little *Ranatra* will follow the movements of the light by walking slowly and awkardly toward it, gradually increasing the vigor and rapidity of its response until it will rush toward the light with frenzied haste. It becomes oblivious to all else but the light which seems to dominate its behavior entirely. If the source of light gives off a good deal of heat the insect will continue to go toward it until overcome by the heat. I have seen Ranatras when nearly killed by the heat of the lamp toward which they were attracted, slowly drawing themselves with the last remnants of their strength a little nearer to the fatal source of light.

Nothing could seem more mechanical or more obviously the result of domination by outer agencies than the phototaxis of this form. There are, however, some curious features of the behavior of *Ranatra* which are disclosed by other experiments and which indicate that this insect is something more than a mere "reflex machine." If one eye is blackened over there is a strong tendency for the insect to perform circus movements toward the normal side. Frequently as the insect veers over toward the normal side in going toward the light and thus brings the unblackened eye more and more out of the region of direct stimulations, a point is reached where there is hesitation, moving this way and that, accompanied with increasing uneasiness and excitement as if exasperated over its predicament. Sometimes the insect may get out of this situation by going completely around in a circle toward the normal side, or it may make a direct turn toward the blackened side and go toward the light. In several cases among *Ranatra* and *Notonecta* individuals which at first performed circus movements and succeeded in going to the light by a very irregular route finally came, after a number of trials, to go to the light in a nearly straight line. Other individuals went to the light in a nearly straight line from the first. In some cases covering all of one eye and all but the posterior face of the other did not prevent the insect from going in a nearly straight path toward the light. Other specimens would do the same with only a small part of the lateral face of one eye uncovered. In the latter case neither the lightest nor the darkest part of the visual field was kept before the eye. The insect behaved as if it were not guided by a mere reflex response, but had an awareness of the general space relations of its region, the relative position of the light and itself and of the movements necessary to bring itself toward the light. If such a general topographical sense seems too high a psychical endowment to be credited to so simple a creature, it must be remembered that other insects, notably the bees and wasps have a much more definite and detailed cognizance of the topographical relations of their environment than anything in the behavior of *Ranatra* would call for. Simple and mechanical as much in the light reactions of *Ranatra* seems to be, there are many features of its phototaxis which are very difficult to explain on the basis of simple reflex orientation.

We might expect *a priori*, to find that somewhere in the course of evolution the tropisms become more or less subordinated to higher forms of behavior. It is quite evident that much in the behavior of animals may be explained as a more or less simple manifestation of phototaxis, geotaxis, chemotaxis, and so on. The daily depth migrations of pelagic animals is traceable to a considerable degree to variations in the sense of the response to light and gravity. One circumstance that leads copepods to swim to the surface at night and go down in the daytime is because they are positive to weak light and negative to strong light. The negative reaction of centipedes, termites and many other organisms keeps them in dark and secluded situations. The positive reactions of many worms and crustaceans to contact stimuli keep them in protected situations in various nooks and niches where they escape many of their enemies. The positive chemotaxis of many animals leads them into situations where they may find their food.

But one of the chief considerations which makes the study of tropisms of such importance is the fact that the tropisms enter as components into more complex activities of higher organisms. Tropisms in their purity are met with only in the simpler animals. As we pass up the scale of life these primary tendencies to action become broken up and combined with other forms of behavior, so that they are lost sight of in the more complex activities into which they enter as component factors.

A most interesting field of investigation in this connection is presented in the relation of phototaxis and vision. It is a field scarcely touched upon as only one investigator, Radl, has entered upon it with any seriousness. There seems to be a close connection in many animals, and especially insects, between phototaxis and what are called compensatory movements. Place a lady-beetle on a turn table which is slowly rotated. The beetle begins to move its head and then its body opposite the direction of movement. Robber flies show the reaction especially well. The reaction depends upon the eyes because it no longer occurs when the eyes are blackened over. It does not depend upon the rotation of the insect's body. If the insect is placed in a cylinder on a stationary center and the cylinder rotated, the insect tends to walk around in the direction of rotation. A frog under the same circumstances will do the same thing. In these cases the animal reacts so as to keep, so far as possible, *in statu quo* with the visual field.

A beautiful illustration of this is afforded by the so-called rheotropism of fishes. Many fishes have the instinct to head up stream against the current. This trait has been shown by Lyon to be dependent upon a visual reflex. He placed fish in an aquarium with the lower side made of glass below which could be drawn a long piece of cloth with alternate black and white stripes on it, giving the appearance of a moving bottom. As the strip was pulled along the fish swam in the direction of movement. Reversing the motion caused the fish to turn about and swim to the other end of the aquarium. In another experiment fishes were placed in a long bottle. When this floated down stream the fishes all swam to the up stream end. When it was pulled up stream the fishes all swam to the opposite end. Fishes in a stream, passively carried along, have no means of becoming aware of their movements except by means of objects in their field of vision any more than a man in a balloon who is carried along in a current of air. This automatic tendency to keep in constant relations with the objects in their field of vision keeps them from being passively carried down stream. Many insects show the same trait in their flying against a breeze. Perhaps the instinct of hovering shown by many kinds of flies is an expression of the same fundamental tendency.

The automatic tendency to keep the body in a certain orientation to its field of vision which we find among crustaceans, insects and lower vertebrates, is to a greater or less extent replaced in forms with freely movable eyes by ocular movements which enable the moving animal to retain the same field of vision. Stalk-eyed crustaceans show compensatory movements of the eye stalks. Similar eye movements occur in fishes, amphibians and birds. A man at night more or less involuntarily directs his steps toward a single light in his horizon much as birds are drawn toward a light house. Such orientation may be conscious and voluntary, but it cannot be denied that there is a sort of instinctive tendency toward it much as there is in all of us a strong tendency toward a certain orientation to the force of gravity.

The reactions of animals to light have been profoundly modified by the evolution of the image forming eye. It has been shown by Cole that if an eyeless form such as an earthworm or a form with simple eyes is subjected to stimulation by two sources of light of equal intensity but of different area, the animal is as likely to turn to the smaller light as to the larger one. In forms with image forming eyes, on the other hand, it is the light of larger area which is the most potent in causing the turning of the body. With the development of image forming eyes it becomes possible for animals to respond to objects and not to mere differences in the amount of light and shade. The image forming type of eye is stimulated by a decrease as well as by an increase of illumination on particular parts of its surface. This stimulation is generally associated with an involuntary turning toward the source of stimulation. Hence, the automatic turning of the head toward a new object in the field of vision, and the tendency to follow the movements of bodies with movements of the eyes. The eyes of animals are notoriously quick to respond to movements. The moving thing is the stimulating thing. With the evolution of the image forming type of eye and the development of acute sensitiveness to change of illumination of particular parts of the retinal surface, the general tendency to go toward or away from light may pass into an involuntary tendency to become oriented toward particular moving objects in the field of vision. When an animal reacts in a definite way to objects impressed on its retina we commonly say that it sees. These reactions to objects come to be very complex and specialized. They come to depend upon the size, form and color of the moving object. But it is not improbable that they have their primary roots in the positive and negative phototaxis of simpler organisms. Josiah Royce in his Outlines of Psychology has gone much farther than I should venture to do, in that he sees in the tropisms a set of tendencies which form a sort of fundamental background even in our own psychology. Objects of our own attention exercise a compelling force over us making us turn toward them. We involuntarily turn toward a person or thing about which we are curious; in fact it requires some voluntary effort not to do so. Is this continual orientation to objects akin to orientation to light or an odor in the lower animals? According to Royce these reactions are fundamentally the same. Perhaps if we should follow the history of behavior closely enough in passing from lower to higher forms we should be able to fill in the intermediate steps. At present the connection is merely a suggestive hypothesis.

Most of the work on tropisms that has been done thus far has consisted in determining the precise way in which tropisms are brought about, and the conditions by which they are modified. To find as it were what becomes of the tropisms in the course of mental evolution, how they are converted into higher forms of behavior, is a more difficult task. Voltaire has made the remark that we are governed by instinct as well as cats and goats. It is possible that we may be justified in going somewhat farther than the celebrated skeptic, in saying that to a certain extent we are governed by tropisms as well as insects and worms.

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Madison, Wis., November 7, 1911.

RECONSTRUCTION OF THE CHALCIDID GENUS *HYPOPTEROMALUS* ASHMEAD OF THE FAMILY *PTEROMALIDÆ*.

Its Position, Redescription, History and the Synonymy of Its Type Species.

By A. Arsene Girault.

Introductory.

Quite incidentally, while examining a quantity of pteromalines reared from the cocoons of *Apanteles congregatus* (Say) taken from nearly fullgrown larvæ of *Phlegethontius sexta* (Johannsen) and having decided by comparison that they were the so-called common hyperparasitic *Hypopteromalus tabacum* (Fitch), I proceeded to verify the determination by a careful examination of their structures.

The results of this examination showed a different structure of the mandibles than one would expect from the present tribal position of the genus, or from the description of what was designated as its type species—*Pteromalus tabacum* Fitch. Other examinations made of the mandibles of two series of specimens determined by the late Doctor Ashmead himself agreed with the structure found in the first, so that there can be no doubt but that all three series of specimens are one and the same species. Other series of specimens were then compared with the first three series, being found identical in every case.

On account of the fact that the genus itself is but poorly described and its type species, due to the times, almost unrecognizably so, I have attempted the following reconstruction based on a large series of specimens, as recorded beyond. At first, however, on account of the characteristic dentation of the mandibles, it should be stated that the removal of the genus from the Ashmeadian *Pteromalini* to the *Rhaphitelini* becomes necessary, and that its type species, as I find by comparison, and which was first pointed out by Riley (1881), is symonymic with what has heretofore been known as *Gastrancistrus viridescens* (Walsh). The history of the genus will be considered later.

FAMILY PTEROMALIDAE—SUBFAMILY PTEROMALINÆ.

Tribe *Rhaphitelini*

Genus **Hypopteromalus** Ashmead.

(Type: **Glyphe viridescens** Walsh.)

Ashmead, 1904, pp. 310, 378.

Schmiedeknecht, 1909, p. 355.

Normal position; description based on the type species.

♀.—Normal in stature. Metallic green, head and thorax punctate. Abdomen with short petiole.

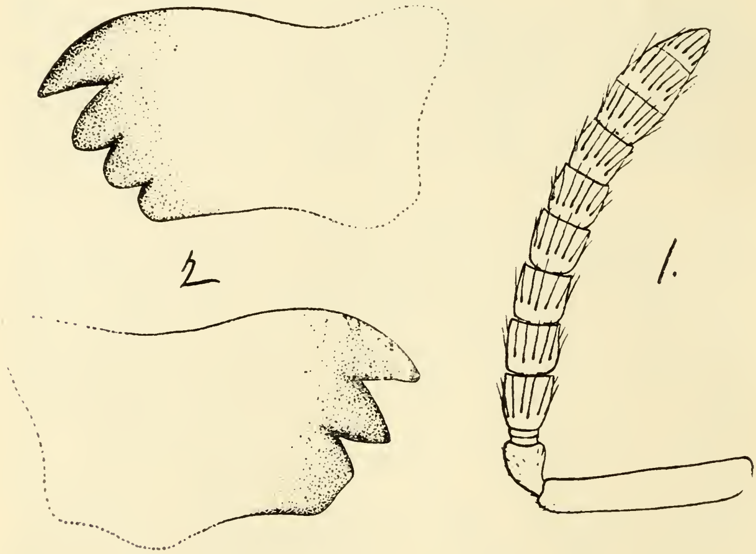
(Cephalic aspect) Head conspicuous, almost circular, its margins rounded, the face broad, sublenticular, the clypeus wider than long, its surface slightly inpressed below the general surface of the face so that the sclerite is distinctly outlined longitudinally, radially rugulose or striate, its sutures obsolete, its apical margin practically truncate, very slightly concave, along its whole length very slightly emarginate at the meson and a slight incision is present along the ventral border of the face just laterad of the clypeus, involving the sclerite's lateral margin; basal (dorsal) margin of the clypeus slightly convex at the meson, bisinuate, its dorso-lateral angle slightly more impressed. Antennæ inserted slightly below (ventrad) of the middle of the "face" or the distance between the cephalic margin of the vortex and the apical margin of the clypeus, slightly over a third of the way up (dorsad) the margins, distinctly above (dorsad) an imaginary line drawn between the ventral ends of the eyes and farther from the clypeus than that sclerite is long at the meson, the bulbs distinctly separated. Face ventrad, directly below the antennal insertions, with two shallow longitudinal impressions, one on each side of the meson, entering the dorso-lateral angles of the clypeus[1]; mesal facial impressions moderately narrow but distinct, extending nearly to the cephalic ocellus from the antennal bulbs, its margins not acute and the antennal scrobes obsolete or not differentiated from the mesal facial impression.

(Lateral aspect) Genal sulcus inconspicuous, short, not half as long as the eye, the latter ovate; genæ rounded; general shape of head, ovate.

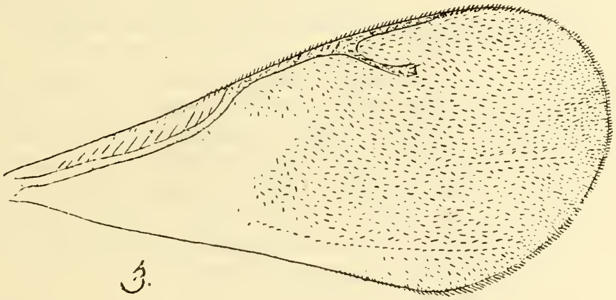
(Cephalic aspect) Head distinctly wider than the greatest width of the thorax, nearly thrice wider than long, the vertex broad, obtuse,

1) Also an obscure oblique impression, narrow, running from about the bulb of the antenna ventro-lateral to the margin of the head, between the dorso-lateral angle of the clypeus and the ventral end of the eye, nearer the former; this is visible in certain lights only.

narrowed slightly at the meson, but its occipital margin distinctly concave; ocelli in a triangle in the center of the vertex, nearer to the cephalic margin of the latter than to its occipital margin and the group distance from the eyes. The occipital foraminal depression marked, concave, its margins rounded or obtuse, immargined. Antennæ 13-jointed, with two distinct ring-joints and a 3-jointed club, the flagellum usually moderately clavate (lateral aspect), the club conical and wider than the funicle but not abrupt or spherical and the funicle cylindrical, very gradually enlarging distad; pedicel obconic, smaller than the first funicle joint or subequal to it, the six funicle joints all subequal and subquadrate. (Fig. 1).



Pronotum visible, widened or dilated laterad, narrow at the meson, at that point but a sixth the length of the mesoscutum, subobtuse; parapsidal furrows not conspicuous but distinct, shallow, incomplete, extending caudo-mesad from the cephalic margin of the scutum to about two-thirds their length; cephalic and caudal margins of the mesoscutum gently convexed; axillæ widely separated; scutellum nearly as in *Habrocytus thyridopterygis* Ashmead, normal, with a rather obscure transverse groove just before (cephalad) of its apex, best seen from the caudo-lateral aspect in shadow and appearing from dorsal and caudal aspects as a brighter colored, brassy, apparently slightly raised line; scutellum along the meson subequal to the length of the mesoscutum. Mesopostscutellum narrow, usual for the subfamily, margined. Metathorax punctate, declivous, slightly shorter than the scutellum, the median carina inconspicuous, complete or extending nearly to the neck, the lateral carina or fold represented on each side by a distinct, slightly curved, complete sulcus with margined, carinated or sharp margins, its lateral margin more distinct, being properly the lateral carina; these lateral sulci are nearly longitudinally straight for half their length or slightly convex, then curve slightly caudo-mesad and then nearly caudad again; spiracular sulcus following laterad, extending from the caudo-lateral end of the spiracle and distinctly shorter than the lateral sulcus and nearly straight; the metathoracic spiracle large, subreniform, oblique in position, its mesocephalic end near to the mesopostscutellum yet not touching the narrow transverse metapræscutum or metascutum; neck not as distinct as in *Pteromalus* Swederus, hood-shaped and from the lateral aspect distinct but not rising very much above the general surface, overlapping the petiole of the abdomen.



3.

Abdomen with a distinct petiole which is short and often hidden by the upper inclination of the region and subequal in length to the pedicel of the antennæ, or nearly so; from lateral aspect, abdomen variable, usually subtriangular, the apex of the triangle ventrad at segment 5, varying to conical or cuneate, pointed caudad, convex ventrad and flat to the concave dorsad, the tip of the ovipositor often exserted; adbomen subequal to the thorax in length; from dorsal aspect, conic-ovate or fusiform, widest at the third or fourth segment (third body segment); segment two longest, twice longer than segment three, its caudal margin slightly convex and entire; segment three nearly twice longer than segment five; four, five and six subequal in length, gradually decreasing, their caudal margins straight; segment six sometimes slightly longer than segment three; segment eight conical, subequal in length to segment seven. Ventrad and dorsad, caudal margins of the segments with a slight whitish pubescence or fringe.

Fore wings normal, with the usual dense discal ciliation, the submarginal vein slenderer than the marginal and about a third longer, widening at its curve; the marginal vein normal, thrice thicker than the submarginal vein at its middle and distinctly wider than either the postmarginal or stigmal veins and a fourth longer than the former and a third longer than the latter; postmarginal vein distinctly longer than the stigmal vein which is slightly curved, bearing a moderately large club with a cuneate uncus from its cephalo-distal margin; marginal cilia short. Hind wings ciliate distally. Fore wings broadest at points opposite the knob of the stigmal vein. (Fig. 3).

Legs normal, slender, the tibial spurs all single, moderately stout, the cephalic femora stout but not abnormally or conspicuously so, the tarsi all 5-jointed, the proximal joint of the caudal tarsi over twice the length of the caudal tibial spur and about twice the length of the second tarsal joint, the fourth joint, as usual, smallest.

Left mandible 3-dentate, the inner (mesal) tooth broadest, nearly truncate, the second tooth intermediate in size and shape, acutely dome-shaped and the third, outer (lateral) tooth longest, slenderest, acute, subfalciform. (Fig. 2). Right mandible 4-dentate, the teeth gradually lengthening laterad, the mesal one shortest, obtusely convex, the second longer, obtusely conic, the third still longer, subacutely conical, the fourth or lateral tooth longest, acute, subfalciform. (Fig. 2). Maxillary palpi 4-jointed, the apical joint longest, twice the size of joint three, clavate, the proximal joint shortest. Labial palpi 3-jointed, the middle minute, the others subequal.

♂. The same. The adbomen flat, depressed, from dorsal aspect elliptical-oval, with a large yellowish white area in the dorsal and ventral basal region. Petiole shorter than in the female, not as noticeable, the segmentation of the adbomen not as distinct. Antennæ inserted slightly higher up on the face, slenderer. Mandibular and other characters the same as in the female. Similar to male *Pteromalus* Swederus or nearly so.

A genus of moderately stout, metallic green hyperparasites with the general aspect of *Pteromalus* and about the same stature.

On account of the insertion of the antennæ, high up on the head, near the middle of the face and not especially near the mouth border, the mandibular characters, the presence of spiracular sulci and general habitus, as well as on account of its habits, the correct position of this genus, is, I think, in the pteromaline tribe *Rhaphitelini,* though its short abdominal petiole would seem to ally it with the *Sphegigasterinæ Sphegigasterini.* The genus appears to be similar to *Pteromalus* Swederus in many respects, especially in the general habitus of the males. In its new position it is closely allied to the genus *Habrocytus* Thomson, falling in that Thomsonion-Ashmeadian division of the *Rhaphitelini* having normal cephalic femora, mediumsized stigmal knobs and relatively short antennal pedicels. The genus is separated from *Habrocytus* by means of the less produced, shorter, usually triangular (lateral aspect) abdomen, the presence of the short petiole, the differences in the length of the abdominal tergites and other less noticeable characters to be summed up in general term *habitus.*

History of the Genus.

This genus is a recent description. In a table of the genera of his tribe *Pteromalini* of the subfamily *Pteromalinæ,* the late Dr. William Harris Ashmead, in his monumental work "Classification of the Chalcid Flies" (Ashmead, 1904, p. 320), established the genus *Hypopteromalus* with the species *Pteromalus tabacum* Fitch as type. As extracted from the table of genera mentioned the following diagnostic characters belong to the genus:

> Occipital foraminal depression emargined; metathorax produced into a subglobose neck, which is not very distinct; postmarginal vein always longer than the stigmal vein, but not very distinctly so; pedicel subequal to the first funicle joint, shorter, the antennæ with two ring joints; metathoracic spiracles large, elliptical; abdomen ovate to conic-ovate, not longer than the combined lengths of the head and thorax, the caudal margins of the segments straight, not incised or emarginate at the meson, the second segment about three times longer than the third, segments four and five united not longer than the third, those beyond variable, subequal in length; venter usually strongly compressed or keeled. Metanotum with a distinct median carina, the lateral folds incomplete, indicated towards the base.

In the table the genus was placed next to *Pteromalus* Swederus, but failing to interpret its characters properly, as an alternative, with *Diglochis* Foerster. During the short time of its existence, it has not been the subject of subsequent systematic treatment, though Schmiedeknecht (1909) briefly gives its characters, and, as it stands today, contains but a single species[2], the one upon which it was founded—(*Gastrancistrus*) *Hypopteromalus* (*tabacum*) *viridescens* (Walsh). It was first mentioned in the literature by Garman (1897), seven years before its description, and again by Ashmead (1900), four years prior to that time. As pointed out later, this genus has nothing to do with the *Miscogasterida*. Crawford (1910) refers to two of its characteristics and gives a table of the species.

Host Relations of the Genus.

Hypopteromalus viridescens (Walsh), representing the genus, is a common hyperparasite of the higher *Lepidoptera,* such as *Sphingidæ* and *Noctuidæ,* attacking primarily the microgaster genus *Apanteles* Foerster, issuing as adults from their cocoons. It is known to attack *Apanteles congregatus* (Say) when a primary parasite of *Phlegethontius, Ceratomia* and *Heliophila;* (*Apanteles*) *Microplitis catalpæ* (Riley) on *Ceratomia; Apanteles militaris* (Walsh) and *A. linguitidis* (Riley) on *Heliophila;* and Fitch (1865) records it as a secondary parasite of *Sphinx kalmiæ* Smith and Abbot, the host being a microgasterid; and Dimmock (1898) as being secondary on *Smerinthus geminatus* and *Ampelophaga myron.* I have reared it from what appear to be the cocoons of *A. smerinthi* Riley on a willow leaf. I also record beyond, rearing it from *Sphecodina abbotii,* upon which it is secondary, and from the cocoons of *Apanteles congregatus* (Say) on the larvæ of *Ceratomia catalapæ* Boisduval.

Hypopteromalus apantelophagus Crawford is parasitic on *Glyptapanteles japonicus* and *H pœcilopus* Crawford on *Glyptapanteles sp.*

Distribution of the Genus.

The species *viridescens* is widely distributed in the United States, of which it is most probably a native. In the literature, it is recorded from the following localities: Illinois (Schuyler

2) Since this was written Crawford (1910) has described two species from Japan and Europe, *H. apantelophagus* and *H. pœcilopus,* respectively; these are not included here, but both differ from the type species in having an elongate first funicle joint. Crawford here and previously (Idem, 1909) calls attention to its abdominal petiole and anomalous tribal position.

County, Algonquin); New York (Saratoga Springs, Long Island); Louisiana (?Baton Rouge); New Hampshire; New Jersey; Kentucky; Ohio (Jackson).

I add the following new localities: Illinois (Urbana, and Champaign, Quincy, Parker, Normal and Polo); Maryland (Baltimore-Sparrows' Point). The genus at present is known to occur over the area bounded by Maryland on the east, New Hampshire on the north, Louisiana on the south and Illinois on the west. Crawford's two new species are from Japan and Europe.

The Type Species of the Genus.

Hypopteromalus viridescens (Walsh).

Glyphe viridascens Walsh, 1861, pp. 364, 370, fig. 11.—Idem, 1865, p. 483, fig. 11.

Pteromalus tabacum Fitch, 1865, pp. 224-225, 227.

Glyphe viridescens Walsh (= *tabacum* Fitch), Riley, 1881, p. 302.

Glyphe viridescens.—Thomas, 1881, p. 39.

Tridymus viridascens (Walsh), Riley, 1883, p. 127.

Glyphe viridescens Walsh, Howard, 1865, p. 44.—Cresson, 1887, p. 242.

Pteromalus tabacum Fitch, Id., Ib., p. 45.—Cresson, 1887, p. 243.

Glyphe viridascens Walsh, Riley and Howard, 1898, p. 138.

Gastrancistrus viridescens (Walsh), de Dalla Torre, 1898, p. 205.

Pteromalus tabacum Fitch, Dimmock, 1898, p. 149.

Hypopteromalus tabacum Fitch, Ashmead, 1900, p. 559.

Hypopteromalus tabacum Fitch, Id., 1904, pp. 320, 378.

Hypopteromalus tabacum Fitch, Nason, 1906, p. 152.

Hypopteromalus tabacum Fitch, Schmiedeknecht, 1909, p. 355

Hypopteromalus tabacum Fitch, Crawford, 1910, p. 21.

Redescription of (Glyphe) Hypopteromalus viridescens (Walsh).

Normal position.

♀.—Length variable, 1.75—2.55mm.; 2.25 mm. average.

Color variable in depth of tones; usual general color deep metallic Prussian green, with brassy reflections, the metanotum with some bluish, abdomen darker greenish, the large second segment metallic purplish and the other proximal segments reflecting purplish in certain lights. Mandibles fulvous, fuscous at tips, palpi pure white, scape, tegulæ and the legs, excepting the lateral aspect of all coxæ, especially the caudal coxæ exteriorly which are metallic greenish, fulvous, the flagellum darker, dusky brownish yellow, subfuscous. Scape often pallid yellowish; femora slightly darker than the tibiæ and tarsi which are often pallid; apical tarsal joints dusky; venation dusky yellowish. Wings hyaline; ocelli pinkish; eyes garnet. Ventum concolorous with the dorsal aspect of the body. Cephalic and intermediate coxæ much less metallic than caudal coxæ.

The whole of the head and thorax dorsad uniformly, moderately, polygonally punctate, the metanotum more coarsely so, subrugose, the thoracic pleura and venter smoother as are also the occipital foraminal depression and the caudal coxæ exteriorly (lateral aspect), the latter delicately reticulated; other coxæ practically smooth. Sparse whitish pubescence on the face, genæ and dorsum of pro and mesothorax, the coxæ, and a small tuft of longer white hairs on the dorso-lateral aspect of the metathorax. Abdomen smooth, with little or no sculpture. Eyes naked; cephalic ocellus and lateral ocelli suboval, equal, the lateral ocelli distinctly farther from each other than either is from the cephalic ocellus and each is still much farther from the respective eye margins than they are from each other, the distance being at least twice that separating other ocellus from the cephalic one.

Apex of hind wings obtuse.

Antennæ moderately hispid-pubescent, the scape practically naked, the pedicel and ring-joint with a few sparse hairs, the hairs on the funicle and club not arranged in well-defined rows. Scape cylindrical, nearly uniform in width, not quite as long as the pedicel, ring-joints and first three funicle joints united; pedicel obconic, narrowed slightly before the apex of the proximal half, not much shorter, but distinctly narrower than the first funicle joint and about three times the length of the united ring-joints; ring-joints small, subequal, the apical one larger, both narrower than the pedicel and the funicle; funicle joints all subequal and subquadrate, gradually shortening distad, joints one to four almost equal, slightly longer than wide, joint one slightly the longest; joints five and six almost equal, slightly shorter than the preceding but still somewhat longer than wide; club widest at the apex of its proximal joint, not quite as long as the united lengths of funicle joints four to six, the proximal club joint the widest antennal joint, widening distad and as long as the preceding joint (funicle joint six); intermediate club joint as wide at its base as the apex of the proximal joint, just the latter's opposite in shape, narrowing instead of widening, distad and equal to the proximal club joint in length or slightly longer; the distal joint somewhat shorter, conical. Under high power (objective ⅙ inch), the hairs of the funicle and club are seen to be unequal in size, some of them wide and somewhat flattened, appearing in balsam mounts as longitudinal, pale furrows or grooves along the joints. (Fig. 1).

From 327 + specimens, ⅔ inch objective, 1 inch optic, Bausch and Lomb.

♂.—Length variable, 1.60—2.47 mm.; 2.08 mm. average.

The same as the female. Besides the sexual differences pointed in the generic description, the following specific details are different from those in the female: The body is a shade lighter in color and more brassy and the antennæ are slightly more pubescent and the joints different as follows: the legs are pallid yellowish, and the caudal coxæ laterally vary to pallid yellow, the other coxæ lighter.

Antennæ the same, the hairs sparser and softer, the funicle joints longer, distinctly longer than wide, and the scape broader, somewhat compressed, the club somewhat more slender, conic-ovate; pedicel distinctly shorter than the first funicle joints, funicle joints one to three subequal, and joints four to six subequal, the proximal group of three broader.

From 136 + specimens, ⅔ inch objective, 1 inch optic, Bausch and Lomb.

The coloration in this species is fairly constant; it may vary, however, to deep metallic French blue; it is more variable in the male, the large abdominal area sometimes more extensive, especially ventrad, and the caudal coxæ are sometimes without metallic coloration. Specimens which have been in collections for some years have a decided bluish color on the head and thorax. The metallic coloration on the intermediate and cephalic coxæ of the female may vary somewhat, too. The shape and size of the joints of the antennal funicle may vary considerably, comparatively speaking. Thus the last joint may be decidedly more transverse than usual, distinctly wider than long, while sometimes all of the joints are longer than wide and subequal; at other times, all are subquadrate, gradually shortening distad, the first and last joints not contrasting. Again, all may be wider than long when the first joint is slightly shorter (but larger) than the pedicel. These variations may all occur in the same series of reared specimens. No variation in the number of antennal segments have been met with.

Redescribed from the following of 472 specimens:

1. *Glyphe viridescens* Walsh; 1 ♂, 5 ♀ specimens reared from white cocoons, Urbana, Ill., June 21, 1887, and determined by Howard and Ashmead (Riley, in litt., June 13, 1891); accession No. 12806, Illinois State Laboratory of Natural History; (1 ♂, 5 ♀, tag-

mounted; two slides, xylol-balsam, ♀ mandibles and antenna and ♀ wings—antenna).

2. *Hypopteromalus tabacum* (Fitch); 1 ♂, 5 ♀, reared at Baltimore, (Sparrows' Point), Md., February 2, 1904, from a small, compact circular mass of erect *Apanteles* cocoons on a willow leaf, covered and hidden by a fluffy mass of fine white silk like the silk of some spiders and probably those of *Apanteles smerinthi* Riley. Determined by Ashmead. Accession No. 41051, Illinois State Laboratory of Natural History. (5 ♂ tag-mounted; 2 slides, xylol-balsam, ♀ head, mandibles, antennæ and ♀ wings, leg and antenna).

3. *Hypopteromalus tabacum* (Fitch): 2 ♀ captured at large, July 10, September 27, 1895; in the Nason collection (Nason, 1906, p. 2), tagmounted, plus one slide bearing two antennæ and a pair of wings). Determined by Ashmead.

4. 110 ♂, 218 ♀ plus 5, reared during September 1908 from the cocoons of *Apanteles congregatus* (Say) parasitic on the larvæ of *Phlegethontius sexta* (Johanssen), Urbana, Ill. Accession No. 41052, Illinois State Laboratory of Natural History. (7 ♀, 6 ♀ tagmounted; xylol-balsam, ♀ legs, antenna and mandible—1 slide, ♂ ♀ antennæ, 1 slide; ♂ ♀ fore wings—1 slide. Accession No. 39857, (1 ♂, 11 ♀, tagmounted; 1 slide, ♀ antennæ and mandibles). No. 39931, (1 ♂, 1 ♀, tagmounted; 1 slide, ♀ head).

5. *Hypopteromalus viridescens* (Walsh): 1 ♂, reared in connection with supposed larvæ of *Ancylys comptana* Frölich, Urbana, Illinois (J. J. Davis), July 1, 1906. Accession No. 37248, Illinois State Laboratory of Natural History; (1 ♂, tagmounted; ♂ mandibles, xylol-balsam, 1 slide).

6. "*Sphegigaster cœruliventris* Ashmead"[3], Riley, in litt., June 13, 1891: 1 ♀, reared from microgasterid cocoon similar to those of *Apanteles congregatus*, Quincy, Illinois, October 1886. Accession No. 10957, Illinois State Laboratory of Natural History. (1 ♀, tagmounted, cocoon of host).

7. 7 ♂, 1 ♀ of *viridescens*, reared at Urbana, Ill., April 24, 1891, from *Apanteles* cocoon taken from larvæ of *Phlegethontius* on tomato, September 20, 1890 (F. M. Webster). Accession No. 16157, Illinois State Laboratory of Natural History. (7 ♂, 1 ♀ tagmounted, cocoons of host; xylol-balsam, ♂ mandibles, antenna).

8. 4 ♀ of *viridescens*, reared July 2, 1908, in the insectary of the state entomologist of Illinois, from the cocoons of *Apanteles congregatus* (Say) on the larvæ of *Ceratomia catalpæ* Boisduval, collected at Parker, Ill. (L. M. Smith), June 30, 1908. Accession No. 39324,

3) I have been unable to find trace in the literature of this species; it is apparently a *nomen nudum*.

Illinois State Laboratory of Natural History. (4 ♀, tagmounted; plus 1 slide bearing ♀ wings, antennæ and mandibles).

9. 2 ♂ of "*Pteromalus n. sp.*", Riley, in litt., June 13, 1891; and 3 ♂, 1 ♀ of *viridescens*, labeled as secondary parasites of *Phlegethontius quinquemaculata* Haworth (reared by S. A. Forbes), Normal Ill., Sept. 9, 1878, from *Apanteles* cocoons. Accession No. 16070, Illinois State Laboratory of Natural History. (4 ♂, 1 ♀ tagmounted, 2 host cocoons; plus 1 slide, ♂ ♀ antennæ, ♂ mandibles and wings.

10. 1 ♂, 6 ♀ of *viridescens*, reared April 25, 1891, from *Apanteles* cocoons taken from larvæ of *Phlegethontius* on tomato, Urbana, Ill., Sept. 20, 1890 (F. M. Webster). Accession No. 16177, same collection. (1 ♂, 6 ♀ tagmounted, 1 host cocoon; plus 1 slide bearing 1 ♂, 5 ♀ antennæ).

11. 23 ♀ of *viridescens* reared at Urbana, Ill., April 27, 1891, from *Apanteles* cocoons taken from larvæ of *Phlegethontius* on tomato, Sept. 20, 1890 (F. M. Webster). Accession No. 16178, same collection. (8 ♀ tagmounted; 14 ♀ alcohol, 1 vial).

12. 1 ♂, 6 ♀, plus 3 individuals of *viridescens*, reared from *Apanteles* cocoons on the larvæ of *Sphecodina abbotii* Swainson, Polo, Ill., July 20, 1893. Accession No. 19457. (1 ♂, 6 ♀ tagmounted, 6 host cocoons).

13. 9 ♂, 54 ♀, plus one specimen of *viridescens*, reared from larva of *Phlegethontius*, secondary, Champaign, Ill., August 27, 1895, (W. G. Johnson). Accession No. 21495, Illinois State Laboratory of Natural History. (63 ♂ ♀ tagmounted).

14. "*Pteromalus n. sp.*" Riley, in. litt., June 13, 1891. 1 ♂ reared in connection with *(Acrobasis) Mineola indigenella* Zeller, Urbana, Ill., March 25, 1889 (John Marten), relations unknown. Accession No. 14783, same collection. (1 ♂ tagmounted; xylol-balsam, ♂ antennæ, mandibles, 1 slide).[4]

15. 1 ♂, 11 ♀ specimens reared from the cocoons of *Apanteles* on the larva of *Phlegethontius sexta* (Johannsen), Urbana, Ill., Sept. 17, 1908 (G. E. Sanders). Accession No. 39857, Illinois State Laboratory of Natural History. (1 ♂, 11 ♀, on tags).

16. A pair of specimens reared from same host as in preceding, same place, Sept. 12, 1908 (G. E. Sanders). Accession No. 39931, same collection. (Tags ♂ ♀).

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4) This is probably an undescribed species, distinguished from *viridescens* only by having the funicle joints of the antennæ twice longer than wide (joint 1), distinctly longer than with the type species, and perhaps in the different shape of the teeth of the mandibles.

The species under consideration was originally described by Benjamin Dann Walsh (1861) in the following manner:

"Family *Chalcididæ.* Subfamily *Peteromalides.*

It is with some hesitation that I refer the following species in this very extensive and difficult family, to *Glyphe,* Wilkinson. It is one of three remarkable congeneric species in my cabinet, which are all characterized by the last joints of the antennæ, when viewed from above, being elongate-acuminate, but when viewed in profile, being reduced to one-fourth the width of the penultimate joint, and attached on one side of it like a tarsal claw. In *Glyphe* the last joint is said simply to be elongate-acuminate. In other respects the characters tolerable well. In one of my three species, parasitic on *Microgaster xylina,* Say, the antennæ are notably moniliform. The other one of the three is the well known parasite of the Hessian fly, which, at the commencement of Say's entomological career, he arranged by mistake under the Proctotrupid genus *Ceraphron* (*C. destructor,* Say), which Westwood subsequently, misled by Say's figure, declared must be evidently one of the *Eulophides,* the fifth subfamily of the *Chalcididæ,* (Westwood's intr., II, page 160,) which Harris afterwards erroneously called a *Eurytoma,* the typical genus of the second subfamily of *Chalcididæ,* (Harris, Inj. Ins., p. 432,) ; but which I have no doubt from the structure of the prothorax, ought to be arranged somewhere among the *Pteromalides,* the third subfamily of *Chalcididæ.* Whether or not we choose to refer it to *Glyphe* is another matter. Perhaps a new genus will have to be founded for the reception of these three species.*

Glyphe viridascens. Fig. XI. New Species. Length of body .07 inch, or not quite 2 millimetres. General color, dark green, verging on black. Head finely and densely punctured; palpi whitish, eyes black; antennæ light brown, the basal joint received in a shallow, wide longitudinal

* The foot note referred to here is omitted as being but indirectly relavant.—A. A. G.

depression. Thorax finely and densely punctured; legs yellowish white; tips of tarsi dusky; wings hyaline; subcostal nervure brown and prolonged on the costa to the extreme tip of the wing. Abdomen black, glabrous, polished, flat above, convex beneath, so as in those individuals with acuminate anus—which I take to be females, but which Wilkinson takes to be males—to appear almost triangular when viewed in profile.

Bred five specimens from a mass of the army worm cocoons for some unknown *Ichneumon* I have not met with in Rock Island county. Four of the five have the antennæ still covered with the transparent pupal membrane which we often find on the antennæ of immature Cerambycids, but the structure of the apical joints of the antennæ is distinctly visible in these." (Walsh, 1861, p. 370).

The figure referred to in the original description is crude and misleading rather than helpful, as erroneous and poorly executed figures always are. Walsh gives nothing more in regard to the species excepting a brief paragraph on page 364 referring to the figure and a remark concerning the status of the species as a parasite of the "ichneumon," which Riley (1881) afterwards stated to be *Apanteles militaris* (Walsh). The spelling of the specific name is evidently due to an error, corrected later by Walsh (1865) himself and others and therefore unnecessarily so by de Dalla Torre (1898).

About four years later Asa Fitch (1865), treating of the parasites of the Northern Tobacco Worm *(Phlegethontius quinquemaculata* Haworth), gave a somewhat running and lengthy account of this hyperparasite and redescribed it as new under the name of *Pteromalus tabacum;* Fitch also gave a brief description of the male, described for the first time.

In order to bring all the literature of this genus together in this connection, as well as for a matter of interest I herewith quote Fitch's description given on pages 225-227:

"These destroyers of the insect which destroys the tobacco worm are very small four-winged flies of a shining dark-green color, with pale yellowish legs and white feet. They belong to the order of *Hymenoptera* and the family *Chalcididæ*, and are closely related to the Hessian fly parasite, *Semiotellus destructor,* figured in my Seventh Report, plate 3, fig. 1, which figure will also serve to represent this insect in almost every particular. It pertains to the genus *Pteromalus,* a name derived from two Greek words, meaning bad wings, the wings in these insects being nearly destitute of ribs or veins. As they, by destroying the parasite of the tobacco-worm, cause that worm to be more numerous, and hereby more injurious to the tobacco, and as they will often occur lurking about this plant in search of the cocoons upon which to bestow their eggs, they may not inappropriately be named the Tobacco *Pteromalus.* All the flies which came from the cocoons were females, from which the following description is drawn:

*The Tobacco **Pteromalus** *(Pteromalus Tabacum),* is one-tenth of an inch long to the end of its body, and is of a dark or bottle-green color with a brassy reflection, and finely shagreened upon the head and thorax. The *head* is large and placed transversely, about three times as broad as it is long, convex in front and concave at its base, viewed in front it is nearly circular, with a large oval eye, slightly protruding on each side, of a dull red color fading to brown after death. On the crown three ocelli or eyelets appear as glassy dots placed at the corners of a triangle. The jaws are yellow, their ends brown, with four minute teeth. the palpi or feelers are dull white. The antennæ are inserted in the middle of the face and when turned backward reach about half the length of the thorax. They become a little thicker towards their tips, and are of a brown color, with the long basal joint dull pale yellow, and are clothed with a short incumbent beard. They are composed apparently of nine joints, the first joint being long and smooth, and forming an angle with the remaining joints. The second is the smallest of the series, being but little longer than thick and obconic in its form. The third joint is thrice as long and nearly thrice as thick as the preceding and has the shape of a pear, the contracted portion of its base being formed of two rings or small joints which are rarely perceptible even in the live specimen when highly magnified, except these organs

* Beginning page 226.

be put upon the stretch. The fourth and following joints are a third shorter than the foregoing and are nearly equal and square in their outline, each successive joint very slightly increasing in thickness and diminishing in length. The last joint is about thrice as long as the one preceding it, of an oval or subovate form, rounded at its base and bluntly jointed at its apex, and is probably composed as in the other species of this genus of three joints compactly united together. The *thorax* scarcely equals the head in width and is egg-shaped and thrice as long as wide. On each shoulder is a slightly impressed line extending obliquely backward and inward. The *abdomen* is a third shorter than the thorax, and in the live insect surpasses it in thickness, is egg-shaped and convex with its tips acute-pointed. When dried it scarcely equals the thorax in thickness and becomes strongly concave on the back and triangular when viewed on one side. It is smooth, polished and sparkling, of a green black color, the middle segments each with a broad purple black band visible in particular reflections of the light. Beneath it is black and at the tip shows some fine impressed longitudinal lines forming the edges of the groove in which the sting is enclosed. The *legs* are slender, pale wax yellow, with the feet and ends of the shanks dull white, the hips of the hind legs being stout and black, with their outer faces green blue and their tips pale yellow. The feet are five-jointed and dusky at their tips. The *wings* are transparent and reach slightly beyond the tip of the abdomen when at rest. The anterior ones are broad and evenly rounded at their ends, and have, near the outer margin, a thick brown rib or subcostal vein, extending more than a third of their lengths and then uniting with the margin and terminating some distance forward of the tip, after sending off a short straight stigmal branch which is thickened at its end, with apex notched. Towards the inner margin an exceedingly fine longitudinal vein* is perceptible, which, near its middle gives off a fine branch running almost to the inner hind end of the wing. The hind wings are much smaller and without veins, except a brown subcostal one which extends into the outer margin and abruptly ends a little beyond the middle.

* Beginning, page 227.

All of the examples of this species which I have obtained from the cocoons of the Tobacco-worm have been females. The last of August, 1862, I received from Dr. Allen, of Saratoga Springs, a larva of the *Sphinx kalmiæ,* to which thirty-six cocoon were adhering. * * * * * * * * * * * * * * *

Of the flies obtained from the Lilac-worm, four were males, whereby it appears that this sex differs from the females above described, in the following particulars; 1st, their color is lighter and more bright, being brilliant metallic green, when dried becoming blue green; 2nd, their antenæ are tarnished yellow, joints being cylindric and a third longer than thick, longer and not at all thickened toward the tips, their joints being cylindric and a third longer than thick, with the last joint egg-shaped, and but little longer than its predecessor; 3rd, the abdomen is flattened oval and rounding at its tip, with a large translucent pale yellow spot near the base; 4th, the legs are paler and pure yellow without any mixture of orange or tawny." (Fitch, 1865, pages 225-227).

Fitch gave a much better description of the species than did Walsh, but he was misled in regard to some of the structures; by comparing the two descriptions one could hardly say that they disagree in essentials; rather, the second supplements the first. Fitch reared the species from the cocoons of *Apanteles congregatus* (Walsh) when parasitic on *Phelegethontius* and also from some microgaster cocoons on the larva of *Sphinx kalmiæ* Smith and Abbot.

Some years later, Riley (1881)[5] mentioned the rearing of this hyperparasite by Walsh from *Apanteles militaris* (Walsh) and called attention to the fact that Walsh's *viridescens* and Fitch's *tabacum* were the same[6], referring to the species as *Glyphe viridescens* Walsh and also recording it as a parasite of *Apanteles congregatus* (Say) when parasitic on *Heliophila unipuncta* Haworth. During the same year Thomas (1881) listed the species among the parasites of *Heliophila unipuncta* Haworth as being a second-

5) And see Packard (1861).

6) But later (Riley, 1883) he referred it doubtfully to *Tridymus* Ratzeburg.

ary parasite on *Apanteles congregatus* (Say), and quoted the original description of Walsh, omitting the first and last paragraphs.

After Riley (1881), the species was listed separately under the names given it, placed in widely separated subfamilies and the error has been continued to the present day.

As I have examined undoubted specimens of both *Glyphe viridescens* Walsh and *Pteromalus tabacum* Fitch, finding them identical and with single tibial spurs on the caudal tibiæ, the species which we shall now call *Hypopteromalus viridescens* (Walsh) belongs to the *Pteromalidæ* and can have no relationship to *Glyphe* Walker (=*Gastrancistrus* Westwood) or *Tridymus* Ratzeburg, both genera of the *Miscognasteridæ*.

But very little has been recorded concerning its habits and host relations since the time of Fitch; it was bred from microgaster cocoons by Morgan in Louisiana, (Riley and Howard 1892). Garman (1897) first recorded it as a secondary parasite of *Phlegethontius sexta* (Johannsen), its host being *Apanteles congregatus* (Say); Lintner (1898) as a primary parasite of *Apanteles limenitidis* (Riley) on *Heliophila unipuncta* Haworth; Dimmock (1898) as a parasite of an *Apanteles* on *Smerinthus* and from *Ampelophaga;* and finally, Howard and Chittenden (1907) record it from *Microplitis catalpæ* (Riley) when parasitic on *Ceratomia catalpæ* Boisduval; and I have bred it at Baltimore, Md., in 1904, from what appeared to be the cocoons of *Apanteles smerinthi* Riley on a willow leaf, as mentioned above; and recently it was reared in large numbers from the cocoons of *Apanteles congregatus* (Say), parasitic on the tobacco worm (*Phlegethontius sexta* Johannsen), State Entomologist of Illinois; the hosts were obtained at Urbana, Ill., August 17 and 28, 1908, and the parasites and hyperparasites emerged during the following September:

From one of the host larvæ were taken 327 cocoons of the *Apanteles* from which afterward emerged 244 *Hypopteromalus viridescens,* 23 *Apanteles congregatus,* and 24 *Mesochorus.* From a second host larva were taken 101 cocoons from which emerged in due course 12 adult *Apanteles,* 68 *Mesochorus* and 2♂, 3♀ of *viridescens.* From a third lot of 111 cocoons removed from a single host larva, there were obtained 7 *Apanteles, 73 Mesochorus* and but a single female of *viridescens* From a fourth lot of 248 cocoons emerged 123 *Apanteles* and 60 *viridescens.* And from a fifth and last lot of 148 cocoons taken from a single host larva, there emerged 93 *Apanteles,* 15 *Mesochorus*, and 23 *viridescens*. Of the total number of 935 cocoons of *Apanteles congregatus* (Say), or of that number of larvæ successfully coming to full growth on five host larvæ, but about 258 or 27.5% survived to maturity. Other rearings of the species are as recorded in the foregoing.

Habits of the Species

The manner of emergence of this parasite from the cocoons of *Apanteles congregatus* (Say) is ably described by Fitch as follows:

"And after these flies have left their cocoons, it is readily told by the appearance of each cocoon whether it is a *Microgaster* or a *Pteromalus* fly which has come out from it. The *Microgaster*, by which all the cocoons are constructed, makes an opening for its escape in a more neat and artistic manner than does its destroyer. * * * * * * * * The enclosed fly then pressing its head against the lid raises it up and crawls forth from its prison. Thus the evacuated cocoon has its end smoothly cut off with the severed portion usually adhering to it. The *Pteromalus* fly, on the other hand, being a size smaller, is able to move about and can probably turn itself around inside the cocoon. And to make its escape, it gnaws a hole through the side near one end, of sufficient size for its body to pass through, this hole in different instances being round, oval, or irregular, and its edges ragged and uneven." (Page 228).

In regard to the habits of the adult, Fitch has the following to say:

"This insect, * * * * * * * * * * * * * *, appears tame and sedate, walking around slowly, and as if with deliberation as to what it is doing; and if any annoyance approaches it, to escape therefrom, it gives a slight skip, throwing itself about an inch, and repeating this leap again and again if pursued, it being not at all inclined to take wing." (Page 227).

Further than what is known concerning its host relation, and the few observations quoted from concerning its habits, but very little else of importance is known concerning the biology of the species.

It hibernates in the cocoons of its hosts as indicated by the records of rearings given in the foregoing and what is stated by

Fitch (1865, p. 225), but in what stage is unknown. The latter author's supposition that a single female deposited a hundred or more eggs is not founded on a good premise, for it is clear that more than one female may have been concerned. The parasite is solitary, a single one emerging from the cocoon of its host and there is good evidence to show that it deposits its eggs into or on the fullgrown larva or recent pupa of its host within its cocoon.

Literature Referring to Hypopteromalus.

1861. PACKARD, ALPHEUS SPRING. Sixth Ann. Rep. Secretary Maine Board of Agric., 1861, Augusta, p. 139.

Glyphe viridescens recorded from *Apanteles militaris* (Walsh). Based on Walsh (1861).

1861. WALSH, BENJAMIN DANN. Insects Injurious to Vegetation in Illinois. Transactions Illinois State Agric. Soc., with etc., Springfield, Ill., IV, (1859-1860). pp. 364; appendix 370; pl., fig. 11. Separate (see Howard, 1885).

Original Description, bred from some primary ichneumonoid parasite of *Leucania unipuncta* Haworth. (Probably *Apanteles militaris* (Walsh).

1865. FITCH, ASA. Insects Infesting Gardens. Sixth, seventh, eighth and ninth reports on noxious, beneficial and other insects, State of New York. Made to the etc., Albany, ninth Rep., pp. 224-228. Separate (see Howard, 1885). ?Transactions New York State Agric. Society, XXIII, 1863, p.

Redescription as new under the name of *Pteromalus tabacum;* its hosts and habits.

1865. WALSH, BENJAMIN DANN. Insects Injurious to Vegetation in Illinois. Trans. Ill. State Agric. Society, with reports etc., Springfield, V. (1861-1864), p. 483, fig. 11. (*Glyphe viridescens*, n. sp. On some undetermined parasite of the army worm).

Premium essay; copied from Walsh (1861); figures and mentions incidentally.

1870. RILEY, CHARLES VALENTINE. The Army-worm. Second annual report on the noxious, beneficial and other insects of the state of Missouri, made to etc., Jefferson City, p. 53, fig. 24.

Glyphe viridascens mentioned as a parasite of *Apanteles militaris* when parasitic upon *Heliophila unipuncta* Haworth; the figure is the original one of Walsh (1861).

1876. RILEY, CHARLES VALENTINE. Ninth report on the noxious, beneficial and other insects of the state of Missouri made to etc., Jefferson City, p. 53.

The same as Riley (1870), without the figure. *G. viridascens.*

1877. PACKARD, ALPHEUS SPRING. Ninth annual report U. S. geological and survey Territories, embracing etc., for 1875, Washington, D. C., p. 706.

Mentioned as parasitic on *Apanteles militaris* (Walsh).

1881. RILEY, CHARLES VALENTINE. Notes on North American Microgasters, with descriptions of new species. Transactions Academy Sciences St. Louis, (Missouri), IV, (1878-1886), p. 302. Separate p. 7.

Glyphe viridascens Walsh equals *Pteromalus tabacum* Fitch; hosts.

1881. THOMAS, CYRUS. Tenth report, State Ent. on noxious, beneficial insects, state of Illinois, Springfield, p. 39.

1883. RILEY, CHARLES VALENTINE. The army worm (Leucania unipuncta Haw.) Third report, U. S. Ent. Commission, relating to etc., U. S. Dept. Agric., Washington, D. C., p. 127.

"From the cocoons of the Military *Microgaster* there often issue individuals of a minute secondary parasite—a chalcid, called by Walsh *Glyphe viridascens,* but which probably belongs to the genus *Tridymus.*"

" * * * * This species is also parasitized by the *Glyphe viridascens* mentioned above. The latter, by the way, is identical with the *Pteromalus tabacum* of Fitch, who bred it from *Apanteles congregatus,* when parasitic upon the tobacco worm (*Macrosila quinquemaculata*)."

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1887. CRESSON, EZRA TOWNSEND. Synopsis of the Hymenoptera of America, North of Mexico. Transactions American Ent. Soc., Philadelphia, supplementary volume, 1887, pp. 242, 243.

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1897. GARMAN, HARRISON. Bull. No. 66, Kentucky Agric. Exp. Station, Lexington, p. 28, footnote.

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1897. LINTNER, JOSEPH ALBERT. Twelfth report on injurious and other insects of State of New York for year 1896. (From the Fiftieth report, New York State Museum), Albany, p. 210.

"*Glyphe viridascens* " parasitizes *Apanteles militaris* (Walsh) and *A. limenitidis* (Riley) on *Heliophila unipuncta* Haworth.

1898. DE DALLA TORRE, CARL G. Catalogus hymenopterorum hujusque descriptorum systematicus at synonymicus, Lipsiæ, V, pp. 150, 205.

Pteromalus tabacum Fitch. *Gastrancistrus viridescens* (Walsh); specific name unnecessarily amended.

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1904. ASHMEAD, WILLIAM HARRIS. Classification of the chalcid flies of the superfamily Chalcidoidea, with etc. Memoirs Carnegie Museum, Pittsburgh, I, No. 4 (Publications of the Carnegie Museum, Serial No. 21), pp. 320, 378.

1906. NASON, WILLIAM A. The parasitic Hymenoptera of Algonquin, Illinois, Ent. News, Philadelphia, XVII, p. 152.

1907. HOWARD, LELAND OSSIAN and CHITTENDEN, FRANK HURLBURT. The Catalpa Sphinx (*Ceratomia catalpæ* Bdv.) Circular No. 96, Bureau Ent., U. S. Dept. Agric., Washington, D. C., p. 5.

"*Hypopteromalus tabacum* Fitch" reared in large numbers from a single lot of larvæ of *Ceratomia catalpæ* Boisduval, together with *Horismenus microgastri* (Ashmead), the former Chalcidid, at least, attacking *Apanteles Micropitis catalpæ* (Riley), the primary parasite of the sphingid.

1909. CRAWFORD, J. C. Proceedings Ent. Soc., Washington, XI, p. 52.

1909. SCHMIEDEKNECHT, OTTO. Genera Insectorum (diriges par P. Wytsman), Bruxelles, 97me fascicule, Family *Chalcididæ*, p. 355.

1910. CRAWFORD, J. C. Bull. No. 19, technical series, Part II, Bureau Entomology, U. S. Dept. Agric., Washington, D. C., pp. 21-22.

On account of the fact that this hyperparasite attacks insects of economic importance, it has been mentioned by the earlier writers such as Walsh, Riley and Fitch in various nonscientific agricultural journals, but as nothing new is contained in such places, it is not considered our place here to take cognizance of them.

Urbana, Ill., August, 1911,

A. A. Girault, Brisbane, Australia.

TOWNSEND'S SOLITAIRE IN WISCONSIN.

By Henry L. Ward.

Although this western species, *Myadestes townsendi* (Audubon), was, in December, 1895, taken at Waukegan, Ill., close to our southern border and has been noted as far east as New York, there appears to exist no record of its occurrence within the limits of Wisconsin.

Mr. Herbert L. Stoddard while collecting for the Milwaukee Public Museum in the Prairie du Sac region this summer, was told by an acquaintance, Mr. Albert Gastrow of West Point, Wis., that he had a bird which was unknown to himself or others of the neighborhood. On seeing the specimen Mr. Stoddard provisionally identified it as a Solitaire and upon his return to the museum brought the specimen with him for more careful determination.

The specimen, which proves to be a Townsend's solitaire was taken on or about February 20th, 1910, by Mr. Gastrow in a ravine having its sides covered with juniper and located not far distant from the Wisconsin river in the town of West Point, Columbia county. The specimen was skinned and mounted by Mr. Gastrow, but was not sexed. He has since very graciously presented it to the museum where it is recorded as No. 9976. Another party resident in that locality is reported to have informed Mr. Gastrow that he had seen several of the same kind of bird at this locality in Winter, Spring and Summer, but Mr. Gastrow has himself been unable to find others.

In this connection it may be recorded for what it is worth that when another of the Museum's expeditions was at Wyalusing, Grant county, Wis., in the latter part of July, 1911, they were informed by a deputy game warden of that region of the recent appearance of a previously unknown bird. His description suggested the Mockingbird, but he insisted that he was familiar with this species and that these were different. When in the first half of August this party was at Rutledge, also in Grant county, some fishermen located near the main channel of the Mississippi on a some time island informed Dr. Graenicher of the recent advent of a number of individuals of a bird previously unknown in the region. Again the description given would about equally well fit either the Mockingbird or the Solitaire.

Somewhat militating against the possibility of either of these reports being based on the Solitaire is the season of the year involved. Its breeding season should be passed in the Boreal Zone except that in Mexico the mountains that it frequents for this purpose are within the Transition Zone.

Milwaukee, December 27, 1911.

A CONTRIBUTION TO THE NATURAL HISTORY OF THE AMPHIPOD, *HYALELLA KNICKERBOCKERI* (BATE).

HARTLEY H. T. JACKSON.

INTRODUCTION.

The facts set forth in this paper result from experiments performed in the Zoological Laboratory of the University of Wisconsin and from observations made in various lakes and streams in Wisconsin. The original aim was an extensive investigation of the life history, behavior, habits and ecology of *Hyalella*, and a comparison of its activities with those of salt-water and land amphipods. The present paper, however, falls far short of this. The study was interrupted in February, 1910, by my moving to Washington, D. C., where material for the work was not available, *Hyalella* being notably absent in that region. Two efforts were made to import cultures from Wisconsin, but in each case without success. The study was undertaken at the suggestion of Dr. S. J. Holmes, to whom I wish to acknowledge my appreciation for kind criticisms pertaining to the work. I also wish to express my appreciation of courtesies received from Professor George Wagner.

Although *Hyalella knickerbockeri* is a common and widely dispersed species, comparatively little has been written concerning its general life history. Holmes ('02) contributed a brief paper upon the habits of *Hyalella*, and in two other papers ('01,B; '03) he discussed their phototactic reactions and their method of sex recognition. These three papers contain practically all that has been written concerning the habits of this species in particular, though considerable work has been done upon the behavior of amphipods in general, the results of which are in many cases applicable also to *Hyalella*. In this connection I might mention the papers of Della Valle ('93), Gerstaecker ('01), Holmes ('01,A), and Smallwood ('03, '05).

DISTRIBUTION AND HABITS.

Hyalella knickerbockeri is found throughout the United States, from Maine to California and Mexico, and from Florida to

Oregon; it also occurs in Southern Canada. In the southern parts of Minnesota, Wisconsin and Michigan, in the northern parts of Illinois and Indiana, and in Iowa it is excessively abundant. It is also plentiful in many of the shallower lakes of Northern Wisconsin and Minnesota. Adams ('09) reports it from Isle Royale, Lake Superior, and Weckel ('10) extends its range to Lake Titicaca, Peru, where it was taken abundantly "underneath small rocks along the shore of Isle Planca (near Puno)."

This species is a littoral form and is seldom found where the water is more than eight feet deep. As far as I am aware it is strictly a fresh water form, and is found in great abundance in lakes and ponds which retain their water throughout the year and which have a bottom of muck and a dense growth of vegetation, especially ceratophyllum and algæ. *Hyalellæ* do not take well to areas where the bottom is sandy, the individuals here being few in number.*

Hyalellæ are frequently found in rivers and creeks, if the temperature of the water is not too low nor the current too swift; sluggish, muddy streams, with vegetative growth are quite certain to contain them in abundance. Near Monroe, Wisconsin, in a little rivulet fed largely by springs, where the water was constantly very cold, and where there was apparently nothing favorable to their welfare, I found *Hyalellæ* very abundant; a species of *Gammarus* was here present in considerable numbers in the same habitat with them. Many such streams in various parts of Wisconsin have been examined and although *Hyalellæ* are usually present in small numbers in such a habitat, it is the exception when they are abundant.

COLOR.

Hyalella knickerbockeri is a most variable species in regard to color. Not only are varying shades of the same color found, but an entirely different color and a different arrangement of pigment are met with in each individual to such an extent that it is

* Shelford (1911) in his studies of ponds at the head of Lake Michigan found *Hyalellæ* more common in the new ponds than in the old ones; in other words, he found them negatively associated with muck, humus and vegetation. This is directly contrary to my observations, and is also directly contrary to what we might expect from our knowledge of the behavior of *Hyallellæa*, they being decidedly negatively phototatic and positively thigmotactic. But it is a curious fact that nearly all specimens taken in such a habitat average unusually large.

difficult to select specimens which are similar to each other in color and pattern unless a very large number are examined. The predominant shade of color seems to be light brown or some shade of green; others may be distinctly bluish, dark purple, dark brown, while a very few have a reddish tint. Older animals appear to have more uniformity of color, a large number being light brown, but even here there is considerable variation. This tendency towards a brown color in adults is probably due to the thickening of the cuticle which then obscures the underlying pigment. There is also a tendency for the animals to assume a light brown color preceding the molt, due to the loosening of the cuticle from the body wall, an effect quite similar to a thickened cuticle. I was at first inclined to believe that the green color of some individuals was due principally to chlorophyl—-containing algæ in the digestive tract. This is true to a certain extent; among several light brown individuals, which were isolated and fed upon green algæ, were two which acquired a green shade of coloration. However, many green *Hyalellæ* were isolated, some of which were starved, others were fed upon nonchlorophyl-containing matter; and all of these animals still retained their green color after several days of isolation. Careful examination of sections of these showed the alimentary tract to be free from chlorophyll, the green color being due to pigment in the hypodermis.

SIZE.

The largest specimen of this species which I have seen measured 7.6 millimeters in length. The average length of adult specimens is considerably less than this, the majority having a length between 5.2 millimeters and 6.5 millimeters. The females average somewhat shorter than the males. The depth and width of the females are proportionately to the length greater than in the males. I measured a number of each sex and found the depth to vary from 15.8% to 23.3% of the length. The males had a depth varying from 15.8% to 21.2% of the length; the females a depth varying from 18.1% to 23.3% of the length. The average depth of the males was 18.4% of the length; the average depth of the females was 20.9% of the length. These measurements were taken through the deepest part of the thorax.

MOLTING.

The molting process in amphipods has been described by several writers, more recently by Holmes ('01,A) for *Amphithoe longimana,* and by Smallwood ('03, '05) for *Talorchestia longicornis* and *Orchestia palustris.* The method of molting in amphipods seems to be quite similar in all species. In *Hyalella* a transverse dorsal split occurs usually between the first and second segments of the mesosome and extends about half way around the animal; this split at times, however, occurs between the head and the first mesosomic segment. Previous to this splitting the skin seems to loosen from the body. The head is now pulled backward out of the hood, and the animal then pulls itself from the loosened body cuticle. Occasionally a longitudinal split occurs along either side or both sides; this is not usual and when it occurs it is generally caused by the extra muscular effort of the animal in withdrawing the body from the skin after the head has been freed; in no case did I observe it to occur at the beginning of the molt such as Holmes ('01,A) observed in *Amphithoe longimana.*

Hyalellæ do not eat their molted skins, a fact which considerably lessens the difficulties in studying their molting. Thirty *Hyalellæ* were isolated during the spring and their molts counted twice a day for a period of thirty-five days; during the autumn twenty-six others were isolated and observations continued for a period of forty days. Most of them were isolated each in a small glass dish in which were placed stones, muck and algæ to reproduce as nearly as possible their natural habitat. Some were isolated without food to determine if possible the effect of lack of nutrition upon the time of molting; but results here were not satisfactory, the animals dying before a sufficient number of observations could be made. However, as long as the *Hyalellæ* lived without food, molting occurred with about the same frequency as in nourished animals. Sex or age have little influence upon the number of molts. The conclusions in regard to age may not be absolutely correct, because, in judging the age of an individual, relative size was largely the criterion employed. It may be that the season of the year affects the rapidity of the molting under natural conditions, but it did not influence appreciably the molting period of individuals kept in the laboratory. A total of one hundred twenty-five molts, and ninety-one intervals between molts were noted. The number of intervals of any given duration can be easily determined from the "Table of Observations upon Molting."

Of the twelve specimens which retained a cuticle for a period of more than twelve days only three survived. Most of the animals that died on account of delayed molting did so within a few hours after the molt was completed; three died during the molting and one lived four days after the molt. Four individuals which molted respectively in twenty-two hours, three days, four days and five days, each died shortly after the molt was completed. The one which molted in twenty-two hours is interesting. This *Hyalella* was isolated October 20th;

TABLE OF OBSERVATIONS UPON MOLTING.

	Age and Sex.	Intervals (in Days) Between Molts.				Number of Molts.	REMARKS.
Autumn Observations.	ad. ♂	21	9			3	
	ad. ♀	15				2	Died three hours after second molt.
	ad. ♀	12	8			3	
	yg. ♂	9	3			3	Died about eight hours after third molt.
	ad. ♂	10	9	8		4	
	ad. ♀	22	hrs.	8		2	Died two days after second molt.
	ad. ♀	10	6	9	8	5	
	ad. ♂	8	8	8		4	
	ad. ♂	9	9	9		4	
	yg. ♂	9	8	9		4	
	ad. ♀	8	9	11		4	
	ad. ♀	8	8	8		4	
	yg. ♀	12	10			3	
	ad. ♀	11	14			3	Died two days after third molt.
	ad. ♂	14	10			3	
	yg. ♀	8	10			3	
	ad. ♂	9	10	9		4	
	ad. ♀	8	13			3	Died four days after third molt.
	ad. ♂	11	10			3	
	ad. ♀	10	10			3	
	ad. ♂	17				1	Died in process of second molt.
	ad. ♀	19				2	Died six hours after second molt.
	ad. ♀	9	9	9		4	
	ad. ♂	8	11			3	
	ad. ♂	28				1	Died in process of second molt.

Spring Observations.	ad. ♀	9	9	8	5	5	Died in less than one day after 5th molt.
	ad. ♂	8	8	8		4	
	ad. ♀	9	8	9		4	
	yg. ♀	10	9	7		4	
	ad. ♂	10	16			2	Died in process of third molt.
	yg. ♂	34				2	Died four hours after second molt.
	yg. ♀	22				2	Died one day after second molt.
	ad. ♂	7	8	8	4	5	Died six hours after fifth molt.
	ad. ♀	12	11			3	
	yg. ♀	8	7	9		4	
	ad. ♂	10	6	8		4	
	ad. ♂	10	11	10		4	
	ad. ♀	8	9	8		4	
	ad. ♀	35				0	Lived thirty-five days without molting.

it was observed molting the next morning (October 21st) and at 9:55 A. M. the molt was completed. The molted skin was removed from the dish. The next day (October 22nd) at 8:00 A. M. the animal had completed another molt. It is difficult to conceive that the hypodermal cells could secrete a new cuticle in twenty-two hours, and in all probability the third cuticle was nearly complete, if not complete, before the first cuticle was shed. The molted skin was carefully examined, but appeared normal in every respect. Two days later the animal died. The time of the molt depends indirectly upon the activity of the hypodermal cells. Death occurs most frequently during the molting process when the molt is either premature or delayed. This being the case, is it not possible that death at the time of the molting is due to an unhealthy or a parasitized condition of the animal rather than to the actual effects of the molting?

BREEDING.

Hyalellæ breed more or less during the entire year, but naturally their period of greatest reproduction is during the summer months. This can quite readily be ascertained by the number of males carrying females, and by the number of young present in their natural habitat. The male carries the female until she molts; during the molting of the female the male releases her, but takes her again soon after the molt is completed. It is then that copulation takes place. The male may continue to carry the female for several hours, or even days; or he may release her almost immediately after copulation. The eggs are passed into the egg sac, as nearly as I can observe, within an hour or an hour and a half after copulation. I have not determined definitely the length of time they are in the sac before hatching. I succeeded in carrying only one pair through complete breeding experiments and here my observations were in many ways incomplete. This pair was isolated April 21st, at 3:00 P. M. in a glass dish in which were stones, mud and algæ, the water in the dish being a trifle over an inch deep. The male was carrying the female at the time of isolation, and continued to carry her until the next day, April 22nd, when he released her at 11:40 A. M. Between 12:10 P. M. and 2:00 P. M. the female molted. I was not present during her molting, but when I returned at 2:00 P. M. she had completed it, and was inactive, clinging to the algæ. Twelve minutes later the male found her, by his usual hit or miss method, and carried her until 2:21 P. M. He then again released her but took her up again at 2:27 P. M.; he carried her until 2:55 P. M., and as nearly as I could judge, copulation took place between 2:40 and 2:55 P. M. About an hour later the eggs were deposited into the sac, and at 4:10 P. M. the male again carried the female. He continued to carry her intermittently until April 30th; sometime between this date and the morning of May 3rd he died. Most of the time, while the eggs were in the sac, the female was very inactive, hiding among the algæ or under stones. Eggs were still in the sac May 11th at 10:00 A. M., but on the morning of May 17th the young had left the pouch and were swimming in the water. From these observations we see that the eggs were in the pouch twenty-five days, at least, before they hatched. After the young had left the pouch, the mother seemed less positively thigmotactic than usual, and in reality was more negatively sensitive to contact stimuli than were males. This period of excitability lasted for four or five days, when she gradually assumed her normal condition.

FOOD AND FEEDING.

Hyalellæ in their natural habitat feed almost entirely upon protozoa, and unicellular and filamentous algæ; they also eat *Ceratophyllum* to a small extent. Although they are often abundant where *Potamogeton* is growing, I have never discovered them feeding upon it, nor have I been able to induce isolated specimens to eat it. Their method of feeding is peculiar; they pasture as it were upon the substance they are feeding upon, crawling along the main stem of the plant and cleaning the branches of food by gnawing it away as they progress. Thus they may have more or less of a symbiotic relation to the plants upon which they feed. In detecting their food they depend largely upon chance collisions with it. When an animal comes in contact with a food particle the antennæ immediately wave to and fro and finally rub against the object. The food is then grasped in the gnathopods and eaten. An animal may detect food without coming into direct contact with it, but it never detects food at any considerable distance, twice the length of the first antenna being the maximum distance observed. When their hunger is satisfied, they crawl in among the branches of the plant, or in the mud, remaining quiet, unless disturbed, until hunger drives them to activity for obtaining food again. Excepting protozoa, animal matter is probably not taken as a regular diet in their natural habitat, but they will eat it occasionally. If a piece of raw beef is dropped into an aquarium containing *Hyalellæ,* it is but a few minutes before several of them will be found eating it. They act similarly with a piece of raw fish, though not to such a marked degree as with beef. Or if a portion of another *Hyalella* is offered them on the point of a needle, they will frequently display cannabilism and will eat from the offered morsel. Decayed flesh, which is a favorite diet of many other crustacea, does not appear to be relished by *Hyalellæ.* They make no attempt to capture prey, and probably they would be unable to succeed if they did attempt it. Animal food other than protozoa, probably enters into their diet only when they chance to encounter freshly killed flesh.

ENEMIES.

Fishes, birds, and predacious insects include all the enemies of *Hyalella.* They form an important article in the food supply of certain ducks and shore-birds (*Anseres* and *Limicolae*) and of several fishes belonging to widely separated families. Of ducks, the Shoveller, *Spatula clypeata* (Linn.), is the principal enemy and it consumes large numbers of aquatic amphipods, a majority of which are *Hyalellæ* since it feeds almost entirely in the shallow waters of inland lakes and marshes. Forbes ('88, pp. 486 and 527) in a summary of the results of his studies upon the food of fishes gives a list of the species he found which had fed upon *Allorchestis dentata* (synonymous with *Hyalella knickerbocker*). Out of twelve hundred and twenty-one fishes, belonging to eighty-seven species of sixty-three genera and twenty-five families which he examined at intervals from 1876 to 1887 in various months from April to November, he found the following which had eaten this amphipod: a single white bass, eleven of the common perch, one of the largest darters, five young black bass, seventeen sunfishes of various species, one rock bass, one pirate perch, one grass pickerel, six top minnows and two of the true minnows, two of the suckers, seventeen catfishes,—mostly young or of the smallest species, one dog fish and one spoon-bill (*Polyodon*). It will be seen from these statements that over 5% of all the fish which Forbes examined had eaten *Hyalellæ*. To this list of fishes I may add our common stickle-back. Six of these which I examined from Storr's Lake near Milton, Wisconsin, had in each of their stomachs from one to four *Hyalellæ*. Two stickle-backs from Lake Mendota, which I kept in the laboratory, seemed to prefer *Hyalellæ* to almost any other food which I could give them. Miller's thumbs (*Cottus*) are also known to feed upon *Hyalellæ*, but their habitat is so different from that of the amphipod that they cannot be considered a serious enemy. Of the insect enemies mention may be made of the various species, both imagoes and larvæ, belonging to the genera *Ranatra, Belostoma,* and *Dytiscus,* and the nymphs of dragonflies (*Odonata*).

LOCOMOTION.

There are two distinct methods of locomotion in Hyalellas: crawling and swimming. When they are taken from the water and made to crawl upon a smooth surface, free from objects which they can grasp, they are very awkward; they assume a position with the head and the urosome bent ventrally beneath the body; the mid-dorsal line of the mesosome and metasome form more or less of an arc of about 110 degrees; the weight of the body rests principally upon the fifth, sixth and seventh peræopods and upon the gnathopods; movement is brought about to a certain extent by means of the third and fourth pairs of peræopods which are used as walking legs, but more by the extension of the abdomen; with the uropods braced against the surface upon which the amphipod crawls, an extension of the abdomen results in a very crude leap forward. During the entire operation the pleopods are in constant motion, as they are in fact during most of the life of the animal. A modification of this method of locomotion is sometimes resorted to by animals in the aquarium: the appendages rest against the surface as before and, upon extending the abdomen, the animal is able to leap through the water a distance of one to two inches. The constant movements of the pleopods aid here, and this means of locomotion is in reality a combination between crawling on a smooth plane and swimming. When the amphipod crawls among objects the body is not so flexed; the first antennæ are extended, the second are employed to feel the way and occasionally to pull the animal along; with the gnathopods, chiefly the second pair, the animal grasps objects and pulls itself forward; the third to the seventh peræopods have the same function as when it crawls on a smooth surface; the uropods push against objects in the rear. It is this method of locomotion to which *Hyalellæ* most frequently resort in their natural habitat. They seldom swim in the daylight unless disturbed and then generally for only a short distance. At night they are more active and may be seen swimming everywhere in their habitat. Swimming is effected by the constant motion of the pleopods and the occasional extension of the abdomen. They swim in a series of undulations lying in a vertical plane. The convexity of the body tends to cause the animal to swim in a circle with the dorsal surface of the body outward. This effect is counterbalanced by the beating of the pleopods on the concave ventral surface. The result is that with each beat of the pleopods the anterior end of the animal is elevated, but, during the progression immediately following, the line of direction curves downward, due to the curvature of the body.

THIGMOTAXIS.

This species, like the majority of amphipods, is strongly thigmotactic. Its reaction to contact stimuli is shown in many ways. If a number of *Hyalella* are placed in water in a glass jar where there are no weeds, stones, or other objects, they at first appear restless, swim around, and finally come to rest in the angles of the jar where the greatest amount of their body surface can be in contact with the glass, or they may come to rest curled up in the surface film, the surface tension then producing the contact stimulus. In their natural habitat their thigmotactic tendencies are exhibited in the manner in which they crawl among the objects; they will crawl into algæ or mud until the entire body is in contact, the antennæ in the meantime protruding into the water.

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U. S. Department of Agriculture,
Washington, D. C., February 5, 1912.

DATA FROM EXPERIMENTS ON PARTHENOGENETIC ANIMALS.

BY NATHAN FASTEN.

A. HISTORICAL

The problem of parthenogenesis has long puzzled the minds of naturalists. The Greeks, with their wonderful insight and philosophical bent of mind, early turned their attention to nature, and were the first to record cases of such development among animals. Aristotle, in his "Historia animalium," and "De Generatione animalium," tells us of parthenogenetic reproduction amongst the insects. In the "De Generatione animalium," he speaks of the development of the honey bee in the following way: "The drones develop in a queenless stock," and further on he adds, "The bees produce drones without copulation."—Apparently this was overlooked for many centuries.

The Renaissance brought a flood of oriental culture to the European continent. The philosophy of Aristotle now began to influence the minds of thinking men. Interest in nature was renewed, and in the seventeenth century, the facts concerning parthenogenesis were brought to light again.

Goedart, in 1667, published his observations on the parthenogenetic development of "*Orgyia gonastigma.*" Immediately, the attention of naturalists was aroused, and very shortly after this we find such students as Leeuwenboek (1695), Blanchard (1696), Albrecht (1706) and Reaumur (1737) all working along similar lines.

In 1745, Bonnet published a rather full account of parthenogenesis in the plant lice. His experiments showed careful and painstaking observations and they attracted the attention of many brilliant investigators.

The most important work on the subject, however, has been done within comparatively recent years. Dzierzon, in 1845, produced his now famous results on the parthenogenetic development of the unfertilized eggs of the common bee, *"Apis mellifica,"* and this may be said to mark the beginning of all modern investigation into the problem. His work is extremely interesting from the standpoint of sex determination, for it has stimulated more experimentation on the subject than any of the researches of his predecessors. Concerning his theory more will be stated in our discussion of the individual parthenogenetic groups.

With this short sketch of the subject, let us now turn to a more direct discussion of parthenogenesis.

The word parthenogenesis is derived from the Greek, and its literal translation is, "a virgin production." The word was first used by Owen in 1849, in the sense of alternation of generations. Ernst von Siebold, on the other hand, in 1856, applied the term parthenogenesis to the development of eggs without fertilization, and this latter definition is the one universally in vogue among zoologists today.

Broadly speaking, parthenogenesis may be classified into,

1. NATURAL PARTHENOGENSIS, where parthenogenetic development occurs as a part of the normal life-history of the species, and

2. ARTIFICAL PARTHENOGENESIS, where development occurs through an artificial stimulus, either chemical or physical.

The wonderful progress that has been made within recent years along the line of artificial parthenogenesis, has disclosed many facts concerning the mechanics of fertilization and of development. Natural parthenogenesis, on the other hand, has given us direct insight into the difficult problem of sex. With this phase of the subject I wish to deal rather fully.

B. NATURAL PARTHENOGENSIS.

The most frequent form of natural parthenogenesis occurs in those species where parthenogenetic generations alternate with sexual ones. In all such cases, the progeny produced from parthenogenetic eggs may be males as well as females, whereas the offspring produced from fertilized eggs are all females.

In many species, on the other hand, no alternation of generation exists. Here, all the fertilized eggs produce individuals of one sex, the female as a rule, whereas the unfertilized eggs produce individuals of the opposite sex.

Natural parthenogenesis may be said to be wholly confined to the invertebrate groups of animals, mainly the Rotifers, Crustaceans, and the Insects.—But Hertwig, Morgan and others, have also cited interesting instances of such partial development among the lower groups of backboned animals. These cases, however, have been seriously questioned by many workers, as will become evident from our later discussion of the subject.

1. Parthenogenesis among Vertebrates.

The eggs of many vertebrate animals show a tendency to divide when not fertilized. Such cases have been observed in the eggs of *Amphioxus,* the Trout, the Sturgeon, and in many of the *Amphibia,* including the Frog. In this last named case, Pflüger showed that there is no actual parthenogenetic segmentation, but that the egg divided under the influence of spermatozoa whose vitality was almost entirely lost through floating about in the water.

In the birds we get examples of parthenogenetic segmentation, and often a blastoderm develops from what seems to be an unfertilized egg. Barfurth, however, showed that in these cases also, segmentation is not brought about parthenogenetically, but through fertilization by a spermatozoon whose vitality has been almost wholly destroyed.

It is thus seen, that all cases of natural parthenogenesis among the Vertebrates, must be looked upon with a great deal of skepticism, unless we are presented with more substantial evidence. It seems probable, however, that parthenogenesis may be induced through chemico-physical means, as has been shown by the recent work of Bataillon on the frog's eggs.

2. Parthenogenesis among the Invertebrates.

A. Rotifers. Cohn in 1856, was the first to note cases of parthenogenesis amongst the Rotifers. He found that the winter eggs were fertilized, producing females only, whereas the summer eggs developed without fertilization, giving rise to males and females (each parthenogenetic individual is capable of producing eggs developed without fertilization, giving use to males and eggs of but one sex, and not both). Among the Crustaceans and some of the Insects we meet with a similar state of affairs.

Recently, interest has chiefly centered on the experiments carried on with the Rotifier, *Hydatina senta.* In this case the method of reproduction seems to be influenced by external conditions.

Maupas, ('90) noted that when cold weather set in, the sexual cycle appeared, and he came to the conclusion that temperature regulated the parthenogenetic and sexual phases of reproduction.

Nussbaum ('97), stated that these two cycles were controlled by the food supply of the surrounding medium. When cold weather arrives, most of the food is killed off, and the sexual cycle makes its appearance. In summer, food is plentiful and then *Hydatina* continues its reproduction through parthenogenesis.

Punnet ('06), and Whitney ('07), in an extended series of experiments, in which they subjected Rotifers to different conditions of food and temperature, failed to confirm the conclusions of either of these investigators.

Shull ('09, '10), claims that the presence or absence of certain chemicals in the environmental medium of the rotifer is the cause for the appearance of one or the other modes of reproduction. The presence of these chemicals induces parthenogenesis, their absence causes the sexual cycle to appear.

Whitney ('10), partially confirmed Shull's results. From his experiments he concluded that chemical substances produced in the culture medium of Rotifers so affect the parthenogenetic females as to cause them to produce sexual daughter females. When these chemical substances are absent, no sexual females are produced, but only parthenogenetic forms.

Whitney and Shull both believe that external conditions are accountable for variations in the sexual and parthenogenetic cycles. The former worker, however, is of the belief that there are certain transitory chemical substances in the culture medium of Rotifers, which directly affect the parthenogenetic females, and cause them to develop sexual daughter females, whereas Shull believes that the chemicals may act indirectly, by interfering with certain internal factors of the organism, that account for the appearance of the male producing forms.

In some of his more recent investigations, Shull ('11, '12) definitely asserts that the production of parthenogenetic females, as well as sexual forms, depends on internal factors of the organism, and that these internal factors may be indirectly affected by conditions of temperature, food, and chemicals, so as to give rise to one or the other cycle. Shull thus puts himself in line with those who adhere to Woltereck's point of view.

All these experiments tend to show pretty conclusively that the method of reproduction depends, to a large extent, on conditions surrounding the organism.

B. Crustaceans.—Among the lower groups of Crustaceans we find a number of interesting cases of parthenogenesis. Recently, investigators have concerned themselves mainly with the *Daphniæ* in which an alternation between parthenogenetic and sexual forms is clearly discernible, producing in the first case males as well as females, and in the second case females only.

The winter eggs produce females in the spring, and these deposit eggs that develop without fertilization. This mode of reproduction continues throughout the summer months, only ceasing in the fall, when unfavorable conditions prevail. Now eggs are laid from which males and females are produced. These copulate to form the winter eggs, from which the parthenogenetic females arise the following spring.

It is rather questionable whether maleness or femaleness is brought about through the influence of external conditions. There is very strong evidence against any such contention. However, from recent investigation we can assert with definiteness that the two different modes of development are brought about by changes in the environment.

Kurz, from his work on Daphnias, concludes that the sexual phase sets in when the waters become scarce or when they become stale.

Issakowitsch, on the other hand, believes that the sexual cycle is brought about through a reduction of the food supply, caused by the decrease in temperature. In summer there is an abundance of food and the Daphnias then develop parthenogenetically. When winter approaches, the food is reduced enormously, and the sexual process makes its appearance.

Other workers, such as McClendon ('10), Papanicolau ('10), and Woltereck ('11), on the other hand, are of the opinion that the environment does not directly account for the appearance of these different cycles of development, but that the sexual and parthenogenetic phases are the results of internal factors within the organism. Environmental conditions may, however, act indirectly, and so interfere with the internal factors of the organism as to bring about a change in its life cycle. Woltereck ('11), is the strongest adherent of this viewpoint. This investigator claims that the proportion of parthenogenetic males and parthenogenetic females produced in *Daphnia* may be influenced by external conditions. He says that each egg has an inner mechanism of causes, or specific sex substances, which determines the sex. This mechanism of causes is not dependent on the equipment of the eggs with either plasma substances, or with heterochromosomes, but acts independently. Exterior conditions (such as temperature, food, chemicals, etc.), may sometimes, through their action on the inner mechanism of causes, have a distinct effect on the developed ovarial eggs, as well as on the eggs to be formed in the future. These specific sex substances (mechanism of causes) must be looked upon as ferment-like bodies, depending to a large extent upon external conditions for activation. The activation of one substance during the maturity of the egg accounts for the production of one sex, whereas the activation of another substance accounts for the other sex.

In the face of all this evidence, Weismann dogmatically asserts that external factors have almost nothing to do with the appearance of the sexual cycle. According to him, this phase in the life history can only be accounted for on the grounds of internal factors of the organism, which are the outcome of natural selection. Weismann says, "The organism is so constituted that it reproduces sexually at the proper time, and it is to a certain degree a matter of no consequence what external conditions exist at that time, so long as they are not of a sort to interfere very materially with the process of assimilation, or to threaten the life of the individual."

C. Insects.—Various groups of insects disclose striking examples of parthenogenesis. Perhaps the most interesting cases are found among the bees, ants, saw-flies, aphids, and *Phylloxera.*

In the bees, ants, and saw-flies, parthenogenetic eggs give rise to male individuals only, whereas, females are produced through fertilization. Undoubtedly, the cases of the bees and ants are the most familiar. Let us consider them more fully.

(1). *Bees and Ants.* Five days after pupation, the queen bee generally leaves the hive and takes the "nuptial flight," in order to meet the male. Copulation occurs in the air, and the sperm become stored in the spermatheca of the female. When the ova are mature, they are passed out of the oviducts and are fertilized by the spermatozoa stocked in the queen's receptacle. In the case of old females, where the sperm has been all used up, and also in cases where the queens have not been fertilized, only unfertilized eggs are laid. Thus, two types of eggs are produced, those that have been fertilized and those that have not received the sperm.

The queen now deposits the fertilized eggs into the queen and worker chambers, while the parthenogenetic eggs she places into the drone compartments. From the former, fertile and infertile females arise, whereas, the latter eggs develop into drones. In the Ants, the development of the queens, workers and males is exactly similar to the Bees.

Johannes Dzierzon was the first investigator to observe parthenogenesis among the bees. He was a careful worker and showed that the eggs of the queen, when they come to maturity in the ovary, are, from all outward appearances, identical, and that their subsequent development into males or females depends wholly on the fact of their being fertilized, or their not being fertilized. Based on these observations, in 1845, he announced the theory, now classic, that the unfertilized eggs develop into males, whereas those that have been fertilized, produce either queens (fertile females) or workers (unfertile females). In other words, the sex is determined by fertilization.

In order to test his hypothesis, Dzierzon carried on a series of experiments, in which he crossed two races of different bees. According to his contention, the males produced from such a cross ought to resemble the mother, since they come from eggs that were not fertilized, while all the females ought to be hybrids. The results he obtained substantiated his theory. For instance, he crossed the virgin Italian queen bee with German drones. The males of the resulting progeny, all looked like the Italian males, whereas the females were hybrid in character. Many other investigators working with Ants as well as with Bees have also been able to confirm this hypothesis.

A few exceptions, however, are not wanting. Even Dzierzon himself found a case that apparently contradicted his contention, and this almost made him retract his former conclusion.

Perez, in 1878, crossed Italian queens with French males, and found that a few of the resulting drones resembled the French males. Although this seems a serious objection, still a great many workers are suspicious that the female with which Perez worked may have been a hybrid, and not an absolutely pure type, as he claimed it to be.

Landois, in 1867, thought he found facts that would overthrow Dzierzon's hypothesis. He placed worker eggs into drone cells, and according to him, drones were produced. On the other hand, when he placed drone eggs into worker cells, the resulting bees were seemingly all workers. He therefore concluded that the sex of the resulting individual was wholly dependent on the amount of nutrition.

Sanson and Bastion, in 1868, repeated Londois' experiments, and they showed that whenever eggs were artificially transferred from one cell to the other, the workers would always destroy these, and clean out the compartment. The queen would then deposit the right kind of an egg into the clean cell, and the respective bee would thereby be hatched.

In the ant family also, a number of investigators have brought forth exceptions to Dzierzon's theory. Tanner (1893), Reichenbach (1909), and Mrs. Comstock (1903), have observed that in certain species (*Lasius niger, Atta*), the unfertilized eggs sometimes develop into workers.

More recently, F. M. Webster ('09), and S. J. Hunter ('09), on experiments with parthenogenetic eggs of *Lysiphlebus tritico,* a parasite on many Aphids, have brought forward data that appear to contradict Dzierzon's contention.

But in spite of these apparent exceptions, nearly all work on parthenogenetic development, amongst Hymenopterus insects, has confirmed the postulated view. However, as T. H. Morgan states it, "These cases serve as a warning not to insist with too much positiveness on the view that in the Bee unfertilized eggs always produce males, since they show that exceptions to such a rule may sometimes occur."

(2). *Aphids and Phylloxera.* In the Aphids and *Phylloxera* we may likewise get parthenogenetic as well as fertilized eggs from the same female. The parthenogenetic eggs here give rise to males as well as to females, while the fertilized eggs produce females only.

Leeuwenhoek, in 1695, and Reaumur in 1737, were the first investigators to observe cases of parthenogenesis among the Aphids.

In the summer the Aphids produce generation after generation of wingless parthenogentic females. When the fall approaches, a generation of winged males, and wingless females appear. After copulation, the females deposit, each, a number of winter eggs on the plant food, and from these, females arise during the spring, and lay parthenogenetic eggs. These develop and start the summer broods.

Bonnet, in 1745, transferred Rose aphids to a green house before cold weather set in, and he observed nine generations of continuous parthenogenetic multiplication. Duval, observed eleven such generations in seven months. Kyber, in 1815, kept Aphids in a green house for four years, and found that all the individuals reproduced parthenogenetically, not a single case of sex-multiplication being discernible.

All these facts seem to point to the conclusion that the change of temperature is the cause for the sexual cycle. Morgan, however, by subjecting Aphids to various changes of warmth and cold, was unable to induce a corresponding change in the mode of reproduction. On closer study Morgan found that a great many individuals do not change from a parthenogenetic to a sexual cycle when cold weather sets in, but that they perish. He also observed that those on the younger branches with new leaves, are the ones that suffer least from changed conditions. Morgan therefore maintains that the amount of food and water may perhaps be responsible for the changes in the process of reproduction.

In some Aphids and in many of the *Phylloxera,* the life-cycle is even more complicated. Generally the parthenogenetic and the sexual modes of reproduction alternate between two plants. Let us, for instance, consider the case of the Aphid *Hormaphis hamamelidis* which alternates between the red birch and the witch hazel. The fertilized eggs are deposited on the witch hazel during the fall, and here they remain through the winter. In the spring, these hatch about a week before the leaves appear, and immediately the young collect on the buds. When the leaves are formed, the Aphids settle on their under side, and form galls in *which are produced many young.* These undergo four moults, become winged, and leave the galls in June. Each contains about fifty embryos.

The Aphids next fly to birch trees, and deposit their embryos on the under side of the leaves. These undergo four moults and form galls that are flattened in appearance. Soon development occurs, and from the galls there emerge young that are exactly similar in appearance to the forms from which they were derived. This last group produces another generation of similar progeny, and these in turn give rise to young that return to the witch-hazel in August. It is of importance to note, that all of the above groups develop parthenogenetically. When the young arrive on the witch-hazel, they give birth to male and female Aphids, that pair, and deposit the winter eggs. During the following spring, females are produced, and these start the parthenegenetic cycle.

Many other Aphids and *Phylloxera,* show a similar complicated life-history. Doncaster notes, that in one species of *Phylloxera,* twenty-one distinct parthenogenetic forms may appear between one sexual cycle and the next.

Experimental evidence, thus far, has done very little toward explaining these complicated changes in the life-cycle.

3. Variation among Parthenogenetic Forms.

Weismann claimed that considerable range of variation occured where individuals were produced through a sexual process. Recent investigation, however, has disclosed the fact that there may be as much variability among parthenogenetic forms as in those producing sexually.

Warren ('96, '97, '02), found that in the Aphid *Hyalopterus trirhodus* and in the Crustacean *Daphnia,* the parthenogentic forms show a marked degree of variability.

Casteel and Phillips (1903), showed that the drones resulting from the unfertilized eggs are even more variable than the sexual females.

Kellogg ('03), has also produced some very interesting measurements in insects, which tend to show that variation among parthenogenetic forms is as well marked as in sexual individuals.

C: ARTIFICIAL PARTHENOGENESIS.

Professor Jaques Loeb may be said to be the pioneer in this field of experimental zoology. His work on artificial parthenogenesis, begun some twelve years ago, has given us a better insight into the problem of fertilization. Loeb, in 1899, succeeded in developing plutei from the fertilized eggs of the sea urchin, when the concentration of sea water was raised about forty to fifty per cent, through the addition of sugar or salt solutions. When the unfertilized eggs were put into a hypertonic solution of sea water, they shrunk, through loss of water, and underwent a process of development. However, no fertilization membrane was brought forth.

In another series of experiments, Loeb exposed unfertilized eggs of *Strongylocentrotus* to a mixture of sea water concentrated with a fatty acid, e. g. butyric, acetic, formic, or the like, (50 c. c. sea water plus 3 c. c. n/10 fatty acid), and after allowing them to remain in this solution for about a minute, he then transferred them to normal sea water, and almost immediately a fertilization membrane appeared. These eggs underwent but little development, and soon disintegrated. On the other hand, when the eggs were placed into a hypertonic solution of sea water, consisting of 100 c. c. of sea water to which 15 c. c. of 2½n. NaCl was added, and allowed to remain for about twenty-five minutes, nearly all of them, when transferred to normal sea water, underwent development. Some progressed as far as the blastula stage, while others developed to the gastrula phase, and a few developed into plutei.

The membrane was also called forth when sea urchins eggs were placed into sea water that was saturated with a hydrocarbon, such as chloroform, benzol, toluol, and the like. Unless the eggs are very shortly removed to a hypertonic medium of sea water, cytolysis sets in. If this is done, and the eggs, after being acted upon by the concentrated solution for about twenty-five minutes, are again transferred to normal sea water, many of them will develop into plutei.

The eggs of starfish, worms, and mollusks, when subjected to the same treatment, were also found to undergo partial development. The fertilization membrane was evoked in each case.

From these experiments it seems that either one of the following two conditions are necessary for bringing about the artificial parthenogenesis of eggs:

1. The cytolysis of the cortical layer of the egg, by means of which a protein membrane, which, in all probability is lipoidal in nature, is formed, and,

2. The action of various hypertonic salt solutions.

Loeb, in the starfish, showed that the formation of the yolk membrane, alone, was sufficient to cause the egg to develop a normal larva. He therefore regards the membrane formation as the essential thing in fertilization. Loeb, Edler, Mathews and others have shown that the yolk membrane in echinoderm eggs may be produced through irritation, as when *Asterias* eggs are touched or dropped into sea water, or through the blood of *Chætopterus* or *Sipunculus,* or through normal salts, or as has been recently shown by many investigators, through crosses between two different species of lower organisms. These last named crosses are commonly designated as "heterogeneous crosses."

It might be well at this point, to briefly summarize the various means that have been employed in securing artificial parthenogenesis. McClendon has grouped them as follows:

a. Hypotonic solutions (distilled water, Schücking).

b. Nearly isotonic solutions, made by adding to sea water, or to distilled water the following substances:

   Acids (Delage, Fischer, Herbst, Lefevre, Loeb, Lyon, Neilson, Schücking, Tennet).
   Alkalis (Delage, Loeb, Schücking).
   Neutral salts (Delage, Lillie).

c. Hypertonic solutions:

   Acids (Delage, Loeb).
   Alkalis (Delage, Loeb).
   Neutral salts (Bataillon, Bullot, Delage, Fischer, Hunter, Kostanecke, Loeb, Lyon, Mead, Scott, Treadwell, Wilson).
   Non electrolytes (Delage, Loeb).

d. Mechanical shock (Delage, Fischer, Mathews, Scott).

e. Thermal changes (Bataillon, Delage, Greeley, Lillie, Loeb, Schücking).

f. Electric changes (Delage, Schücking).

g. KCN or lack of oxygen (Loeb, Lyon, Mathews).

h. Fat solvents (Loeb, Mathews).

i. Alkaloids and glucisides (Hertwig, Loeb, Schücking, Wassilieff)

j. Blood sera (Bataillon, Loeb).

k. Soap and bile salts followed by hypertonic solutions (Loeb).

Let us now consider the question of heterogeneous crosses. Loeb crossed Echinoid eggs with *Asterias* sperm in a concentrated solution of sea water, and although the sperm entered the egg, it nevertheless was thrust out again during early development, seeming thus to contribute nothing to the developing embryo. But the thing of importance is that the mere contact between the egg and the sperm induced segmentation and the formation of the yolk membrane.

Loeb also crossed Echinoids with *Chlorostomen,* and more recently, Hagerdoon, working in the same laboratory as Loeb, produced crosses between *Strongylocentrotus* eggs and *Asterias* sperm.

Kupelweiser, Tennet, Godlewski, Baltzer and others, have carried on work along similar lines.

Godlewski ('06), crossed Echinoid eggs with sperm of Crinoids. Baltzer, in 1910, produced somewhat similar crosses. In 1911, Godlewski succeeded in producing crosses between Echinoderm eggs (*Sphærechinus, Strongylocentrotus,* etc.), with the sperm of the Annelid *Chætopterus,* and also with the sperm of the Mollusc *Dentalium.* He, for the first time, was also able to show, cytologically, that the sperm actually penetrated the egg.

Kupelweiser ('06, '09), crossed Echinoid eggs with *Mytilus* sperm, and Tennet ('10), successfully crossed the eggs of *Toxopneustes* with *Holothuria* sperm.

In all of the above cases the yolk membrane was called forth, but unless the eggs were transferred to a hypertonic solution of sea water, cytolysis sets in, and the eggs disintegrate. When the change to the concentrated medium is made, however, development proceeds to the gastrula and even to the pluteus stages.

Godlewski ('11), showed conclusively that although the sperm of *Chætopterus* actually enters the egg of the Echinoderm, it nevertheless plays no part in the development of the embryo, for it is thrown out very shortly after its entrance. Its action, probably, is similar to that of the acidulated sea water, tending to call forth the yolk membrane. These so called crosses may thus be said to be mere cases of artificial parthenogenesis; the foreign sperm acting like chemicals, as stimuli toward development.

This phase of experimental work is so young that one cannot speak with any certainty as to its probable fruitful disclosures within future years. The progress already made, however, makes one thing definitely certain, and that is that development is essentially a metabolic process, depending upon certain chemico-physical conditions of the female germ cell.

D. PARTHENOGENESIS AND SEX.

Nearly all investigators working on the problem of sex determination, are of the opinion that the sex of zygote is fixed at a very early period, and that it is not dependent upon environmental factors acting on the developing embryo. It is true that external influences may modify the structure of the resulting individuals considerably, but there has been no proof brought forward to show that the sex of a developing egg can be modified by environmental conditions. All that the experiments on parthenogenetic forms, such as those of Morgan, Shull, Whitney, and others have shown, is that the external conditions influence the methods of reproduction, in fact determine whether the parthenogenetic or the sexual cycle shall make its appearance.

The investigations described above all seem to point to the conclusion that sex is determined through fertilization, the spermatozoan carrying the determining factor.

This view has recently been substantiated by a considerable amount of careful investigation. McClung, Stevens, Morgan, Wilson, Payne and others have shown that in a great many Invertebrates, two kinds of spermatozoa are produced, differing from each other by one chromosome, or by a group of chromosomes, called the accessory, or the x-chromosome. All the eggs produced, on the other hand, contain this x-element (except in a few cases). In some forms, it was also found that the spermatozoa each contained an accessory chromosome, but that in half the sperm this chromosome was larger in its chromatin content than in the other half. These were respectively called the x and the y-elements.

It was then shown that a female was produced whenever an egg was fertilized by a sperm containing the x-chromosome, while a male resulted when an egg was fertilized by a sperm without the x-element, or by one containing the y-element.

In the Vertebrates, Guyer was the first to show the existence of an x-element, and other investigators have since brought forth similar evidence.

As already stated, this postulation of sex determination can be extended to parthenogenetic forms. In species producing by this method, the fertilized eggs always develop through parthenogenesis, although in some cases, as in *Daphnia, Aphis,* and *Hydatina,* both males and females may develop from the unfertilized eggs.

In the Aphids and *Phylloxera,* Morgan and Von Baer have shown that in the sexual phase, two types of sperm are produced, one-half containing the x-element, while the other half was without it. These investigators further showed that the portion of the spermatozoa without the accessory chromosome all die before coming to maturity, and on that account the male germ cells fertilizing the eggs all brought in an x-chromosome and thereby caused the production of females. Further investigation may show us that this is also the case in the bees and ants.

Light has been shed on the causes for the development of females and males from the parthenogenetic eggs. It has been found that in the cases where the unfertilized eggs produce females exclusively, one polar body is formed, while in the other cases, where males only are produced, two polar bodies appear. Castle's work showed that in the latter case the sex determinant is thrown out of the egg in the second polar division, whereas in the first case, it is retained within the germ cell.

Where males as well as females are produced from the parthenogenetic eggs, but one polar body is formed. Morgan's recent work on *Phylloxera* makes it quite certain that in half of these unfertilized eggs the sex determinant is thrust out with the formation of the polar body, while in the other half, the sex chromosome is retained. Males are therefore produced in the first case, and females in the second.

In spite of all the criticism that has recently been lodged against the chromosome theory of sex determination, still it may be stated with certainty, that it is the only plausible hypothesis that has given us enough evidence to warrant its acceptance. The facts already cited, make it evident that sex in parthenogenetic forms can be accounted for on the grounds of such an explanation. There is no positive evidence for the assumption that sex is determined by food, temperature, or other environmental factors surrounding the germ cell.

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THE CHALCIDOID FAMILY *TRICHOGRAMMATIDÆ*.

I. TABLES OF THE SUBFAMILIES AND GENERA AND REVISED CATALOGUE.

By A. A. Girault

I. INTRODUCTORY.

The family *Trichogrammatidæ* was first recognized as such by Arnold Foerster in 1856. Since that time it has held its identity. A half century later, Ashmead (1904a) recognized two subfamilies, founded upon the two groups of genera first outlined by Haliday in 1851. The family seems to be worthy of the rank attributed to it, although it is certainly a derivative of insects like the *Aphelininæ* of the *Eulophidæ* or some Aphelinine-like Eulophid. Certain of the genera bear a number of encyrtine characters but the assemblage of characters more nearly resembles those of the *Eulophidæ*. Indeed, are not the members of this family merely Eudophids which have lost one tarsal joint and which have other characters and habits giving them group distinctness?

The family seems to be of comparatively recent origin, more youthful than the Eulophids; no fossil species have been discovered; the species of such genera as are well known appear to be highly variable and still in process of formation, a criterion which I believe denotes comparative youthfulness; otherwise we should expect to find gaps between them. Moreover, minuteness is a characteristic of the group. The genera are also in many cases indistinct, bearing this out more conclusively. In a word, we appear to have here a natural group evolved from an Aphelinine-like ancestor and which is still evolving, not having as yet reached comparative stability*. Whether we call this group a family or subfamily matters not.

For the sake of clearness and convenience the family *Trichogrammatidæ* was divided by Ashmead (1904a) into two group-

* On the other hand, the group has been in existence long enough to develop parthenogenesis and both color and sexual dimorphism. There are no other Chalcidids known to have two structurally distinct male forms and this phenomenon is rare, if not absent, in all other Hymenopterous groups, excepting ants. It is therefore a special development. Parthenogenesis may be a persistence here. It is true, too, that great variability indicates old age but with this group it is not excessive.

ings of genera based on the discal ciliation of the fore wing. A glance at his arrangement shows such marked parallelism that the thought at once arises that these groups are not natural, since parallelism in a small group of this kind would scarcely have arisen. Divergence would fulfill the expectations, and, moreover, since discal ciliation of the fore wing is more variable (therefore less fundamental) than venation of the fore wing, I have concluded that a division based upon the latter would give us a more natural arrangement. Consequently, Ashmead's subdivisions have been rejected and others made which I believe more nearly attain the truth.

In August, 1910, I gave a summary of the number of valid genera and species of this family, then admitting fourteen genera and thirty-two species. Now, I reject two of these genera as synonyms—namely, *Pentharthron* Riley and *Westwoodella* Ashmead; but have described fifteen new genera and twenty new species. Perkins has added three more species and I have about three new genera and two dozen more new species described in manuscript*.

Thus the family now (December, 1911) consists of thirty genera and approximately seventy-five species and two varieties, fifty-six species described to date and admitted as valid and recognizable**.

II. REVISED TABLE OF THE TRICHOGRAMMATIDAE, BASED ON FEMALES.

Family *Trichogrammatidæ* Foerster.

Submarginal vein of fore wing reaching the costal wing margin at the point where it joins the marginal vein, the latter straight or nearly so, the stigmal vein forming more or less of an acute angle with it. Venation of fore wing straight.

* All Australian species. One genus belongs to the tribe *Trichogrammatini*; the species are not catalogued here. The genus mentioned is based on *Paratrichogramma cinderella* new genus and species and is characterized by bearing but a single funicle joint; the antennæ 5-jointed and otherwise as in *Trichogramma*; the venation is weak, the curved marginal vein shorter than the stigmal. The species *cinderella* is dusky yellowish, the antennæ and legs dusky or greyish black (proximal two tarsal joints, trochanters, knees and distal third of tibiæ white); caudal wings colorless; fore wings sooty out to riddle of the marginal vein, then clear, its venation colorless excepting the brownish stigmal vein and distal, clavate end of the submarginal. The genus and special will be fully described later, in a more proper place The male is not known.

** One new name is proposed in this paper because of preoccupation.

Subfamily I. *Chætostrichinæ* Girault.

Submarginal vein of fore wing not reaching the costal wing margin but joining directly with the incurved proximal end of the marginal vein, the latter curved, the distal end of the submarginal, the marginal and stigmal veins forming a regular sigma or arch whose apex is at about the middle of the marginal vein, where it reaches the costa; or the veins forming a regular bow at the marginal vein. Venation of fore wing curved.

This subfamily includes the following genera: *Chætostricha* Haliday, *Brachista* Haliday, *Oligosita* Haliday, *Centrobia* Foerster, *Lathromeris* Forester, *Ophioneurus* Ratzeburg, *Prestwichia* Lubbock, *Pterygogramma* Perkins, *Aphelinoidea* Girault, *Tumidiclava* Girault, *Abbella* Girault, *Zaga* Girault, *Uscana* Girault, *Ufens* Girault, *Ittys* Girault, *Japania* Girault, *Tumidifemur* Girault, *Uscanella* Girault, *Uscanoidea* Girault and *Brachistella* Girault. In order to facilitate recognition of the genera I have established the following tribes, none of which, however, appear to be natural groups. But I have reduced the value of the kind of discal ciliation to a generic basis.

Antennal funicle present—Tribe I. *Chætostrichini.*

Genera: *Brochista, Oligosita, Prestwichia, Chætostricha, Centrobia. Ittys, Abbella, Japania* and *Brochistella.*

Antennal funicle absent— Tribe II. *Lathromerini*

Genera: *Lathromeris, Ophioneurus, Pterygogramma, Aphelinoidea, Tumidiclava, Zaga, Uscana, Uscanaoidea, Uscanella* and *Tumidifemur.*

Table of the Genera of the *Chætostrichini.*

A. Ovipositor not exserted nor prominent, nor is its valves.

B. Antennæ 8-jointed.

C. Antennæ bearing two ring-joints, one funicle joint and a 3-jointed club. Fore wings broad, distad with long marginal cilia. **Brachista** Haliday (Type: *Brachystira pungens* Mayr).

CC. Antennæ bearing one ring joint, two funicle joints and a 3-jointed club.

D. Fore wings with the discal ciliation normal.

Fore wings moderate in width, the marginal cilia at apex moderately short; adbomen conic-ovate; pedicel of antennæ larger than funicle; stigmal vein nearly neckless.

Brachistella Girault (Type: *Trichogramma acuminatum* Ashmead).

DD. Fore wings with the discal ciliation arranged, more or less, in longitudinal lines.

E. Stigmal vein sessile or neckless; no oblique line of discal ciliation leading back from stigmal vein.
Discal ciliation of fore wing sparse, the marginal cilia long. Fore wings as in Oligosita; antennæ with the funicle joints wider than long. **Abbella** Girault (Type: *A. subflava* Girault).

EE. Stigmal vein with a short but distinct neck; an oblique line of discal cilia leading back from that vein.

F. Marginal vein of fore wing long, over twice the length of the comparatively long stigmal vein.
Antennæ long, distinctly segmented; ciliation of fore wings comparatively coarse; dense discally, those of the margin short; body large, robust, the abdomen conic-ovate. Fore wings regularly rounded at apex. Funicle joints of antennæ longer than wide. **Ittys** Girault (Type: *Trichogramma ceresarum* Ashmead).

FF. Marginal vein of fore wings short, only slightly longer than the stigmal vein.

G. Antennæ with the funicle apparently twisted and indistinctly divided obliquely, much larger than the pedicel; male antennæ with one more joint, differing in shape, cylindrical and clothed with long hairs; abdomen short, stout, obliquely truncate at apex. Fore wings short and broad, oblately rounded at apex, the discal ciliation bearing some peculiarly distinct lines; marginal ciliation of the fore wing very short; neck of stigmal vein not slender. **Ufens** Girault (Type: *Trichogramma nigrum* Ashmead).

GG. Antennæ with the funicle normal and shorter than the pedicel; male antennææ not differing in shape; abdomen longer than the thorax, conic-ovate; acute at apex; fore wings slender, without some of the lines of discal ciliation peculiarly distinct; convexly rounded at apex, the marginal ciliation moderately short neck of stigmal vein slender. **Japania** Girault (Type: *J. ovi* Girault).

BB. Antennæ 7-jointed; discal ciliation of the fore wing sparse and more normal than otherwise.
Fore wings slender, with long marginal cilia, the marginal vein long; antennæ with one funicle joint and one ring joint, slender, distinctly segmented; stigmal vein subsessile; abdomen long, conic-ovate. **Oligosita** Haliday (Type: *O. collina* Haliday).

BBB. Antennæ 6-jointed; discal ciliation of the fore wing dense and arranged in regular longitudinal lines.
Fore wings noticeably broad, with short, close-set marginal and discal ciliation. Abdomen conical, larger than the thorax. Antennæ without a ring-joint, the club 3-jointed, not especially stout or enlarged, the funicle one-jointed, stout. **Chætostricha** Haliday (Type: *C. dimidiata* Haliday).

AA. Either the ovipositor or its valves is distinctly exserted or else long and prominent.

B. Antennæ 7-jointed, Ovipositor long, enclosed to its tips within the long and tubular terminal segment of the abdomen which is nearly a third of the latter's length; legs long and slender; abdomen long and jointed. Antennæ bearing a minute, ovate ring-joint, one funicle joint and a 3-jointed club; wings moderately narrow, with long marginal cilia. **Prestwichia** Lubbock (Type: *P. aquatica* Lubbock).

BB. Antennæ 6-jointed. Ovipositor nakedly exserted and long; antennæ without a ring-joint, the club 3-jointed, not enlarged, the funicle 1-jointed. **Centrobia** Foerster (Type: *Trichogramma walkeri* Foerster).

The males of *Abbella, Ittys, Japania, Oligosita, Chætostricha, Centrobia* and *Prestwichia* are essentially the same as the females; but in *Ufens,* the male antennæ are cylindrical and 9-jointed, the club terminating in a small fourth joint; the males of *Brachista* and *Brachistella* are unknown.

Table of the Genera of the *Lathromerini.*

A. Antennal club more than 2-jointed.

B. Ovipositor or the valves exserted, not always to a great length, but distinctly so.

C. Antennæ 9-jointed, without a ring-joint, the club 7-jointed, stout. Fore wings moderately broad, the marginal vein moderate in length, apparently curved; stigmal vein curved, distinct, with a neck. Ovipositor much exserted. **Ophioneurus** Ratzeburg (Type: *O. signatus* Ratzeburg).

CC. Antennæ 6-jointed, bearing a single, hidden, minute ring-joint and a conic-ovate 3-jointed club; marginal vein of fore wing long, straight, subequal to the submarginal vein, the stigmal vein subsessile; ciliation sparse, regular, the marginal cilia very short. Valves of ovipositor plainly but shortly exserted. Normal. **Pterygogramma** Perkins (Type: *P. acuminata* Perkins).

BB. Ovipositor not exserted.

C. Antennæ 7-jointed.

D. Antennæ bearing *one* minute ring-joint; the club 4-jointed, slightly enlarged. Fore wings with the marginal vein moderately long, the marginal ciliation short, the discal ciliation rather dense and in more or less regular lines. **Lathromeris** Foerster (Type: *L. scutellaris* Foerster).

DD. Antennæ bearing *two* minute ring-joints, the club 3-jointed, conspicuously enlarged, the antennæ capitate. Discal ciliation of fore wing not so dense and more or less irregular or normal. **Tumidiclava** Girault (Type: *T. pulchrinotum* Girault).

CC. Antennæ 6-jointed.

D. Discal ciliation of the fore wing dense, but arranged in regular lines; no oblique hairless line.

E. Antennæ *with* a ring-joint, the club 3-jointed; body short and stout, the abdomen blunt, not any longer than the thorax and head taken together; marginal vein of fore wing not clavate. **Uscana** Girault (Type: *U. semifumipennis* Girault).

EE. Antennæ *without* a ring-joint, the club 4-jointed; body long and slender, the abdomen pointed, conic-ovate, longer than the head and thorax together; marginal vein of the fore wing clavate. **Zaga** Girault (Type: *Z. latipennis* Girault).

DD. Discal ciliation of fore wing dense and normal, not arranged in regular lines. An oblique hairless line as in *Aphelinus* Dalman. Antennæ with *one* ring-joint, the club 3-jointed; abdomen short obtusely conical; marginal vein of fore wing long. **Tumidifemur** Girault (Type: *T. pulchrum* Girault).

AA. Antennal club 2-jointed.

B. Discal ciliation of the fore wing arranged in regular lines.

C. Antennæ 6-ointed, jbearing two ring-joints; marginal cilia of fore wings moderately long; discal ciliation sparse, the oblique line absent; abdomen short, blunt. **Uscanella** Girault (Type: *U. bicolor* Girault).

CC. Antennæ 4-jointed, without ring-joints; marginal cilia of fore wings moderately short; the oblique line of discal ciliation present; abdomen conic-ovate, as long as the head and thorax combined. **Uscanoidea** Girault Type: *U. nigriventris* Girault).

BB. Discal ciliation of fore wing normal and dense. Antennæ 5-jointed, bearing a single ring-joint, the club cylindrical; stigmal vein very short. **Aphelinoidea** Girault (Type: *A. semifumipennis* Girault).

The males of *Ophioneurus, Aphelinoidea, Tumidiclava, Tumidifemur, Uscanella* and *Zaga* are unknown; those of *Lathromeris, Uscana* and *Uscanoidea* are practically like the females; likewise the male of *Pterygogramma* which differs from the female noticeably only in the shape of the abdomen.

Subfamily II. *Trichogrammatinæ* Girault.

This subfamily includes the following: *Trichograma* Westwood, *Calleptiles* Haliday, *Poropœa* Foerster, *Asynacta* Foerster, *Neotrichogramma* Girault, *Trichogrammatoidea* Girault and *Trichogrammatella* Girault. For convenience it may be subdivided into the following tribes, the division based on what appears to be natural evolution of the venation.

Arch formed by the venation of the fore wing (Marginal vein mostly is bow or crescent shaped, a gradual convexity, less pronounced—Tribe I. *Trichogrammatini.* Genera: *Trichogramma* Westwood, *Calleptiles* Westwood, *Trichogrammatoidea* Girault, *Trichogrammatella* Girault and *Neotrichogramma* Girault.

Arch formed by the venation of the fore wing (marginal vein mostly) is ( ) shaped or sigmoid, pronounced, the marginal vein touching the costa only at its extreme apex.—Tribe II. *Poropœini.* Genera: *Poropœa* Foerster and *Asynacta* Foerster.

Table of the Genera of *Trichogrammatini.*

A. Antennal club solid, comprising but a single joint; antennæ 6-jointed, the funicle 2-jointed*.

B. Ovipositor not exserted, merely attaining to the end of the abdomen, the latter blunt.

C. Fore wings relatively broader, the discal and marginal ciliation short; antennal funicle without minute bladder-like appendages; male antennæ not distinctly segmented, apparently 4-jointed, the distal joint long, a funicle-club, and nodular. **Trichogramma** Westwood (Type: *T. evanescens* Westwood).

CC. Fore wings relatively narrower, the marginal ciliation distad moderately long; antennal funicle with minute bladder-like appendages; male antennæ distinctly 8-jointed. **Trichogrammatoidea** Girault (Type: *Chætostricha nana* Zehntner).

BB. Ovipositor plainly exserted, but not for a great length; abdomen more or less acutely pointed. Like *Trichogramma* Westwood. **Neotrichogramma** Girault (Type: *Trichogramma japonicum* Ashmead).

AA. Antennal club 3 to 5-jointed; antennæ 8-jointed; the funicle sometimes absent.

B. Antennal club 3-jointed, the funicle 2-jointed; abdomen subcylindrical, thorax long. (Male) **Calleptiles** Haliday (Type: *C. latipennis* Haliday).

BB. Antennal club 5-jointed, the funicle absent; abdomen with parallel sides and blunt apex; intermediate tibial spurs long and slender; posterior wings short. **Trichogrammatella** Girault (Type: *T. tristis* Girault).

The males of *Trichogramma and Neotrichogramma* differ from the females in antennal structure, the funicle not being differentiated from the club; the males of *Trichogrammatoidea* bear 8-jointed antennæ; those of *Trichogrammatella* are practically identical with the females.

Table of the Genera of the *Poropœini.*

A. Ovipositor exserted, long.

Antennæ 7-jointed, clavate, without a ring-joint, the funicle 2-jointed, the club 3-jointed. Fore wings moderately broad, their marginal cilia moderately short. Submarginal veins much longer than the stigmal or marginal veins. Pedicel of antennæ shorter

* Funicle 1-jointed—*Paratrichogramma cinderella;* see introductory.

than the first funicle joint. Discal ciliation of the fore wing arranged in regular lines. **Poropœa** Foerster Type: (*P. stollwerckii* Foerster).

AA. Ovipositor not exserted.
Antennæ 9-jointed, with 2 ring-joints, the club 3-jointed; fore wings broad with short marginal cilia. Discal ciliation of the fore wing dense, normal. **Asynacta** Foerster (Type: *Eulophus exiquus* Nels).

The male antennæ of *Poropœa* are slenderer than those of the female but otherwise similar; the male of *Asynacta* is not known.

SYNONYMIC AND REVISED CATALOGUE OF THE *Trichogrammatidæ*.

The following catalogue does not include every citation for genus and species, but just the principal nomenclatorial facts for each genus and species and for the family.

FAMILY *Trichogrammatidæ* FOERSTER.

Eulophidæ (postition uncertain) Haliday, 1833.
Eulophidæ (partim) Nees ab Esenbeck, 1834.
Encyrtidæ (partim) Westwood, 1840.
Unnamed tribe Haliday, 1843.
Eulophidæ (partim) Walker, 1846.
Trichogrammini (tribus) Haliday, in Walker, 1851.
Trichogrammatoidæ (family) Foerster, 1856.
Trichogramminen, Reinhard, 1858; Kirchner, 1867; Walker, 1851; Dours, 1874.
Trichogrammina (tribus) Thomson, 1878.
Trichogramminæ (subfamily) Howard, 1885*a*; 1886; Cresson, 1887.
Trichogrammidæ (family) Ashmead, 1896.
Trichogrammatinæ Aurivillius, 1897; De Dalla Torre, 1898; Howard, 1898*a*.
Trichogrammidæ Ashmead, 1904*a*; Perkins, 1906*b*.
Trichogramminæ Schmiedeknecht, 1907; 1909.
Trichogrammatidæ Girault, 1911*a*.

The subfamilies proposed by Ashmead (1904*a*), after much consideration, have been rejected as being less natural than the following arrangement.

SUBFAMILY I. *Chætostrichinæ* GIRAULT.

Tribe I. *Chætostrichina Girault.*

Genus **Brachista** Haliday, 1851.
Brachista Walker—Foerster, 1856.
Brachysticha Foerster, 1856.
Brachysticha Foerster—Ashmead, 1894.

Brachista Haliday—Aurivillius, 1897.
Brachista Haliday—Ashmead, 1904*a*.
Brachystira Foerster—Mayr, 1904. (Nomen lapsus for *Brachysticha*).
Brachista Walker—Schmiedeknecht, 1909.

Really no synonymns. Genus without a species until 1904.

1. **Brachista pungens** (Mayr).
   Brachystira pungens Mayr, 1904, pp. 590-592.

Genus **Brachistella** Girault, 1911.

1. **Brachystella acuminata** (Ashmead).
   Trichogramma acuminatum Ashmead, 1888, p. 107.
   ? Brachysticha acuminata (Ashmead), 1894-1895, p. 172.
   Brachista acuminata (Ashmead)—Schmiedeknecht 1909, p. 482.
   Abbella acuminata (Ashmead)—Girault, 1911*b*. pp. 77-82.

Genus **Abbella** Girault, 1911.

1. **Abbella subflava** Girault.
   Abbella subflava Girault, 1911*a*, pp. 11-13; pl. I, figs. 4-5.
2. **Abbella nympha** Girault.
   Abbella nympha Girault, 1911*e*, pp. 197-198.

Genus **Ittys** Girault.

1. **Ittys ceresarum** (Ashmead).
   Trichogramma ceresarum Ashmead, 1888, p. 107.
   Ittys ceresarum (Ashmead)—Girault, 1911*a*, pp. 25-30; pl. I, figs. 8 and 9.

Genus **Ufens** Girault, 1911.

1. **Ufens niger** (Ashmead).
   Trichogramma nigrum Ashmead, 1888, p. 107.
   Ufens niger (Ashmead)—Girault, 1911*a*, pp. 32-38, pl. I, fig. 10.
2. **Ufens luna** Girault.
   Ufens luna Girault, 1911*e*, pp. 198-199.

Genus **Japania** Girault, 1911.

1. **Japania ovi** Girault.
   Japania ovi Girault, 1911*b*, pp. 44-45.

Genus **Oligosita** Haliday, 1851.

Westwoodella Ashmead, 1904*a*.

1. **Oligosita collina** Haliday.
   Oligosita collina Haliday, 1851, p. 212.
2. **Oligosita subfasciata** Westwood.
   Oligosita subfasciata Westwood, 1879, pp. 591, 593; pl. 73, figs. 14-19.
   Westwoodella subfasciata (Westwood)—Ashmead, 1904*a*, p. 359.
3. **Oligosita staniforthii** Westwood.
   Oligosita staniforthii Westwood, 1879, p. 591; pl. 73, figs. 20, 21.

4. **? Oligosita nodicornis** Westwood.
    Oligosita ? nodicornis Westwood, 1879; p. 592; pl. 73, fig. 22.
5. **Oligosita americana** Ashmead (Girault).
    Oligosita americana Ashmead—Girault, 1909, pp. 106-110.
6. **Oligosita hilaris** (Perkins).
    Westwoodella hilaris Perkins, 1911, pp. 658-659, text fig.
7. **Oligosita sanguinea** (Girault).
    Oligosita sanguinea Girault, 1911*b*, pp. 58-63, fig. 1.
    Westwoodella clarimaculosa Girault, ib., p. 67.

7a. **Westwoodella sanguinea clarimaculosa** Girault, 1911*g*, p. 126.

8. **Oligosita subfasciatipennis** (Girault).
    Westwoodella subfasciatipennis Girault, 1911*b*, pp. 63-66.
9. **Oligosita comosipennis** (Girault).
    Westwoodella comosipennis Girault, 1911*b*, pp. 66-67

Genus **Chætostricha** Haliday.

Chætostricha Walker—Foerster, 1856, pp. 86, 89.
Chætostrinx Foerster, ib., p. 89.
Lathromeris Foerster—Aurivillius, 1897.
Paracentrobia Howard, 1896, p. 178.
Only one true synonym.

1. **Chætostricha dimidiata** Haliday.
    Chætostricha dimidiata Haliday, 1851, pp. 211-212.
2. **Chætostricha punctata** (Howard).
    Paracentrobia punctata Howard, 1896, p. 178.
3. **Chætostricha flavipes** (Girault).
    Paracentrobia flavipes Girault, 1905, pp. 287-288.
    Chætostricha flavipes (Girault), 1911*b*, pp. 75-77, figs. 2-3.

Genus **Prestwichia** Lubbock, 1864.

1. **Prestwichia aquatica** Lubbock.
    Prestwichia aquatica Lubbock, 1864, pp. 140-141.
    Prestwichia aquatica Lubbock—Girault, 1911*d*, pp. 209-210.

Genus **Centrobia** Foerster.

Trichogramma Westwood—Foerster, 1851, pp. 26-28.
Calleptiles Haliday—Foerster, 1856, p. 89.
Really no synonyms.

1. **Centrobia walkeri** (Foerster).
    Trichogramma walkeri, Foerster, 1851, pp. 26-28 and footnote to p. 27; tab. I, fig. 9, a, b, c.
    Calleptiles walkeri (Foerster), 1856, p. 89.
    Centrobia walkeri (Foerster), ib., p. 87.

2. **Centrobia odonatæ** Ashmead.
    Centrobia odonatæ Ashmead, 1900*a*, pp.616-617.
    Centrobia odonatæ Ashmead—Girault, 1911*b*, pp. 74-75.

Tribe II. *Lathromerini.*

Genus **Ophioneurus** Ratzeburg.

Poropœa Foerster, 1856.
Chætostricha Haliday—Reinhard, 1858, pp. 16-17.
Chætostricha Walker—Kirchner, 1867, p. 187.
    Really no synonyms.

1. **Ophioneurus signatus** Ratzeburg.
    Ophioneurus signatus Ratzeburg, 1852, p. 192, text figs.
    Poropœa signata (Ratzeburg)—Foerster, 1856, p. 88.
    Chætostricha signata (Ratzeburg)—Reinhard, 1858, pp. 16-17.

Genus **Pterygogramma** Perkins, 1906.

1. **Pterygogramma acuminatum** Perkins.
    Pterygogramma acuminata Perkins, 1906*b*, p. 265.

Genus **Lathromeris** Foerster, 1856.

Ophioneurus Ratzeburg—Reinhard, 1858, p. 323.
Chætostricha Walker—Kirchner, 1867, p. 187.
Chætostricha Haliday—Aurivillius, 1897.
Brachysticha Foerster—Ashmead, 1894-1895, pp. 171-172.
    Really no synonyms.

1. **Lathromeris scutellaris** Foerster.
    Lathromeris scutellaris Foerster, 1856, p. 89.
    Chætostricha scutellaris Foerster—De Dalla Torre, 1898, p. 4.
2. **Lathromeris fidiæ** (Ashmead).
    Brachysticha fidiæ Ashmead, 1894-1895, pp. 171-172.
    Brachysta fidiæ (Ashmead)—Girault, 1907*d*, p. 29.
    Lathromeris fidiæ (Ashmead)—Johnson and Hammer, 1910, pp. 51, 56-57, fig. 27.
    Lathromeris fidiæ (Ashmead)—Girault, 1911*b*, pp. 62-71.
3. **Lathromeris cicadæ** Howard.
    Lathromeris cicadæ Howard, 1898*b*, pp. 102-103.
    Lathromeris cicadæ Howard—Girault, 1911*b*, pp. 71-74.

Genus **Tumidiclava** Girault, 1911.

1. **Tumidiclava pulchrinotum** Girault.
    Tumidiclava pulchrinotum Girault, 1911*a*, pp. 8-9; pl. I, fig. 3.

Genus **Uscana** Girault, 1911.

1. **Uscana semifumipennis** Girault.
    Uscana semifumipennis Girault, 1911*a*, pp. 23-25.

Genus **Zaga** Girault, 1911.

1. **Zaga latipennis** Girault.
    Zaga latipennis Girault, 1911*a*, pp. 31-32.

Genus **Tumidifemur** Girault, 1911.

1. **Tumidifemur pulchrum** Girault.
Tumidifemur pulchrum Girault, 1911*g*, p. 125.

Genus **Uscanella** Girault, 1911.

1. **Uscanella bicolor** Girault.
Uscanella bicolor Girault, 1911*g*, p. 129.

Genus **Uscanoidea** Girault, 1911.

1. **Uscanoidea nigriventris** Girault.
Uscanoidea nigiventris Girault, 1911*g*, pp. 130-131.

Genus **Aphelinoidea** Girault, 1911.

1. **Aphelinoidea semifuscipennis** Girault.
Aphelinoidea semifuscipennis Girault, 1911*a*, *pp.* D-F; *pl. I*, figs. 1-2.

SUBFAMILY II. *Trichogrammatinæ* GIRAULT (NEC ASHMEAD).

Tribe I. *Trichogrammatini**.

Genus **Trichogramma** Westwood.

Calleptiles Haliday—Westwood, 1840, Synopsis, p. 73.
Trichogramma (Aprobosca) Westwood, 1879, pp. 592-593; pl 73, figs. 24, 25.
Aprobosca Westwood—Ashmead, 1904*a*, pp. 360, 361 and 366.
Pentarthron Riley—Packard, 1872, p. 8; Riley, 1881, pp. 68-69.
Pentarthron Riley (nec Wollaston), 1879, pp. 161-162.
Oophthora Aurivillius, 1897.
Xanthoatomus Ashmead, 1904*a*, pp. xi, 360 (Nomen nudum).
Real synonyms: .*Pentarthron* Riley, *Oophthora* Aurivillius.

1. **Trichogramma evanescens** Westwood.
Trichogramma evanescens Westwood, 1833, p. 444, figs. 8 and 9 (p. 443).

2. **Trichogramma minutum** Riley.
Encyrtus sp., Peck, 1799. /m
Trichogramma ? minuta Riley, 1871, pp. 157-158, fig. 72.
Pentarthron minutum (Riley)—Packard, 1872, p. 8.
Pentarthron minuta (Riley), 1879, pp. 161-162.
Trichogramma pretiosa Riley, ib.
Trichogramma minutissimu Packard, 1883, pp. 37-38.
Trichogramma odontotæ Howard, 1885*b*, p. 117.
Trichogramma intermedium Howard, 1889*a*, pp. 1894-1895; pl. 89, fig. 8.

* Including *Paratrichogramma cinderella* Girault. See antea.

Oophthora minutum (Riley)—Aurivillius, 1897.

Xanthoatomus albipes Ashmead, 1904*a*, pp. xi, 360 (Nomen nud).

Pentarthron minutum (Riley)—Girault, 1910, p. 275.

2a. **Trichogramma minutum nigrum** Girault.

Trichogramma pretiosa nigra Girault, 1906*a*, p. 82.

3. **Trichogramma erosicorne** Westwood.

Trichogramma (Aprobosca) erosicornis Westwood, 187—, pp. 592-593; pl. 73, figs. 24-25.

Aprobosca erosicornis (Westwood)—Ashmead, 1904*a*, pp. 361, 366.

As stated elsewhere the position of this species is not known and it is placed here provisionally.

4. **Trichogramma semblidis** (Aurivillius).

Oophthora semblidis Aurivillius, 1897, pp. 253-254; tafel 5, figs. 1-3, 3*a* and 4-10.

Pentarthron carpocapsæ Ashmead—Schreiner, 1907, pp. 218 220, text-fig.

Pentarthron semblidis Aurivillius—Girault, 1911*b*, pp. 48-50.

Pentarthron carpocapsæ Schreiner—Masi, 1909.

5. **Trichogramma brasiliense** (Ashmead).

Pentarthron brasiliensis Ashmead, 1904*a*, p. 521.

Pentarthron brasiliense Ashmead—Girault, 1911*b*, p. 52.

6. **Trichogramma helocharæ** Perkins.

Trichogramma helocharæ Perkins, 1907.

7. **Trichogramma semifumatum** (Perkins).

Pentarthron semifumatum Perkins, 1910, p. 659, text-fig

Pentarthron semifumatum Perkins—Girault, 1911*b*, pp. 50-51.

8. **Trichogramma perkinsi** Girault.

Pentarthron flavum Perkins, 1910, p. 660, text-fig.

Trichogramma perkinsi Girault (nomen novum—preocc. by "*Trichogramma flavus*" Ashmead).

9. **Trichogramma euproctidis** (Girault).

Pentarthron euproctidis Girault, 1911*b*, pp. 46-48.

10. **Trichogramma retorridum** (Girault).

Pentarthron retorridum Girault, 1911*b*, pp. 52-55.

Genus **Trichogrammatoidea** Girault, 1911.

1. **Trichogrammatoidea nana** (Zehntner).

Chætostricha nana Zehntner, 1896, pp. 14-16; pl. I, figs. 9-11.

Trichogrammatoidea nana (Zehntner)—Girault, 1911*a*, pp. 15-19; pl. I, figs. 6-7.

2. **Trichogrammatoidea lutea** Girault.
Trichogrammatoidea lutea Girault, 1911*a*, pp. 19-22.

Genus **Neotrichogramma** Girault, 1911.

1. **Neotrichogramma japonicum** (Ashmead).
Trichogramma japonicum Ashmead, 1904*b*, 165.
Neotrichogramma acutiventre Girault, 1911*a*, pp. 38-41; pl. I, figs. 11-13.
Neotrichogramma japonicum (Ashmead) — Girault, 1911*c*, pp. 192-194.

Genus **Calleptiles** Haliday.

Microma Curtis, (partim), 1831, No. 595.
Pteroptrix Westwood—Walker, 1839*a*; 1846.
Trichogramma Wetswood—Editor, 1833.—Walker, 1839*a*.—Haliday, 1842.—Foerster, 1856.—Schmiedeknecht, 1907, p. 490.
Really no synonymns.

1. **Calleptiles latipennis** Haliday.
Microma latipennis Curtis, 1831, No. 595. (nom. nud).
Calleptiles latipennis Haliday, 1833, p. 341.
Trichogramma evanescens Westwood—Editor, 1833, p. 341.—Haliday,1843, pl. k, figs. 4, 4a—4d.—Walker, 1846.—Newman, 1871, pp. 357-358.—Walker, 1872.—Id., 1873.
Pteroptrix evanescens (Westwood)—Walker, 1849*a*.
Calleptiles latipennis Haliday—Westwood, 1879.

2. **Calleptiles carina** (Walker).
Trichogramma carina Walker, 1843, p. 104.
Trichogramma carina Walker—De Dalla Torre, 1898, p. 2.

3. **Calleptiles vitripennis** (Walker).
Trichogramma vitripennis Walker, 1851, p. 212.
Trichogramma vitripennis Walker—Westwood, 1879, p. 589.
Trichogramma vitripenne—De Dalla Torre, 1898, p. 3.

Genus **Trichogrammatella** Girault, 1911.

1. **Trichogrammatella tristis** Girault.
Trichogrammatella tristis Girault, 1911*g*, pp. 126-128.

Tribe II. *Poropœini.*

Genus **Poropœa** Foerster.

Ophioneurus Ratzeburg (partim), 1852, pp. 196-197, fig; p. 248.
Ophioneurus Thomson—Aurivillius, 1897, p. 251, footnote.
Trichogramma Westwood—Reinhard, 1858, p. 16.
Really no synonyms.

1. **Poropœa stollwerckii** Foerster.
   Poropœa stollwerckii Foerster, 1851, pp. 29-30; tab. I, figs. 10, a-e.
   Ophioneurus simplex Ratzeburg, 1852, p. 197, text-fig. p. 248.
   Trichogramma simplex (Ratzeburg)—Reinhard, 1858, p. 16.
   Poropœa stollwerckii Foerster—Ashmead., 1904*a*, pp. 360, 361.
2. **Poropœa grandis** (Thomson).
   Ophioneurus grandis Thomson, 1878, p. 299.
   Poropœa grandis (Thomson)—Aurivillius, 1897, p. 251, footnote.
   Chætostricha grandis (Thomson)—De Dalla Torre, 1898, p. 4.
3. **Poropœa attelaborum** Girault.
   Poropœa attelaborum Girault, 1911*b*, pp. 68-69.

Genus **Asynacta** Foerster.

1. **Asynacta exiqua** (Nees).
   Eulophus exiquus Nees ab Esenbeck, 1834, pp. 183-184.
   Asynacta exiqua (Nees)—Mayr, 1904, pp. 589-590.

IV. LIST OF THE SPECIES DESCRIBED TO NAMES AS NEW AND REFERRED TO THE FAMILY *Trichogrammatidæ*.

The following list is arranged chronologically:

1. *Microma latipennis* Curtis, 1831.—Nomen nudum, intended for *Calleptiles*.
2. *Trichogramma cranescens* Westwood, 1833.
3. *Calleptiles latipennis* Haliday, 1833.
4. *Trichogramma carina* Walker, 1843. (=*Calleptiles* Haliday).
5. *Trichogramma vitripennis* Walker, 1851. (=*Calleptiles* Haliday).
6. *Chætostricha dimidiata* Haliday, 1851.
7. *Oligosita collina* Haliday, 1851.
8. *Trichogramma walkeri* Foerster, 1851. (Type of *Centrobia* Foerster).
9. *Poropœa stollwerckii* Foerster, 1851.
10. *Ophioneurus simplex* Ratzeburg, 1852. (=*Poropœa stollwerckii* Foerster).
11. *Ophioneurus signata* Ratzeburg, 1852.
12. *Lathromeris scutellaris* Foerster, 1856.
13. *Trichogramma fraterna* Fitch, 1856. (Belongs to the *Eulophidæ*).
14. *Trichogramma orgyiæ* Fitch, 1856. (Belongs to the *Eulophidæ*).
15. *Prestwichia aquatica* Lubbock, 1864.
16. *Trichogramma minuta* Riley, 1871.
17. *Ophioneurus grandis* Thomson, 1878. (=*Poropœa* Foerster).
18. *Trichogramma pretiosa* Riley. (=*T. minutum* Riley).
19. *Oligosita subfasciata* Westwood, 1879.

20. *Oligosita nodicornis* Westwood, 1879.
21. *Oligosita staniforthii* Westwood, 1879.
22. *Trichogramma (Aprobosca) erosicornis* Westwood, 1879. (= *Trichogramma* Westwood).
23. *Trichogramma flavus* Ashmead, 1881. (An unknown *Aphelinine*).
24. *Trichogramma minutissimum* Packard, 1883. (= *T. minutum* Riley).
25. *Trichogramma odontotæ* Howard, 1885. (? = *T. minutum* Riley).
26. *Trichogramma intermedium* Howard, 1889. (= *T. minutum* Riley).
27. *Trichogramma nigrum* Ashmead, 1889. (Type of *Ufens* Girault).
28. *Trichogramma acuminatum* Ashmead, 1889. (Type of *Brachistella* Girault).
29. *Trichogramma ceresarum* Ashmead, 1889. (Type of *Ittys* Girault).
30. *Brachysticha fidiæ* Ashmead, 1894-1895. (= *Lathromeris*).
31. *Oophthora semblidis* Aurivillius, 1897. (= *Trichogramma* Westwood).
32. *Lathromeris cicadæ* Howard, 1898.
33. *Paracentrobia punctata* Howard, 1898. (= *Chætostricha* Haliday).
34. *Chætostricha nana* Zehntner, 1898. (Type of *Trichogrammatoidea* Girault).
35. *Centrobia odonatæ* Ashmead, 1900.
36. *Brachista pallida* Ashmead, 1900. (= *Brachistella acuminata* Ashmead).
37. *Xanthoatomus albipes Ashmead*, 1904, (Nomen nudum, intended for *Trichogramma minutum* Riley).
38. *Synacta exiqua* (Nees) Mayr, 1904. (= *Eulophus exiquus* Nees).
39. *Brachystira pungens* Mayr, 1904. (Type of *Brachista* Haliday).
40. *Trichogramma japonicus* Ashmead, 1904. (Type of *Neotrichogramma* Girault).
41. *Pentarthron brasiliensis* Ashmead, 1904. (*Trichogramma* Westwood).
42. *Paracentrobia flavipes* Girault, 1905. (= *Chætostricha* Haliday).
43. *Pterygogramma acuminata* Perkins, 1906.
44. *Trichogramma helocharæ* Perkins, 1907.
45. *Pentarthron carpocapsæ* Ashmead—Schreiner, 1907. (= *Trichogramma semblidis* Aurivillius).
46. *Oligosita americana* Ashmead—Girault, 1909.
47. *Pentarthron semifumatum* Perkins, 1910. (= *Trichogramma* Westwood).
48. *Pentarthron flavum* Perkins, 1910. (= *Trichogramma* Westwood; *Perkinsi* Girault, new name).
49. *Westwoodella hilaris* Perkins, 1910. (= *Oligosita* Haliday).

50. *Aphelinoidea semifumipennis* Girault, 1911.
51. *Tumidiclava pulchrinotum* Girault, 1911.
52. *Abbella subflava* Girault, 1911.
53. *Trichogrammatoidea lutea* Girault, 1911.
54. *Uscana semifumipennis* Girault, 1911.
55. *Zaga latipennis*, 1911.
56. *Neotrichogramma acutiventre* Girault, 1911. (= *Trichogramma japonicum* Ashmead).
57. *Japania ovi* Girault, 1911.
58. *Pentarthron euproctidis* Girault. (*Trichogramma*).
59. *Pentarthron retorridum* Girault, 1911 (= *Trichogramma*).
60. *Westwoodella sanguinea* Girault, 1911 (= *Oligosita*).
61. *Westwoodella subfasciatipennis* Girault, 1911 (= *Oligosita*).
62. *Westwoodella comosipennis* Girault, 1911 (= *Oligosita*).
63. *Westwoodella clarimaculosa* Girault, 1911 (= *Oligosita sanguinea* Girault).
64. *Poropœa attelaborum* Girault, 1911.
65. *Abbella nympha* Girault, 1911.
66. *Ufens luna* Girault, 1911.
67. *Tumidifemur pulchrum* Girault, 1911.
68. *Trichogrammatella tristis* Girault, 1911.
69. *Uscanella bicolor* Girault, 1911.
70. *Uscanoidea nigriventris* Girault, 1911.

Of this list of seventy specific names, all are valid so far as known excepting fourteen: the numbers 1, 10, 13, 14, 18, 23, 24, 25, 26, 36, 37, 45, 56 and 63. These numbers are either nomina nuda (1 and 37), extralimital (13, 14, 23) or else synonyms. The number 63 is a varietal name*. Of the fifty-six names supposedly valid, the representatives of at least a dozen or more have never been recognized since their original description and consequently, through inadequate description, may be lost. These numbers are 2, 3, 4, 5, 6, 7, 11, 12, 17, 20, 21 and 22.

A new name, *Trichogramma perkinsi*, is proposed above for *Pentarthron flavum* Perkins. The numbers 44 and 48 should be compared with *Trichogramma minutum* Riley.

V. LIST OF SPECIFIC NAMES PROBABLY REFERABLE TO THE *Trichogrammatidæ* BUT WHICH WERE PLACED IN OTHER GROUPS.

1. *(Myina) Pteromalus atomos* Fonscolombe, 1832.

VI. LIST OF THE GENERIC NAMES USED IN THE *Trichogrammatidæ*.

* The variety *Trichogramma minutum nigrum* Girault is omitted in the list as is also *Paratrichogramma*.

The following list is arranged chronologically and does not include names erroneously applied to species of the family (of these *Microma, Eulophus, Encyrtus* and *Pteroptrix* are the only ones; *Myina* and *Pteromalus* may be doubtfully included).

1. *Trichogramma* Westwood, 1833.
2. *Calleptiles* Haliday, 1833.
3. *Poropœa* Foerster, 1851.
4. *Chætostricha* Haliday, 1851.
5. *Brachista* Haliday, 1851.
6. *Oligosita* Haliday, 1851.
7. *Ophioneurus* Ratzeburg, 1852.
8. *Lathromeris* Foerster, 1856.
9. *Centrobia* Foerster, 1856.
10. *Asynacta* Foerster, 1856.
11. *Chætosricha* Walker—Foerster, 1856 (intended for *Chætostricha* Haliday).
12. *Chætostrinx* Walker—Foerster, 1856 (intended for *Chætostricha* Haliday).
13. *Brachysticha* Walker—Foerster, 1856 (intended for *Brachista* Haliday).
14. *Prestwichia* Lubbock, 1864.
15. *Pentarthron* Riley—Packard, 1872 (=*Trichogramma* Westwood).
16. *Aprobosca* Westwood, 1879 (of doubtful validity and now treated as a synonymn of *Trichogramma* Westwood).
17. *Pentarthrum* Riley, 1879 (nec Wollaston) (intended for *Pentarthron* Riley).
18. *Oophthora* Aurivillius, 1897 (=*Trichogramma* Westwood).
19. *Brachysticha* Haliday—Webster, 1896 (intended for *Brachysticha* Walker).
20. *Paracentrobia* Howard, 1898 (=*Chætostricha* Haliday).
21. *Brachystira* Foerster—Mayr, 1904 (intended for *Brachisticha* Walker).
22. *Westwoodella* Ashmead, 1904 (=*Oligosita* Haliday).
23. *Xanthoatomus* Ashmead, 1904 (=*Trichogramma* Westwood; a nomen nudum).
24. *Pterygogramma* Perkins, 1906.
25. *Aphelinoidea* Girault, 1911.
26. *Tumidiclava* Girault, 1911.
27. *Abbella* Girault, 1911.
28. *Trichogrammatoidea* Girault, 1911.
29. *Uscana* Girault, 1911.
30. *Ittys* Girault, 1911.

31. *Zaga* Girault, 1911.
32. *Ufens* Girault, 1911.
33. *Neotrichogramma* Girault, 1911.
34. *Japania* Girault, 1911.
35. *Tumidifemur* Girault, 1911.
36. *Trichogrammatella* Girault, 1911.
37. *Uscanella* Girault, 1911.
38. *Uscanoidea* Girault, 1911.
39. *Brachistella* Girault, 1911.*

Of the above names, all are valid excepting the numbers 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22 and 23, leaving twenty-seven in all. The twelve nonvalidies are either synonyms (15, 19, 20, 22, 23) emendations of original names (11, 12, 13, 17, 18, 21) or of uncertain position (16). Of the valid names, only those of 2, 4 and 7 may fall because of possible non-recognition of their representatives. Of the synonymns, only 16 and 20 may prove to be distinct and valid. *Paratrichogramma* is not included in the above nor are the other two Australian genera, as yet without names.

Brisbane, Australia,

February 1, 1912.

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* And see the next paragraph.

ANON THE REASONS FOR BIRD MIGRATION: A FAVORITE FOOD THEORY.

By A. C. Burrill.

For many years the various attempts to explain the migration of North American birds has interested the writer, although no one seems to have arrived at a conclusion which all will accept. The theory of avoidance of extreme cold has been overturned by the fact that certain birds who have been proved to resist cold equal to the winter extremes, go south long before such cold weather arrives; the theory that the bird's food supply is running short has been overturned by proof that the birds leave their northern nesting grounds before the actual food supply is anywhere near exhausted; the theory that the birds seek the North for nesting purposes in order to avoid tropical enemies has been partly exploded by the presence of bird-destroying enemies in the North and the fact that many birds linger in the Northern regions months after breeding is over; and the theory of migration routes and instincts inherited from their time of origin during the Glacial Period is most seriously combatted by comparative psychologists— who claim that a habit fails to persist for milleniums after the original stimulus, viz., glacial conditions, is inoperative.

An unprofessional opinion is that the reason of bird migration has something to do with the food question together with the widespread habit throughout the animal kingdom of an inquisitive desire to wander or explore (Prof. N. S. Shaler, 1906, "Exploration," Atlantic Monthly v. 97, No. 2 for Feb. pp. 145-156).

In 1909, the writer suggested the need of studying bird phenomena connected with the flocking habit, especially flocking before migration ("Swallow Migration, 1909", Bulletin of the Wisconsin Natural History Society, Vol 7, Nos. 3 and 4, page 132, October, 1909). This was dwelt on at further length in the sketch on "Migrations of the Swallows and Other Birds" (in "By the Wayside," Vol. 11, No. 6, pages 41-42, Dec. 1909), in which notes on some flocking points of red-winged black-birds in Wisconsin were included together with references to the literature on robin roosts.

It is a common habit among birds for the young to congregate in flocks after the breeding season, often some time before the migration flocks of older birds begin to gather, so that the mere gathering of birds may not furnish any proof on the migration habit. Nevertheless, the requisite food supply becomes a greater problem with a concentration of young or old birds in large numbers and this must have considerable effect on the foraging instincts. The desire of birds to keep together forces them to seek the very best feeding grounds in order to provide sufficient food for the larger numbers.

Until recent publications of the Biological Survey, the lack of definite data as to the exact species of insects and seeds which a larger number of our migrants devour, has made it impossible to specialize on the requirements of each species for each month in the year. Most birds have a quite different food supply during the flocking season than that during the nesting period, if one mean thereby the exact species of insects or plant seeds consumed. It must be evident to any one that there will be considerable variation in the supply of any particular species, especially in insect life. Is it not possible that some birds may leave feeding grounds for the South, not because of the lack of all of their food supplies, but through the lack of those items which are most liked, especially if any of their scouts discover larger supplies to the southward?

While wintering on the bluffs of the Arkansas River, East of Ponca City, Oklahoma in 1906-7, I was interested to note the local migrations of ducks up and down this river valley throughout that season. This region is, of course, in the latitude of the Northern boundary of our Northern ducks during their winter sojourn in the South. During two or three slight cold spells, ice formed on the river and on such occasions, flocks of ducks going Southward were noticeable. With every recurring warm spell and breakup of ice, flocks of ducks were seen going Northward. With the spring breakup of ice when large masses came down the stream, some even from Colorado, larger flocks of ducks were seen going Northward. After that time, no further flocks of ducks were noticed going Northward. The slight variation in temperature shows at once that the hardy ducks were not particularly influenced by cold as a factor, but a more probable reason would be the freezing over of the water so that they could not reach their food supply so far as obtained from the water. The final breakup of the ice in spring must have indicated to the ducks that food supply could be found in open water spaces further North. If this be too anthropomorphic a supposition, can we not say that the local migration of ducks up and down the river for twenty-five miles (or probably much further than the observer could locate and show by actual observation), would discover to the older ducks strips of open water Northward which had been frozen previous to the local migrations Southward? Leaving this question open for those who have more leisure and special opportunity to observe these facts, I wish to turn to another illustration of local migration which seems to bear out the same point of view.

On the way from Neenah to Oshkosh, Wisconsin, along the shores of Lake Winnebago, August 17, 1910, the thousands and thousands of midges observed along the way were especially remarkable. There was only one species so far as sight or collecting efforts could discover . (*Chironomus plumosus*), this species covering the trees, fences, mail boxes, ploughed ground, and even the dusty roadway. Some miles South from Neenah, many swallows were noticed coming Northward along the fields, slowly advancing and busily feeding in the fields and flying low over all the country as they normally do on cloudy days (further observations on this species of midge in particular will be published in Bull. Wis. Nat. Hist. Soc. Vol. 10, 1912). Three different flocks of these swallows must have numbered into thousands each. Without other proof as to the presence of a large variety of insects, it seems quite reasonable to suppose that these birds were eating the midges everywhere abundant, undoubtedly gorging their stomachs with the only adequate food supply visible. The flocks were chiefly white-bellied tree swallows (*Trachycineta bicolor* (Vieill)) one barn swallow, solitary (*Chelidon erythrogaster* (Bodd)), and I thought I recognized one bank swallow (*Riparia riparia* (L.)). Not necessarily in these flocks but apparently attracted in the same way was a kingfisher (*Ceryle alcyon* (Linn.)) and several sand pipers (perhaps *Actitis*).

In the afternoon, further flocks of swallows and some blackbirds (*Agelaius phoeniceus* Linn) were seen. These birds were in rather more scattered flocks at this time of day and were also passing Northwards in the direction of Neenah. As dusk was coming on, the midges were beginning to fly in larger numbers, as is commonly true of these insects, so that it seemed unnecessary from my standpoint that the flocks of birds should move further north. At this season of the year when flocks tend Southwards, I cannot but correlate a Northward trend with a sudden appearance of midges from the lake attracting all birds towards such fortuitous and phenomenal feeding ground. In the midge article referred to above, climatic reasons for the sudden appearance of the enormous numbers of this midge are dwelt on in detail.

Can it be possible that the reason for so many of these birds which normally appear in flocks at this time of year, making their gathering foci about marshes and lakes, is due to this very abundant emergence of this midge or other insect life inhabiting wet places and maturing in August or September? If so, the disappearance of such abundant food in these marshes would certainly urge the gathering flocks Southward to later maturing broods of similar insects in like abundance long before all food has disappeared in the coming on of the winter's cold in Wisconisn. This would then be another factor in the migration period favoring the food scarcity idea. It does not argue, however, that the birds are forced Southward by an entire lack of their normal food, but that the failure of some superabundant favorite food species is the cause for the Southward movement. This relieves observers of the need of proving that all favorite foods are gone in watching for the cause of migrations of each species. It is to be understood, of course, that the sudden appearance of such excessive midge swarms is followed within a week by their sudden demise, due to the particular species having passed its normal span of life. If this be true, have we not the right sort of answer as to why the birds know enough to start even before cold weather sets in?

In the same way, it might be shown that the superabundance of insect life reappearing from hibernation in the spring, causes the birds' return Northward. By this, I do not mean that there are necessarily any more insects in the regions Northward emerging from their winter sleep, but that there may be greater abundance of species highly delectable to each particular species as is shown by the difference in date of migration of the different bird waves. Even disallowing this factor, the claim might still be made that the speedy reappearance of so many delicate insects with springtime makes such a marked change in the complexion of the Northland that birds which are subject to local migrations in the South would unwittingly move Northward as the abundance of insects lured them on. This presupposes that most species have some advance guards of value as scouts.

The fact that the advance birds do not return to the main flocks in the South, as the instance of the ducks fluctuating Northward with the warm and South with the cold days of an Oklahoma winter would suggest that the birds' instincts are readily appealed to to follow, after the absence of older birds is noticed. This presupposes also, that the birds have at least a slight knowledge as to the makeup of their flocks to the extent of following the lead of experienced individual birds rather than the young and erratic ones. I think there is little question on this score, that birds acknowledge leadership and miss leaders which disappear. Perhaps the disappearance Northward of other species, consociates on the Southern feeding grounds, would be noticed at this restless mating time of the year. It is realized that there are important exceptions to this argument, just as to every argument thus far advanced, also that there are several species of birds, especially water birds, which make such long trips over night that the abundance of some specially delectable insect will have no influence in solving the migration stimulus.

It has been shown in literature by members of the Biological Survey that the robin and other species accelerate their Northward progress in unison with the accelerated advance of spring in the Northern half of the continent. This evidence is as useful in proving the synchronous appearance of animal food suited to robins as it has been made useful in proving the entire dependence of birds on weather in the spring migration.

As weather has been generally disproved as influential in the autumn migration, it should be abandoned for spring migration. To this tenet I can conceive of only one exception in favor of climate. That is, there has been little work done to show if the autumn migrations coincide with the falling off of the average weekly heat increment during the summer, a climatological fact starting about the time the first warblers start southward.

In conclusion, the evidence is given for what it is worth as to the actual observations without regard to what fate befalls the theories presented. At the lower end of the lake August 18, there were almost no midges and there were also no flocks of birds. This is proof enough that the birds were not merely there because there was low wet country, since it is this South end of the lake which is most marshy. This fact also points the argument that the Northward trend of birds was due to the majority of midges being Northward along the lake.

State Entomologist's Office, April 10, 1912,

Madison, Wisconsin.

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ERRATA.

Page 13.—Paragraph 1. Insert **the** before **science,** the last word of the paragraph.

Page 13.—Paragraph 3, line 3. Change **complimentary** to **comple=mentary.**

Page 14.—Paragraph 2, line 2. **Directive** instead of **direct.**

Page 15.—Paragraph 1. **Enjoy** for **enjoyed.**

Page 15.—Paragraph 2. **Heliotropism** for **Heliotropisms.**

Page 16.—Paragraph 3, line 8. **Larva** for **Larvae.**

Page 64.—Line 4. **Omit entire line.**

Page 71.—C. Artificial Parthenogenesis.

Paragraph 1. Sentence three should read as follows:
"Loeb, in 1899, succeeded in developing plutei from the **unfertilized eggs** of the sea urchin, when the, etc.,—

Page 75.—Paragraph 5. Sentence two should read as follows:
"In species producing by this method, the fertilized eggs always develop **into females, while males develop** through parthenogenesis, etc.,—

BULLETIN

OF THE

WISCONSIN NATURAL HISTORY SOCIETY

Vol. 10 | DECEMBER, 1912 | Nos. 3 and 4

OBSERVATIONS OF THE BEHAVIOR OF *EUBRANCHIPUS DADAYI.*

By A. S. Pearse.

During the spring of 1912 (April 22 to May 10) the writer had opportunity to observe the hebavior of *Eubranchipus dadayi* Pearse in a small pool on the low ground along the Merimec River near St. Louis, Missouri. According to the farmer who owned the land, this pool had contained no water until the snow melted in the spring; and it became temporarily a part of the river during the high water period of April 28 and 29. Though the pool was rather large (330 x 55 ft.) and shaded to some extent by the trees and shrubs which grew in and around it, the water was shallow (2½ feet) and became warm during the day. For example, on April 27 the temperature just below the surface at 8.25 a. m. was 12° C., at 17.07 p. m., 16.9° C., and at 2.35 p. m., 15.3° C.

The movements of fairy-shrimps are extremely easy and graceful; those of this species are no exception. While in locomotion the ventral side is usually uppermost and the body glides through the water slowly but steadily. Changes in direction are accomplished by a quick "flirt" of the tail. In ordinary swimming, waves of movement appear to pass along the ventral side toward the posterior end—each appendage stroking a little oftener than twice per second—and the body moves through the water at the rate of about one foot in ten seconds. An animal swimming at the surface may produce a small ripple. The orientation of the body, as Holmes ('10) and McGinnis ('11) have pointed out is such that the ventral side is toward the source of light (hence usually uppermost), and *Eubranchipus dadayi,* like *E. ornatus* and *E. serratus,* will change its position so as to preserve such a relation if it is placed in a glass dish and a light moved about it in various positions. Calman

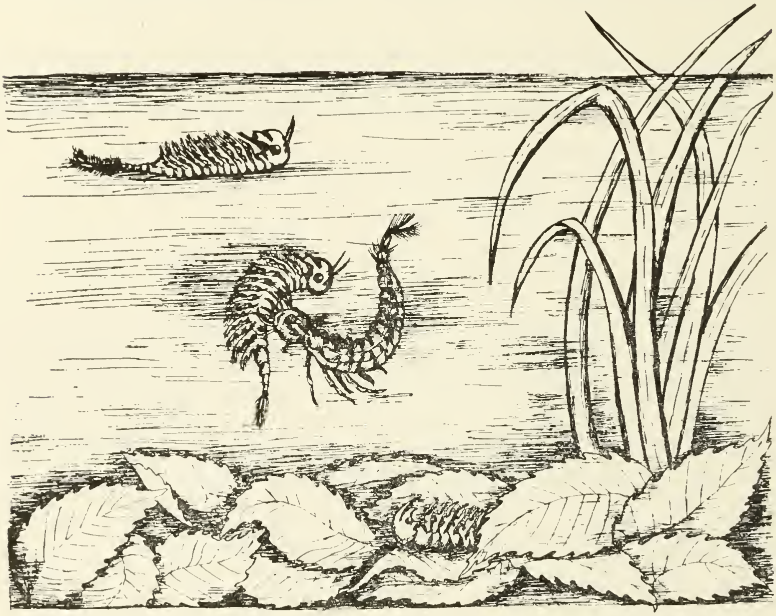

Fig. 1. *Eubranchipus dadyi.* *One male is swimming near the surface of the water; another is being borne away by a dytiscid larva. A female lies among the leaves on the bottom.*

('11, p. 163) suggests that the fairy shrimps are better protected from their enemies by swimming upside down, the delicate appendages thus being less readily injured.

When tested in a rectutangular glass dish in the laboratory, individuals of this species proved to be positively phototropic,—

*The figures in this paper were drawn by Miss Barbara Bradley.

thus agreeing with other representatives of this genus (Holmes, '10; McGinnis, '11; Howland, '11). They sometimes reacted to moving objects above the water by darting to the bottom of the dish, but were frequently indifferent. In nature the males swam everywhere without regard to shadows, but females showed a tendency to remain in shaded situations, such as the underside of sticks, when above the bottom of the pool. McGinnis ('11) found that *Eubranchipus serratus* (when tested in the laboratory) avoided shadows and remained in the light, even when there was only a narrow illuminated band through an aquarium.

Like all fairy-shrimps, *Eubranchipus dadayi* shows marked sexual dimorphism. In the males the second antennae are two-segmented and form Y-shaped clasping organs; whereas in the female these appendages are short, conical, and consist of one segment. Furthermore, females are readily distinguished from males by the large egg sac which projects from the ventral surface of the body just back of the swimming appendages; a pair of small appendages, the copulatory organs, occupy a similar position in the male. Sexual dimorphism is not limited to differences in form only. The color of the sexes is characteristic and different. Males have a delicate translucent, almost transparent, creamy color, with reddish cercopods at the posterior end and white testes in the middle of the body. Females are reddish throughout. Both sexes may show more or less iridescent greens and blues, which are apparently "refraction colors," not due to specific pigments, and these are usually more intense and striking on the deep red background of the females. Packard ('78) speaks of red and white phases of *Eubranchipus vernalis* which may occur in either sex, but the writer examined more than a hundred and fifty specimens of *E. dadayi* without finding a "white" female or a red male.

The difference in color between the sexes is associated with difference in behavior. McGinnis ('11) found that *Eubranchipus serratus* was "positively geotropic in light and negatively geotropic in darkness," and the same is true in a general way of *E. dadayi*, when tested in the laboratory. Males are, however, less definite in their geotropic reactions than females, and though they often remained at the bottom in holes between the leaves for hours at a time, they commonly swam at the surface of the water or wandered boldly about "poking" between the dead leaves. Their transparency made them difficult to see, even when their location was approximately known. The most conspicuous parts of a male were the two white testes which could often be seen when the rest of the body was indistinguishable. The females were even more difficult to discover than the males, for they lurked on the bottom in spaces between the debris or lay on their backs "fanning" with their appendages. They were never seen to swim about in leisurely fashion like the males, and in moving from place to place they usually made quick darts from one shadowy hole to another. Occasionally a female was seen at the surface in the shadow of a floating stick, usually with the body at an angle of about 55° with the surface of the water and with the ventral side toward the bottom—a peculiar position. The coloration of the males is apparently adapted to their needs for they must wander about in order to find mates. That of the females also makes them inconspicuous, as they rest quietly in holes at the bottom, keeping their eggs from harm, or await a mate at the surface in the shadow of some shelter. The coloration of each sex is apparently adjusted to its behavior in such a way that it is well protected.

More males were observed and collected than females, but this may have been on account of the secretive habits of the latter.

A number of animals were seen in the pond where the fairy-shrimps occurred which might have fed upon them. Among these may be mentioned:—Tadpoles, *Dytiscus, Hydrophilus,* and wood frogs. On two occasions dytiscid larvæ were seen swimming with dead male Eubranchipi in their mandibles. Little was learned concerning the food habits of the fairy-shrimps. The contents of the stomachs of several males were examined with a compound microscope and found to consist of fine silt, minute organic particles, oil droplets, etc.; but there was nothing that could be surely identified.

Many individuals were brought into the laboratory and put in large glass dishes where they were observed from time to time, the sexes being kept separate. The males lay quietly at the bottom on their backs or swam about belly up; the females behaved in a similar manner, but spent more time at the bottom, and also sometimes swam about at the top of the water with the ventral surface down and the body inclined somewhat.

The males were for the most part ever ready to grasp females with their claspers if given an opportunity, and, when kept by themselves, were sometimes seen to clasp other males. If a male was placed in a dish with an unfertilized female he usually clasped her every few minutes until copulation took place, and sometimes even after that. Two often clasped the same female. After clasping, a male usually attempted to insert his penis several times before he was successful. He grasped the female about the body from the dorsal side in front of the egg sac and bent his own body underneath hers, first on one side of her, then on the other, until he finally introduced his penis or was shaken off. Males showed no preference (*i. e.*, right or left handedness) in the side of the female they first attempted to use or finally used. The average time that actual copulation occupied after the insertion of the

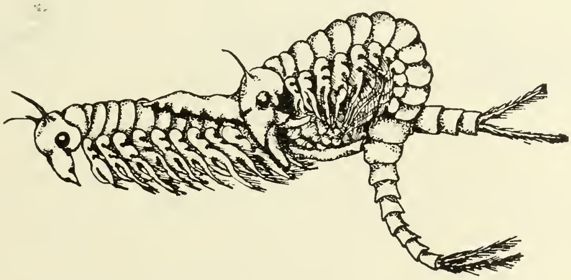

Fig. 2. *Eubranchipus dadayi.* Copulation.

penis was 1.88 minutes for twelve instances recorded. While a pair were *in copula* the male spread his frontal organs out along the female's back, and rather jerky rhythmical contractions could be observed in his vasa deferentia. Packard ('78) says that in *Eubranchipus vernalis* copulation is always terminated by the male giving a few jerks with his "post-abdomen," but in all cases observed by the writer the female wriggled away from the clasp of the male. Copulation took place at the surface of the water or in the bottom of a dish. After it was over the female always became quiet and lay on her back at the bottom for some little time. A white mass of sperm could be seen at the posterior ventral angle of her ovisac and sometimes a white spermatophore projected a little way from its opening. One female after copulation bent her head over and with her second antennae forced out the white mass inserted by the male. Perhaps the use of these antennae in female Eubranchipi may be to force eggs or sperm from the ovisacs. Their shape would suit them for such a purpose and is characteristic in each species.

A male that has copulated with a female and injected a sperm packet is soon ready to repeat the process. Several were observed to mate a second time within a few minutes. One male injected sperm into four different females during one hour and thirty minutes on April 24,—*i. e.,* at 8:45, 8:52, 9:48, and 10:10 a. m.

The females showed two conditions in regard to the position of the eggs in the ovisac. In some individuals the eggs were yellowish in color and were carried high along the sides (in the

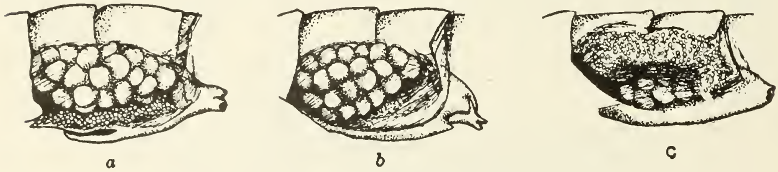

Fig. 3. *Eubranchipus dadayi*, showing egg-sac. *a*, unfertilized female; *b*, shows recently injected spermotophore projecting from egg-sac; *c*, egg-sac of a female that is ready to deposit eggs.

oviducts), thus leaving a clear space down the median ventral region; in others the eggs were larger, had a slaty color, and occupied the median ventral portion of the ovisac. Judging by observations on other species (Baird. '50; Packard, '78) the former were unfertilized and the latter fertilized females. Baird ('50) in describing his observations on the genus *Chirocephalus* says:— "The female begins to lay before she has attained her full size, and lays several times during the season. Each time the ova are transmitted from the internal to the external ovary the animal throws off its skin." Packard ('78, p. 422) in speaking of *Eubranchipus vernalis* says: "After copulating the eggs are emptied from the oviducts into the outer 'uterine' bag—where they undergo the process of segmentation." Packard also maintained that, "in both the red and white races attempts were never made by males on already copulated females with filled uterine bags." But the writer observed several instances in which males *attempted* to clasp females which had eggs in the median portion of the ovisac.

In order to ascertain what differences in behavior would appear when males were placed with the two types of females, tests were made in which twenty-four males and eighteen females were used. Six males and an equal number of females had been left in pairs in six small dishes for half an hour and five pairs had copulated. All these were dumped into a larger dish which contained eighteen other males and allowed to remain for five minues; the females were then removed. Six other females having the eggs in the median ventral portion of the ovisac were next placed in the dish with the twenty-four males and left five minutes; these were then removed and replaced by six females with eggs on the sides of their ovisacs, and were left for a similar period of time. The number of clasps and copulations in each case is shown in Table I. Females which had recently copulated or which had eggs in the lower part of the ovisac did not submit to the clasp of the males.

TABLE I.

Showing the number of times three lots of six females were clapsed or copulated with when placed with twenty-four males; five minuates for each lot. April 28, 1912.

Condition of Females.	Time, a. m.	Clasps.	Copulations.
6 females that had been with males for half an hour. Five of them had copulated.	10:40 to 10:45	11	0
6 females with eggs in median ventral portion of ovisac.	10:53 to 10:58	5	0
6 females with eggs on sides of ovisac.	11:10 to 11:15	10	3*

*) It was difficult to get females with the eggs on the sides of the ovisacs—apparently most had changed to the other condition. Of the three which did not copulate, one died immediately after the experiment, the other two were very small and although a male tried persistently to copulate with one of them, he was unable to do so.

Copulation apparently produces an immediate change in the physiological condition of the female. Her behavior is modified—she no longer swims or rests near the surface of the water, but goes to the bottom and remains quiet; she also resists (at least for a time) the clasps of the males.

All females carried on rhythmical movements within the ovisac. The organs within the chitinous covering rotated back and forth about the antero-posterior axis. Such movements were more rapid and pronounced in females carrying large eggs in the median portion of the ovisac. They doubtless help in the aeration of the eggs.

SUMMARY.

From the observations described it may be asserted that *Eubranchipus dadayi* shows certain adjustments to the conditions in which it lives. The coloration and behavior of the females are so correlated as to render them inconspicuous as they lurk among the dead leaves at the bottoms of ponds or wait for mates in the shadows of objects near the surface. The transparency of the males enables them to wander about with comparatively little danger of being seen; they are thus able to seek out and fertilize the females. As soon as a female has been provided with sperm she resists the advances of males, goes to the bottom of the pond in which she lives, and remains quiescent so that the eggs may descend into the ventral portion of her ovisac, undergo fertilization, and develop.

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Zoological Laboratory, University of Wisconsin,
Oct. 15, 1912.

SOME NOTES ON THE HABITS AND DISTRIBUTION OF WISCONSIN CRAWFISHES.

By S. Graenicher.

All the crawfishes inhabiting that portion of the United States and Canada lying east of the Rocky Mountains belong to the genus Cambarus. This genus has been split up by Dr. A. E. Ortmann[1] into five subgenera, three of which are represented in the fauna of our state. The following seven species of Cambarus (sens. lat.) are known to occur within the boundaries of Wisconsin:

Subgenus **Cambarus** (sens. strict.) Faxon.
1. **C. gracilis** Bundy.
2. **C. blandingi acutus** Girard.

Subgenus **Faxonius** Ortman.
3. **C. propinquus** Girard.
4. **C. rusticus** Girard.
5. **C. virilis** Hagen.
6. **C. immunis** Hagen.

Subgenus **Bartonius** Ortmann.
7. **C. diogenes** Girard.

In the collection of the Public Museum of Milwaukee all of these are represented with the exception of *C. rusticus,* no specimens of which have been seen by the writer from any part of the state, although a sharp lookout has been kept for this species during the past three years.

According to previous records[2] it occurs in Racine Co., Sauk

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1) A. E. Ortmann. The mutual affinities of the species of the genus Cambarus and their dispersal over the United States. Proc. Am. Phil. Soc. Vol. 44, pp. 91-136, Pl. 3.
A. E. Ortman. Procambarus, a new subgenus of the genus Cambarus. Ann. Carn. Mus. Vol. 3, No. 3, pp. 435-442.

2) W. F. Bundy. The crustacean fauna of Wisconsin. Geology of Wisconsin, Vol. 1, pp. 402-405.
See also J. Arthur Harris. An ecological catalogue of the crawfishes belonging to the genus Cambarus. Kans. Univ. Sc. Bull. Vol. 2, No. 3, pp. 51-187, Pl. I.-V.

Co. (Ironton), Rock Co. (Beloit), and in the Fox River. The Lake Superior record (Hagen) is considered doubtful by Dr. Ortmann.

C. gracilis Bundy. Dr. P. R. Hoy of Racine found this species in the prairie region of Racine Co., and its range, as given by Dr. Ortmann is from "eastern Kansas through Missouri to Illinois, Iowa, and southern Wisconsin." There are fifteen specimens, males and females, in the collection of the Public Museum of Milwaukee, which were taken on July 1, 1910, from a swamp at St. Francis in Milwaukee Co., a short distance south of the city limits of Milwaukee.

C. blandingi acutus Girard. From a southern center of distribution the typical *blandingi* has migrated northeastward along the Atlantic coastal plain, while the form *acutus* has taken a northward course up the Mississippi Valley (Ortmann). In Wisconsin it has been previously reported from Racine and Sauk Cos. Pearse[3] found it in southwestern Michigan; from Minnesota there is, so far as our knowledge goes, no published record.

Specimens are on hand from the following localities: Pond in Mitchell's woods, Milwaukee Co., April 2, 1910, and April 13, 1910. Pond in Johnson's woods, Town of Wauwatosa, April 11, 1911.

Creek running through the prairie about a mile east of Corliss, Racine Co., May 15, 1910 (males and females).

Slough connected with the Mississippi River at Fountain City, Buffalo Co., August 15, 1910.

A male was taken, together with specimens of *C. virilis* and *C. propinquus* on Oct. 9th, 1910, from a creek west of Wauwatosa, a tributary of the Menomonee River.

It is a species belonging to both the Lake Michigan and the Mississippi drainage, and is found in various kinds of habitats. The pond in Mitchell's woods, referred to above, is a permanent one, and belongs to the type of pond mentioned by Williamson[4], as being the favorite haunt of this species. The pond in Johnson's

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3) A. S. Pearse. The crawfishes of Michigan. Mich. Geol. & Biol. Surv., Biol. Ser. Publ. 1, pp. 9-22, Pl. I.-VIII. (1910.)

4) E. B. Williamson. Notes on the crawfishes of Wells County, Ind., with description of a new species. 31. Ann. Rep. Dept. Geol. & Nat. Res. Ind. Ind., pp. 749-763, Pl. 35. (1907.)

woods, on the other hand, is one of the upland variety that receives its water from the rain and melting snow, and dries out regularly toward the middle of the summer, thereby forcing its crawfish inhabitants to resort to burrowing. Specimens of *C. immunis,* and *C. diogenes* have been taken, together with *C. blandingi acutus* from the same pond and on the same date. The slough at Fountain City contained little water at the time, and may have become entirely dry later in the season, while the creeks near Wauwatosa and Corliss, mentioned above, are running throughout the year.

C. (Faxonius) propinquus Girard. This is a species of the lakes and permanent streams, and is quite common in the eastern part of the state, especially so in bodies of water draining into Lake Michigan. It occurs throughout the State of Michigan (Pearse), and in the Mississippi drainage of Illinois, Iowa and Minnesota (Ortmann). As to its connection with the Mississippi drainage in our state, it has been formerly reported from Green Co. (tributaries of the Pecatonica river), and Madison (tributaries of the Rock River). The writer has taken it on April 10th, 1910, in Okauchee Lake, Waukesha Co. (draining into the Rock River), but has not come across it anywhere along the St. Croix and Mississippi rivers, although collections were made at various points between the headwaters of the St. Croix river and Rutledge on the Mississippi river in the southwestern corner of Wisconsin.

Around Milwaukee males and females have been found as early as March 13th, 1910, in the Menomonee river, a tributary of the Milwaukee river, and on various other dates throughout the season in both of these streams. This species occurs also in Oak Creek, a small stream flowing into Lake Michigan near South Milwaukee.

We have specimens from Lake Michigan, collected at Newport, Door Co., on August 6th, 1910, and some from Cedar Lake in Washington Co., and the outflowing Cedar creek, a tributary of the Milwaukee river.

C. (Faxonius) virilis Hagen. This is undoubtedly the most common and widespread of our crawfishes, and the one most frequently used for food. Like the foregoing, it inhabits the lakes and streams with a constant supply of water, and may be expected to occur in any suitable habitat within our state, since it has been found in all of the neighboring states, and extends its range northward as far as Lake Winnipeg.

The following localities have been given heretofore: Appleton, Outagamie Co. (Fox River); Ironton, Sauk Co. (Baraboo River); Sauk City, Sauk Co. (Wisconsin River); Milwaukee Co.; Green Co. (Sugar River); Rock Co. (Rock River); Jefferson Co. (Lake Koshkonong).

Along our western border it has been collected at the following points:

St. Croix river—

Mouth of the Yellow river, Burnett Co., Aug. 2, 1909.
Randall in Burnett Co., Aug. 6, 1909.
North Hudson in St. Croix Co., July 8, 1910.

Mississippi river—

Prescott, Pierce Co., July 19-25, 1910.
Maiden Rock, Pierce Co. Specimens from the mouth of the Rush river and from Lake Pepin, Aug. 1, and 2, 1910.
Fountain City, Buffalo Co., Aug. 15, 1910.
Wyalusing, Grant Co., July 21, 1911.

From the eastern part of the state we have quite a number of records. In Milwaukee County it has been taken from the Milwaukee, Menomonee and Kinnickinnick rivers and some of their tributaries, as also from Oak Creek at South Milwaukee. The earliest date of capture is March 20, 1910 (Honey Creek, a tributary of the Menomonee river, joining the latter near Wauwatosa), the latest date is Nov. 11, 1911, when a large male was found on the beach of Lake Michigan near Lake Park, Milwaukee.

Additional localities in eastern Wisconsin are as follows: Newport, Door Co., August 6, 1910; specimens from Lake Michigan. Suamico; specimens from Green Bay bought in the Milwaukee market Sept. 30, 1912. Corliss, Racine Co., May 15, 1912; taken together with *C. blandingi acutus* and *C. diogenes* from a creek in the prairie, about a mile east of Corliss.

From the interior of the state specimens are on hand from Okauchee Lake in Waukesha Co. (April 10, 1910), and Golden Lake in Waukesha County (Oct. 16, 1910).

C. (Faxonius) immunis Hagen. In Michigan it occurs in the southern part of the state (Pearse), and in Minnesota it was found in a tributary of the Mississippi river in Hennepin County. In Wisconsin previously reported from Milwaukee.

Regarding its occurrence in Ohio, Williamson refers to it as "an inhabitant of mud-bottomed streams and pools, from which the water disappears early in the season."

Three females with eggs were taken in the exceptionally early spring of 1910 from a pond of this type in Johnson's woods, Town of Wauwatosa, on March 20th, and four days later one male and three females, two of which carried eggs, were obtained from the same pond. On the first mentioned date the greater part of the surface of the pond was still covered with melting ice, but there was a broad belt of open water along the margin. At Ann Arbor, Mich., females with eggs were found on April 18, 1909 (Pearse).

In the neighborhood of Milwaukee this species seems to be rather common, and we have specimens from two different ponds in Johnson's woods taken on the dates given above, and on April 2, 1910, and April 11, 1911, as also from ponds in Mitchell's woods southwest of the city captured April 2, and April 13, 1910.

As already mentioned in the discussion of *C. blandingi acutus*, males and females of *C. immunis* were found in a creek running through the prairie near Corliss in Racine Co. on May 15, 1910.

Above the juncture of the Chippewa river and the Mississippi river the latter broadens out to a lake-like body of water called Lake Pepin. Along the Wisconsin side of Lake Pepin north of Maiden Rock in Pierce Co., the water is extremely shallow, and in many places the bottom is covered with a dark, sticky mud. In the summer of 1910 the water in the Mississippi river was extremely low, and males and females of *C. immunis* were found on August 3, and 9, in burrows along the wet shore, quite a distance from the lake. Maiden Rock is about 50 miles southeast of Hennepin Co., Minnesota, the only locality in that state from which *C. immunis* has been reported.

C. (Bartonius) diogenes Girard. This, our typical chimney-building crawfish has a wide range of distribution, extending from the Atlantic coastal plain in the east through the central states to Wyoming and Colorado in the west, and southward as far as Louisiana (Ortmann).

In Michigan it occurs, according to Pearse, throughout three-fourths of the southern peninsula, and in Minnesota it has been found in the Minnesota River at Fort Snelling in Hennepin County. Previous records from Wisconsin are as follows: Green Co. (tributaries of the Pecatonica river); Racine Co.; Appleton in Outagamie Co. (tributaries of the Fox river).

On March 20th, 1910, two females with freshly hatched young were found in a temporary pond in Johnson's woods, Town of Wauwatosa, together with females of *C. immunis* carrying eggs as reported above. (See *C. immunis*). Females have been taken on various dates in March and April from ponds that dry up later in the season situated in Johnson's woods and Mitchell's woods (southwest of Milwaukee).

On May 1st, 1910, four young of this species were found in a small ditch near the tracks of the electric car line at Sunny Slope in Waukesha Co.

Females carrying eggs were come across as late as May 15th in the creek running through the prairie east of Corliss in Racine Co. and a male was captured on the same occasion.

The following additional records are given: One male March 21, 1910, from the Menomonee river near Wauwatosa. A male specimen from Green Bay (Suamico) bought in the Milwaukee market Sept. 30, 1912. Prescott, Pierce Co., July 19, 1910, one male from a burrow. Maiden Rock, Pierce Co., Aug. 3, 1910, two males in burrows along the shore of Lake Pepin. Fountain City, Buffalo Co., Aug. 15, 1910. Genoa, Vernon County, July 9, 1911. Wyalusing, Grant Co., July 21, 1911.

The five last named localities are situated along the Mississippi river; Prescott, the most northern of these, lies about 25 miles below Fort Snelling in Minnesota, from where this species has been reported.

Public Museum, Milwaukee, Wis., Dec. 4, 1912.

ECONOMIC AND BIOLOGIC NOTES ON THE GIANT MIDGE:

Chironomus (*Tendipes*[1]) *plumosus* Meigen.

By A. C. Burrill.

Entomologist's Office, Madison, Wis.

CONTENTS.

INTRODUCTORY.

Much has been written of the economic importance of the mosquitoes (*Culicidæ*) in the recent decades, but only in later years has entomological literature recorded economic facts about their near relatives, the *Chironominæ* of the family of midges, *Chironomidæ*. Most of the bibliography of the latter deals with the taxonomy of midges and notes in catalogues. Thus we have for *C. plumosus* a long list:

Goedart	1669, pl. x	Higginson	1867, 174
Frisch	1730, pl. 3	Rymer	1868, 99
Linnaeus	1758, 587	Van d. Wulp	1877, 249
	1761, 434	Siebke	1877, 193
	1767, 974	Cox	1878, 261
DeGeer	1776, 379	Osten Sacken	1878, 21
Fabricius	1781, 406	Korschelt	1884, 189
	1787, 324	Meinert	1886, 438

1) Johannsen (1908, 264) says, "If Meigen's 1800 name is accepted, *Tendipes* will replace the genus name of *Chironomus*." We are hardly anxious to change without a clear case for *Tendipes*. Kellogg (1908, 673) translates "*Chironomus* (one who moves hands in gesticulations) [symmetrical spreading of feet when at rest]", both translations true of adults' use of forelegs. Compare Higginson, 1867, 177.

Gmelin	1792, 2820	Neuhaus	1886, 2
Fabricius	1794, 242-3	Riley	1887, 503, 592.
Geoffroy	1799, 560	Giard	1888, 299
Schruk	1803, 70	Mik	1889, 95
Meigen	1804, 11	Fedtschenko	1891, 181
Latreille	1805, 289	Levi-Moneros	1891, 7
Fabricius	1805, 37&c	Theobald	1892, 177
Latreille	1809, 249	Kow	1894, 1
Meigen	1818, 20-1	Strobl	1895, 186
Macquart	1826, 193	Van d. Wulp & Meij.	1898, 17
Meigen	1830, 243	Jacobs	1898, 58
	1830, pl. 4	Strobl	1898, 613
Macquart	1834, 48	Thalh	1899, 14
Zetterstedt	1838, 809	Vignon	1899, 1596
Staeger	1839, 557	Kertész	1902, 198-9
Westwood	1840, 508 514-16, app. 125	Johannsen	1903, 432-6
Grimmerth	1845, 298	Austin	1904, 1-2
Walker	1848, 10	Aldrich	1905, 113
Zetterstedt	1850, 3481	Johannsen	1905, 80, 82- 6, 186-9, 197, 236-8
	1852, 4345		
Staeger	1854, 557	Kieffer	1906, 21
Zetterstedt	1855, 4838	Kellogg	1908, 310-11
Walker	1856, 171	Williston	1908, 110-11
Van der Wulp	1858, 8	Johannsen	1908, 277
Schiner	1864, 601		

The author and date refer to full citation in alphabetic bibliography at end of paper; following the comma is the more important page or plate reference.

Much of the remainder of Chironomid literature has to do with the economic value of Chironomid larvæ, pupæ, and adults as the food of fishes,[2] and frogs (Needham, 1905, 13), for which they form an important diet, often the major portion.

Besides their occurrences in both shallow[3] and deep[4] fresh

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2) Smith 1874, 693, 708-9.
Forbes 1870-1890, 483.
1891, 228.
Garman 1896, 158 including *plumosus* specifically.
Howard 1908, 110.
Washburn 1905, 53.
Johannsen 1903, 432.
1905, 79.
Needham 1903, 203, 204, 206.

3) Chautauqua Lake, N. Y., Riley 1887, 503; quoted by Howard 1908, 110.

4) Lake Superior at nearly 1000 ft. depth, Smith 1874, 693; quoted by Howard 1908, 110; and Washburn 1905, 53.

water lakes, they are found in salt lakes[5] and even twenty fathoms deep in the Atlantic ocean,[6] so that they form a widespread supply of fish food, that is, if the fishes of these different habitats shall be proved to eat them. For the fresh water lakes we can state with certainty that (Needham, 1903, 209) a "constant succession of generations through the year, leaving no period of absence of the larvæ from the water constitute the claim of these larvæ to economic importance," a paraphrase on Garman (1896, 155-6, 159) who adds, "Some species, at least, are found in water when cold weather comes in the fall, and doubtless remain in the larval condition till the next season—even under the ice in winter."

The genus *Ceratopogon*, which includes the gnats called "punkies" and, occasionally, "sand flies," has also a growing literature on annoyance to man and beast. Hardly a word has been said, however, about the annoyance which midges of the genus *Chironomus* may cause to man or beast, especially at the height of the midge season. In fact, some authors state that besides fish food "the family has no other economic importance" (Howard, 1908, 110) and (Smith, 1900, 626) "as a rule they are harmless, except for the annoyance caused by the biting tribes, but the larvæ of one species at least mines the leaves of water-plants and thus becomes injurious in a very limited and special way." Apparently most of the writers have not considered that the very numbers of these creatures may become annoying or obnoxious on occasion. Osborn (1896a, 405-7, quotted in Osborn 1896b, 30) does speak of a "species which has been present in great numbers in the water mains of Boone, Iowa, and which occurs in water tanks and reservoirs" and notes a letter, July 1895, from the Chairman of the Water Commission relating how it came there, through failure of the city artesian pumps, necessitating pumping through hose from a 45′ vein into a large cement-lined reservoir, containing immense numbers of larvæ. The latter "were drained into the mains at times when the reservoir was low, doubtless due to the formation of strong currents over the bottom. Specimens have also been received from Des Moines," Ia. Osborn considers that their quondam use in clearing water of organic matter in

5) Washburn 1905, 53, as the Great Salt Lake, Packard 1871a, 41.
6) Packard 1870, 230; 1871a, 41; 1871b, 133; 1871c, 100 stating catch at Eastport, Me.; and quoted by Howard 1908, 110; and Washburn 1905, 41.

reservoir or mains is more than offset by the imminent danger of becoming so numerous in hot weather as to prove on dying, a source of pollution; while less important, "the presence of masses of such 'ugly' looking creatures would be objectionable" even though they "in themselves could be considered harmless."

The superabundance of any insect may be an annoyance to man just as truly as we affirm for a weed defined as a "plant out of place." The idea that superabundance in any creature constitutes a pest to man wherever its numbers come in man's way is but gradually meeting with acceptance in this country. A comparable case with its inevitable conclusion which I wish to apply to midges is cited by the well-known observer, Dr. Sylvester D. Judd (1901, July 3, p. 35). Speaking of the Marshall Hall, Maryland, opposite Mt. Vernon, Virginia, he says "during May, 1899, the May-flies which emerged from the river, became a plague, alighting upon the farm buildings and literally covering them, frightening the horses, annoying the workmen, and infesting the farmhouse in such swarms that it was well-nigh uninhabitable........May-flies do not ordinarily become obnoxiously abundant, but when they do, even their function in furnishing subsistence to valuable food fishes does not save them from being ranked as pests, the destruction of which is beneficial." Once granted that this annoyance may become occasionally serious, a study of the creature's habits and of methods for its control may be supposedly welcome and timely.

I shall attempt to set forth a few facts, indicating to what extent the giant midge may become obnoxious to man, so far as I have been able to gather data, and at the same time combine field notes on this 'roaring' midge which have appeared in the literature in previous years but have not, I believe, been accredited usually to a definite species. The data compared with the habits of other midges may be said to furnish materials for a monograph of the Giant Midge, since the only monograph published on a boreal midge, "The Harlequin Fly, *C. dorsalis*" (Miall and Hammond, 1900) lacks much in field notes for American students, however complete it may be for the English student. Dr. A. Thienemann's (1911 380-2) proposed task of restudying all the species and of working out the life histories for all is indeed well-timed and brilliantly conceived.

LIFE HISTORY.

Habits: Swarming Time and Notes on Flight.—Attention was first called to this species in Wisconsin during a cavalry trip from Milwaukee around Lake Winnebago, Wisconsin, and return, August 12th to August 21st, 1910. The experience of these cavalrymen (Troop A, W. N. G.) proved an object lesson in the obnoxiousness of midge habits at swarming time.

July and the first part of August had been unusuallly dry, but on August 16th, rains changed the roads to mud. That afternoon we encountered for the first time large numbers of midges south of Neenah. Some midges were undoubtedly in the city section of Neenah at noon time, but were too scattered to be noticed until the evening, when street lights attracted the midges to definite points. As the line of calvary swung down the road south of the city towards the Neenah riflemen's camp ground, several large midges were noticed flying around and, on coming to a thick clump of roadside bushes and trees, hundreds of these midges swarmed out and buzzed in the air about the men so that no one could help remarking their abundance. Troopers were inclined to fear them as giant mosquitoes with proportionately enlarged biting propensities. But no one was bitten as it developed, for they were without the mosquito beak and were more strikingly colored, with yellow and black-banded abdomen and gracefully plumed antennae on the males.

The material later collected was determined for me by Doctor O. A. Johannsen[7] of the Maine Agricultural Experiment Station, Orono, Maine, in a letter of September 30, 1910, stating, "*Chironomus plumosus*, a widely distributed and not uncommon species," the word "*Chironomus*" meaning one who moves hands in gesticulation, for the adults (Johannsen 1905, 81) "have a peculiar habit of holding their forelegs high above the surface upon which they stand, while the mosquitoes usually hold up their hind legs." They seem to use "their front legs as feelers" (Howard 1908, 110), keeping them "constantly vibrating" (Williston 1908, 111) as was observed at Lake Winnebago. There are times, however, when they are resting that they are quite motionless.

7) Prof. Johannsen has also obliged me in proposing in a letter, Jan. 4, 1912 (at my request) the common name "Giant Midge."

Beyond this first clump of road-side trees, every succeeding clump of bushy vegetation along the country road added its quota of hundreds of midges which would buzz noisily out at us like the singing of telephone wires but much louder, and would tend to follow us, some alighting on the horses, on their dark manes, flanks, and tail, but failing to light to any numerous extent on the light khaki of the troopers, a response to color like the tsetse fly of Africa, which prefers dark clothes and dark skins to light clothes and white man's skin. Our horses were mostly a dark roan color, and on them these midges would rest for several minutes. When alighting on the men, they took to their wings immediately in most cases. Where there was a considerable hedgerow of tall weeds, small trees and bushes, the whole troop would be enveloped in buzzing, flying swarms, which beat into the men's faces, getting into their eyes, ears, and noses, but especially mouths, in a most disconcertingly familiar way. In fact, the larger nostrils of the heavily breathing horses were regular flues up which these midges were sucked, until the whole line of horses would frequently be sneezing and coughing at once. Meantime, troopers were ducking to cover their faces or swishing the midges away with their hats. It was then noted that the swarms did not really follows us, that most individuals did not fly very far from where they had been disturbed, unless they were carried along while resting on the horses, but seemed to return towards their former roosts.

Further along we could see ahead of the column (my position that day was in the twelfth pair, "By two's!", from the head of the troop, about forty-five meters) scant irregular swarms made up of a few individuals flying lazily in front of a clump of road-side trees and usually on the shady side of the clump. As soon as the first pairs of horses passed such a scant swarm, the midge myriads would suddenly swarm out around us, greatly increasing this lazy flight to a remarkable darting speed. This sudden flight suggested that the vibration of their wings may not have increased as much in number perhaps, as the strength of wing beat had been increased to carry them further during their evident agitation.

These midges were noticed for much more than a mile of roadway, swarming from the taller vegetation only, none flying from the grass. When we pitched camp in the short grass of a treeless pasture, we found the midges there still avoided grass but sought whatever vegetation was slightly taller, all weeds one and a half decimeters to a meter in height, such as mullein, goldenrod, and small bushes or stool shoots of old stumps. The under sides of the mullein leaves, etc., and even the upright stems were actually dark with these numberless midges. When some of the troopers started through a knee-high sedge marsh back of camp to go bathing in Lake Winnebago, a quarter mile to the rear, we were so beset by swarms of thouusands that we began to run involuntarily; so sudden was their onslaught that we had no time to reflect if these were new swarms of real mosquitoes in the wet lands or of the same midge as had previously come from the trees. As the men ran over the rough land, they became out of breath, and, when opening their mouths to gasp breath, were sure to choke with the annoying little flies. Then they realized the folly of their actions, and finding only midges and no bites, came to a walk and swinging of hats with better results.

Suggestive of this account is the story of Dr. Asa Fitch (1874, May, 282; quoted by Lintner, 1882, Jan. 12, 13, and reproduced by Lintner, 1885, 243), probably an experience of his own on April 27, 1846, with a little midge *C. nivoriundus*. "On one occasion, in traversing a forest, it was observed in such countless myriads as to prove of the greatest annoyance to the tourist, getting into his mouth, nostrils, and ears at every step, and literally covering his clothing" (probably dark clothes?) and so continuing for above a quarter of a mile near an adjacent swamp, whence, he thinks, they may have come. Kirby and Spence (1858, 60-1) quote authors on similar plagues of *Tipulariæ* (of Latreille, the former systematic position of the *Chironomidæ*). "In Lapland their numbers are so prodigious as to be compared to a flight of snow, when the flakes fall thickest, or to the dust of the earth. The natives can not take a mouthful of food or lie down to sleep in their cabins, unless they be fumigated almost to suffocation. In the air you can not draw breath without having your mouth and nostrils filled with them."[8]

8) His footnote cites "Acerbi's 'Travels,' v. 2, 5, 34, 35, 51.
Linn. 'Flor. Lapp.' 380, 381.
Larch. Lapp. v. 2. 108.
De Geer, v. 6. 303, 304."

As soon as the higher and dryer lake shore terrace or ridge was reached by the troopers, hardly a midge was encountered in the bright sunlight, and even in a forested section of the lake bank, there seemed to be no midges at the level of passing people. In this case, possibly, they had sought to rest in the tree tops, as clouds of midges were seen there above the groves later in the evening.

Towards dusk, swarms of midges began to appear in ovoid or irregular masses often as big as a cabin, flying above our campground, many getting in our mess plates and cups (cf. Kirby & Spence, 1858, 60-1, already quoted), but chiefly forming great dancing clouds over the marsh at our rear, over the cornfields next in front of the camp grounds, and over the woods already mentioned, suggesting brown smoke rising from brush fires at twilight. Schuster (1904, 345) says: "The effort of the dancing swarm to poise over some prominent object was impressive. As we approached the nucleus of the swarm zone and became the highest point on the hillside, the chief swarm moved towards us and danced over our heads so that the column towered directly above us so long as we kept still, but by our moving apart, it poised between our heads and the lower end of the column occupied a space a meter broad." In comparison my own observations, about 7 p. m., show that midges tended to hover over the troop camp at different points, but the swarms were not stable for long. Schuster continues, "If we made quick motions the swarm dashed instantly one to two meters higher in the air, but as soon as we became still, they dropped down nearer again." This ready response of the swarm would seem to explain why the midge swarms failed to hold stable forms about a hustling camp.

The smoke-like appearance is heightened by the "wavering dancing" (Howard 1908, 110) of the swarm. Westwood (1840, 515) mentions their "immense cloud-like swarms" and the performance of their "aerial dances, composed for the most part of males," and Washburn (1905, 52) suggests "calling them 'Sunset Flies' since they are wont to appear in clouds just before or after sunset, preferably in damp places, about water in the woods, and elsewhere, though one meets with them in all localities." Neither writer connects the habits with any species as *plumosus,* nor Kellogg (1908, 310) "dancing time, when they collect in great swarms and toss up and down in the air over meadows, pastures, and stream sides." Evidently, then, the midges did their flying normally at dusk, instead of mid afternoon, except where they could secure the advantage of shade or a cloudy morning as we observed to occur next morning. It is concluded that they begin to form up for the nightly dance above the taller vegetation of the region; whether trees, crops, or high grass tufts, seems to make no perceptible difference. In some cases the cloud of midges near the woods would stretch out in a wavy layer nine to two yards thick, about 100 yards in length, and with a width I could not estimate for, seeing it in side view. This formation was of short duration as the midges would ball up in the thicker clouds noted above.

On going down town after mess, observations of the midges were continued till almost midnight. There was bright moonlight so that the midges could be seen flying over the woods as late as that hour. Schuster's (1904, 344-5) note on the swarms of the same species, July 16, 1904, by a pond near the town of Lich, northwest Germany, states that the swarm discovered at 8:45 p. m., varied greatly in shape; and he, likewise, likens it to smoke—"a heavy black cloud of smoke," easily seen at 300 meters distance. He says "the whole air was filled with thousands upon thousands of midges flying around in every direction, so that one had to close his eyes amidst the mass of flying insects. The sight of numberless interweaving hordes wavering up and down is indescribable." Then there was a swarm amidst these "which had the form of a column and a height of 10-15 meters, was stationed above the highest bush of a hedge extending along a hillside. A second but much smaller cloud danced about 300 meters distant from the main swarm over an oak, and a third above the hilltop itself. .these three as thick as black clouds. .The form of the cloud changed every second. Now the nucleus was at the upper now at the lower end; now the column parted in two, then the parts united again. The midges danced in clouds rising and sinking and all the time with a peculiar jerking flight." Once or twice only did the irregular cabin-sized masses I witnessed rise at all like towering smoke, or a column as Schuster calls it, and then not long enough to be recorded as a normal formation. Knab (1906, 127-9) cites many such columns from early literature.

perhaps all referring to Culicids, as, for example, Dale (1883), "countless numbers of flies or gnats, dancing in a partly perpendicular column." The latter was at 8 p. m., July 14, 1833, in Kensington Garden, where unidentified humming gnats formed a column two or three feet in diameter and twenty feet high, like an inverted J, curved to the east, all gnats in most lively motion.

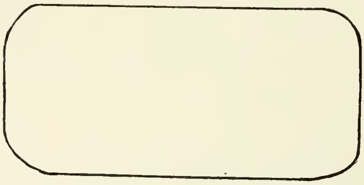
Swarms about brightly lighted windows.—While down town I noted that thousands of them were attracted to the brightly lighted store windows of Neenah, so that all passersby remarked the sight. On the outside of a drug store window a few were caught in a bottle, from which the identifications of alcohol material were made, the specimens being subsequently so jarred on horseback as to be worthless for permanent preservation. At the same time many smaller midges appeared on the window panes, some colored pale Nile green, others light brown, and even deep red, similar to those previously collected on the lake shore at Whitefish Bay, Wisconsin, 1910, and awaiting identification at the Milwaukee Public Museum (discussed in a paper before the April 4, 1912, meeting of the Wisconsin Academy of Sciences, Arts, and Letters, Madison Wis.).

C. plumosus, however, had by far the majority of individuals on the window pane, and being much larger than any of the others, was the only one noticed by the ordinary passerby. Yet the numbers of this midge on the windows of the stores was in no way comparable with the immense swarms outside the town, despite that some windows were completely checkered over with them. Only the very brightly lighted windows brought them in any numbers, and owing to the negatively phototropic observations made previously in daylight, I am in doubt what sort of actinic effect the electric globe lights had on them.

Lateness of the Hour of Dancing.—Towards midnight the amount of buzzing was greatly lessened although swarms of them were still easily visible in the bright moonlight at distances of a 100 rods or so, and the pitch of the note remained the same. Schuster (1904, 345) notes that the dance was at an end by 9:30 p. m.

When we arose in the morning about 5 a. m., we found hundreds of the midges in our shelter tents, hanging all over the underside of the tent canvas.

Flight Movements of the Individual.—Three or four of the troopers spent a little time after mess the same night in studying the flight movements of this midge. We saw that this fly has the power of flying backward as well as forward; that is, that there is a complete reversal of motion without turning the body around, so that it can dart backward rear-end first at nearly the same high speed that it can fly forward. Usually in the main swarms, the course of the individual flight was that of a pretty fair oval in a



plane always perpendicular to the ground. But some of those darting rearwards for whatever reason, could take a backward flight in almost a straight line. Wheeler (1899, 373) notes what are probably other species "often seen on summer evenings moving up and down for hours over the same spot. If the observer stand with such a swarm between himself and the setting sun he will see the tiny flies orient themselves to every passing breeze." This was not uniformly true of *C. plumosus,* since something like 5% of the flies were interweaving flights throughout the swarm, in a manner to break up the fair uniformity of body direction or orientation.

Westwood (1840, (506), probably referring to midges, as he says, "*Nemocera* of the smaller size") seems to have been the first to mention this body orientation and relegates his observation to a footnote, whether to make it the more conspicuous or to hide it for fear of inaccuracy, others must decide,—saying, "I have observed that in these dances the insects always fly with their heads toward the quarter from which the wind blows." Ainslee (1907, 28) notes the same habit in a Tipulid and generalizes for all weak-winged flies. He describes the individual Tipulid's flight as in three movements, repeated continually, viz.: a slow curving rise for 2.5-3.5 dm. (10 or 15 inches), a rapid perpendicular fall, and a peculiar swaying flight that affected the exact position of the swarm in the air. In the same way I might divide my flattened ellipse above into four components, the flattened sides being over a meter long and the rise or fall at the ends 3-5 dm. Besides this was the reversed motion in the same horizontal plane and the separate wavy jerking of the whole swarm.

Fly on Cloudy Days.—August 17th proved a cloudy day so that the midges were still flying in swarms, though in lessened numbers, all along Lake Winnebago. It was perhaps as much due to the obnoxious quantities of midges as to the poor state of the camp ground that we took a hasty departure this day, despite the fact that we had planned to spend some time in special drills on horse and on foot.

Mating.—Walking or standing still amidst the swarms, I did not observe one case of mating where the pairs fall to the ground and the males return to the swarm (Miall & Hammond 1900, 183), although in most swarms of smaller midge species previously observed this feature was characteristic. I cannot account for my failure to see mated couples, having found it so easy to note in far tinier species.

Egg-laying vs. Legs with Gluey Drops.—Of those *plumosi* caught and others seen at ease after alighting, a few were discovered to have one or more mud-covered masses, like dried Le Page's glue drops, on one or the other of their hind legs, as if the leg in question had been broken and had had the body fluids ooze out and harden. These were probably all females, as those seen at rest were such. As the smashed bodies of these soft creatures did not seem to have enough fluid in the body either to make the amount or to color this gluey drop to the shade of Le Page's Glue, it may have been due to the disturbing of certain females so that they flew before their egg mass was wholly discharged (cf. Miall & Hammond 1900, 10; Howard 1908, 111); or less likely, it may have been some of the gelatinous larval case still adhering (Johannsen 1905, 187). As the eggs are laid in the late evening or early morning in a dark gelatinous mass (Howard 1908, 111) or egg-rope (Miall 1903, 146) it might not have been too early at mid-afternoon for some females to begin voiding. Balbiani (1885, 542, 1 and 2) figures the beginning and end of egg-laying of an unknown species, the egg-rope being attached to the side of a glass containing water. On touching the water in out-door conditions, the mother fly attaches the egg-rope to some object close to the water's edge (Higginson 1867, 176; Howard 1908, 111), the eggs not being arranged as in the *Culicidæ* (Westwood 1840, 515), and at once the egg-rope (Miall 1903, 146-7) swells "into an abundant transparent mucilage making the eggs so slippery that birds or insects can not grasp them; it also spaces the eggs, and enables each to get its fair share of air and sunlight." It must also be antiseptic as it "prevents water-molds from attacking the eggs. Long after the eggs have hatched out, the transparent envelope remains unchanged," having been found nearly an inch long "on the edges of a stone fountain in a garden, or in a water-trough by the side of the road." As to dimensions (Higginson 1867, 176) says the egg-rope is "cylindrical in form, not exceeding three-fourths inches in length and one-eighth inch in diameter, one end free," containing over 200 eggs. As to the time of year, Kofoid (1908, 286-7) found in the Illinois River, 1894-9, fragments of the egg-string of unidentified species "in all months but February and December, though twenty of the thirty records and 81% of the individuals appeared in May-August. The numbers are never very large, the maximum record, 5,424 per cubic meter (of water-tested) on June 29, 1894, being due to a number of fragments of egg-strings."

Breeding Grounds.—Without further opportunity to investigate at the time of observation, one would feel justified in saying that the midge swarms originated in and around Lake Winnebago, that they do not fly many rods from the point of emergence; as witness the less numbers at the Neenah store windows and no evidence of swarms over house yards or streets in town, (Fedtschenko, 1891, 181, notes their localised distribution)—that they find food enough in the "bloom" hereinafter noted, and other abundant organic matter, and have, we may suppose, something to do with the excellent fish supply of Lake Winnebago. Many of these matters need experimental proof and this preliminary paper, after noting such lacunæ, will best confine itself to further facts. Lake Winnebago is a shallow lake "28 miles long by 10 or 12 broad in its greatest width" (Marsh 1903, 2 and 3) and "it is probable that it is nowhere over about 25 feet in depth. It is evident to a superficial observer that the plant life during the summer is very large, and it has been assumed that the abundant production of fish is correlated with the plant growth,. .the lake may be considered simply as an expansion of Fox River. .At the south end the shore is swampy." This is worthy o fnote since larvæ and pupæ were collected from swamps at Cayuga Lake, Ithaca, New York, the former being blood red and about 22 mm. long (Johannsen 1905, 236-7; Westwood 1840, 516).

In a description of that part of the lake near which the midge observations were made, Marsh says, "The west shore of the lake is low, but not, to any considerable extent swampy, and is gradually being dotted over with summer cottages.........The bottom of the lake is generally composed of a fine mud filled with organic matter." (p. 6, do.) "Lake Winnebago can not be said to have an abyssal fauna, the animals of the bottom in the deeper parts of the lake not differing appreciably from those of the littoral region." Then follows a long list of species of *Entomostraca* and algæ without a word as to blood worms occurring in the larval or pupal stage in the plankton, though collections were made twice a day all summer and in winter. Dean E. A. Birge, director of the Wisconsin Geological and Natural History Survey, under whom the Winnebago studies were made, does not (1912) recall any Chironomids in the plankton; but Prof. Marsh (in litt. Feb. 2, 1912) states "*Chironomus* larvæ are very abundant in the mud at the bottom of Lake Winnebago; I do not remember to have found them in so great numbers in any other locality. I made no attempt to determine the species. I do not now remember that they ever formed a part of the plankton."

Marsh makes further remarks on the interrelations of animal and plant life, relations which must affect the abundance of *plumosus*, as follows (1903, 40): "The real determining cause for the maximum of *Daphnia hyalina* early in September, 1900, was the enormous number of *Anabæna, Clathrocystis,* and an unnamed alga." These algæ make up what is called (p. 36) the "bloom" or the "working of the lakes," a phenomenon (p. 37) "especially marked in Lake Winnebago in some summers. It is due, of course, to the enormous growth of the plants of the plankton, that growth being particularly fostered by the hot weather of midsummer. The plants especially concerned in forming the bloom are *Clathrocystis, Anabæna, Aphanizomenon, Oscillaria, Lingbra,* and *Gloiotrichia*.........Following the maximum period of the "bloom,"*Cladophora* appears and covers the littoral rocks with a thick mat of green."

The summer of 1910 was another marked season of the bloom, *Clathrocystis* being especially abundant. The lake was quite low and the rocky beach had masses of drying green scum, turned brown on the higher sun-scorched stones, still greenish nearer the water. The lake itself looked for more than a mile out like a sea of green paint. Is there any ground for the belief that the food supply has something to do with the green voidings of the adult? Cases among the insects are known where voidings are colored by the food eaten just as certainly as examples where the voidings differ in color from the food eaten. And it is also known that voidings may be green from other causes than the presence of chlorophyll. Thus the question may be dismissed as one for theoretical curiosity only, were it not for the practical need of ascertaining the food supply of the larva in tracing the life history of any insect, and also the economic nuisance made by the colored droppings. I therefore attempt a review of the literature dealing with the Chironomid larvæ.

Larval Food and Habits vs. Green Specks Made by Adults.— Papers on the internal anatomy of midge forms seem to throw no light on the question of excreta colors, a question primarily concerned with the nuisance of the adults. The only internal anatomy studying the alimentary canal of the species, seems to be by Vignon (1899, 1596-8) although Balbiani (1881) and Korschalt (1884) studied the salivary glands, and Folsom (1909, 91) shows the nervous system from Brandt (1879, 101), and Meinert (1886, 438) some other details of structure. But these authors fail to elucidate the query. Long before this, the metamorphosis of *plumosus* seems to have been worked out by Schubaert (1849, 1850, 1854), but remains, in the language of Holland, buried to most authors. Anatomical papers on the family in general are not cited in particular although reference must be made to them as they treat frequently of species which were not identified, and, on the other hand, detail structures that must hold for the whole subfamily. Thus the embroyology of *C. nigro-viridis* Macq. has been worked out by Dr. Weismann (1864,3) with 101 figures on seven copper plates, and Jaworowski (1882), and Kupffer (1866 and 1867); this species studied being the one to reveal pædogenesis

(Von Grimm, 1870, 1871). Balbiani (1882 and 1885, 243) worked four years on the embryology of a similar unidentified species, especially to trace the sexual organs. Jaworowski has worked out the development of the heart for near species (1880), as has Ritter (1890) for the reproductive system and intestines.

An examination of the droppings as found upon the shelter halves of our tents at 5 a. m., August 17, showed them to be of a dark green color. These green specks occurred on drinking cups, saddle equipment, in fact everything including the men's foreheads. The specks were larger than those of the common house fly, and were easily washed off from skin or metal, but in the dewy morning ran the green, like green paint stains, down our canvas and khaki, so that from then on the cloth part of the equipment looked quite "travel stained." With the excessive green algal formation in the lake where these midges arose, it is a question if the midges had fed in the prepupal stage on these algæ and retained green in the rectum as adults? Two authors mention this greenish fluid filling the stomach of both the pupa and adult (Miall & Hammond, 1900, 107; quoted by Johannsen, 1905, 78), placing in juxtaposition the observations, "The larvæ of *Chironomus* feed on dead leaves and other vegetable refuse. Microscopic examination of the stomach reveals a blackish mass of vegetable fragments, besides Diatoms, *Infusoria,* eggs of other aquatic animals and grains of sand." Still earlier Osborn wrote (1896a, 406), "the food is for the most part apparently minute aquatic organisms, ***algæ,*** etc., (the italics are mine). That the food does color the intestinal mass is averred by Packard (1871a, 43) for *C. oceanicus* which feeds "upon the fine sea-weeds, such as the green filamentous species.......Its food, then, mainly seems to consist of sea-weeds, the red kinds coloring the intestine and fæces brown, but it also probably consists in part of animal matter." As he did not note an individual eating wholly green algæ, it is not surprising that he fails to mention any green fæces in that species. In opposition to these statements of algivorous food stands Garman's (1896, really 1890, 158) that plant tissue is undiscoverable other than bacteria in fluviatile Chironomids. It is probable that this general statement refers in a very limited way to the particular species *C. plumosus* (ib., 160), but Garman also notes the colored intestinal contents (ib., 158), "Their digestive tube is often filled with a brown granular material consisting, as nearly as can be made out with the microscope, of decomposed organic matter containing great numbers of bacteria and a good many empty frustules of diatoms. In one example was found the fragments of an insect," and further discussion follows. Higginson (1867, 176) says they ate the chlorophyllous tissue of the grass blades bending into the water in an earthen garden pot. Were they starved to this through lack of algæ or through desire for a varied diet?

It is this feeding on organic debris and sediment accumulating at the bottom of a body of water (Folsom, 1909, 185) which brings them most often into stagnant water (Kirby, 1892, 221) and people do well to keep ornamental earthen water pots of the garden (Higginson 1867, 174), rain-water barrels and horse-troughs cleaned if they do not want to see, lying at the bottom, a vision of tiny red threads (Craigin, 1899, 279). Here they make larval cases of silk and mud or decomposing leaves (Howard, 1908, 110; Osborn, 1896a, 30; Reaumur, 1737, 179; and 1740, 29-39, 51, being the earliest account of their metamorphosis); or, in the case of those used by fish, a large deep-water "red larva" species in a loose gelatinous case (Needham, 1903, 208-9; Osborn, 1896a, 406), showing that Westwood may have meant another species than *plumosus* which he was reviewing when he said (1840, 516-7), "These larvæ assemble in a mass, and form tortuous [?] tubes which unitedly compose an irregular mass at the bottom of the water, formed of particles of decomposed leaves." Garman (1896, 158), summarizing several Mississippi species, says that they "commonly live at the bottom, under stones, and rubbish, where they construct galleries of agglutinated sand in which numbers live together.........They are extremely common and may be captured at night in surface nets literally by the pint." This points to the peculiarly nocturnal frequency of the following habit added by Miall (1903, 123), "Now and then they leave their burrows and swim through the water with a lashing movement, twisting themselves into figures of 8" (So Higginson, 1867, 174). "Occasionally they rise to the surface, as if to renew their supply of oxygen. They are careless about finding their way back to their burrows, for in a short time they can glue together enough fresh fragments to conceal themselves." Earlier observations of Cox (1878, 261-2) disagree with this, for, after criticising all older drawings for incorrect number of segments and the notion that the four prolegs were air-tubes, he says that "the larva keeps always under water, never coming to the surface for air. It generally remains concealed, and only when disturbed, or when seeking a fresh resting place, is it seen swimming about with that peculiar writhing motion which everybody has observed." The statement is inexact as the frequency of these larvæ in plankton has been studied by Kofoid (1908, pp. 285-6). Miall goes on to show that despite the protection afforded by their hiding tubes, the larvæ are hampered by such enclosures in stagnant water from proper air supply, unless they make these swimming trips to the surface. Miall (1900, 130) concludes that "the thin-walled and transparent appendages near the hinder end of the body are probably of special service in taking up dissolved oxygen. The tracheal system is rudimentary and completely closed, and hence gaseous air can not be taken into the body. The dissolved oxygen, procured with much exertion and some risk, must be stored up within the body of the larva, and used with the greatest economy. It is apparently for this reason that the larva of *Chironomus* contains a blood-red pigment, which is identical with the hæmoglobin of vertebrate animals." This oxygen-carrying hæmoglobin occurs only in such Chirnomid larvæ as exist at the bottom and burrow in the mud, as *C. dorsalis, C. plumosus,* etc. Several points needing further study on both living and dead larvæ are suggested by the previous review and must be dropped at this point in the present paper.

The larvæ make several moults, being observed from May to October (Higginson, 1867, 174, for the year 1865). This, as Garman surmises (1896, 155-6) indicates an overwintering larva.

Pupal Life and Emergence of Imago.—Later the pupæ may come to the surface to permit emergence (Osborn 1896b, 30) of the adult, though the pupa of *plumosus* swims about in the larval case (Johannsen, 1905, 187).

Higginson (1867, 175) and Cox (1878, 263) note the quick emergence of the adult. The latter says, "This wonderful transformation is performed in less time than a man takes to change his coat. When the pupa comes to the surface of the water, the skin of the thorax parts, the head and shoulders of the gnat appear and it comes forth steadily as though some one were squeezing it out. In fifteen seconds it is free, and flies away!"

Adult, Vitality: Annual Occurence or Oftener?—On the way, it was discovered that unlike some flies, the midges caught the previous night were still living although in tight vials, thus showing their ability to get along on little air. They were killed seventeen hours after the time of capture by chloroform. In contrast to this vitality, note their short lease of adult life, suggesting Mayflies: In the afternoon, as only one midge was seen near the baseball grounds, a ramble nearly a mile northeastward towards the lake shore of Lake Winnebago disclosed the fact that many more midges were near the lake in this section, just as had been observed at Neenah. Moreover some were dead in the fields, but one day later, Aug. 17. Dead ones were seen on and about stumps in the pastures, and many others seemed to be hardly able to move or were feebly kicking on their backs. No apparent cause for this could be found except that their natural life was spent by the time the necessary mating swarm was over. Both males and females were among the dead, but the males seemed to be twice as abundant as the females. Thus we may explain the few females seen in the night swarms by the deduction from observations that more males were produced than females. Stumps, fences, and other weather-worn wood masses were all specked up with the green midge voidings, just as mentioned for the calvary tents the day before.

As dusk deepened this same afternoon, Aug. 17, the midge dance went on with hardly abated resonance. From the number of dead and sluggish midges seen in the fields in the earlier afternoon, I judge that the maximum of the swarm period had been reached the previous night and that this evening of the 17th must have commenced the beginning of the decline in abundance.

Aug. 18th, 1910, the cavalry trip took us towards Fond du Lac where the presence of midges became almost unnoticeable, despite the fact that we were approaching a favorable breeding ground, the south shore swamp. Thus the swamp could hardly be considered the center of their present breeding grounds. Aug. 19th, the troop passed beyond the lake margin. Thence midges were absolutely undiscoverable as we mounted the rising ground towards Eden.

Farmers in the lake neighborhood of Oshkosh informed me that they called these midges "lake flies" and that the midges usually made their appearance earlier in the year, but on account of the very dry spell which had been broken for the first time that summer by the slight rains encountered on the cavalry trip, the emergence of the "lake flies" seemed to have been delayed until the accumulated transformations occurred in numbers greater than ever. One gentleman living near the lake told me that the "lake fly" swarms never lasted more than a week. This accords with the observed facts in the previous paragraph.

Another farmer claimed that they are troubled about Lake Winnebago with earlier "lake fly" swarms, even in spring. As there are so many chances to confuse *Ephemeridæ* or smaller *Chironomidæ* in the popular mind under the term "lake fly," I can not accept the statement as more than a suggestion, until year-long quantitative tests on the abundance of lake insects have been made. This I have begun for a stretch of partly wooded bluffs of Lake Michigan north of East Milwaukee, but *plumosus* did not once occur there if I recall correctly the 2298 specimens already contributed to the Public Museum.

Sounds.—I noted a varying loudness in the sound produced by this midge under varying excitement. The initial stirring up of the roosting midges by the passing of the head of the cavalry column always brought out a louder buzz than that a minute or two later. This was not merely because many at once returned to roost, but because the swarm spread out as if to reconnoitre, perhaps, the passing objects. Possibly the sweaty smell of horses and the rising dust attracted them. It would seem that there was no good explanation of this variation in the degree of loudness except to surmise that in proportion as they were excited, they controlled the sound by their spiracles or by faster vibrations of their wings and quicker flight. The faster vibrations of their wings did not greatly raise the pitch of their buzz so as to run through a great musical range as telephone wires will in varying winds, but increased merely the loudness of the ordinary hum of such wires to a markedly stronger volume, audible above the rustle of the moving horses and later, during the bustle of camp life. On this point, Miall & Hammond quote interesting observations on alar, spiracular and other noises of midges and flies (M. & H. 1900, 96-9 and 183-4) with which I was not familiar at the time of my note-taking—views which have since been disputed and limited by Pemberton (1911, 117) to two forms of alar sound. His tests suggest De Geer's (Kirby & Spence, 1858, 487), who cut off a Tipulid's wing in part, only to find the fly still buzzing; but on eliminating the whole organ, the buzz ceased. "The friction of the base of the wings against the thorax seems to be the sole cause of the alarming buzz of the gnat as well as that of other *Diptera*" (ib. p. 488).

Thus the sound has been traced to the wings only. No observation of any other midge species has recorded so audible a buzzing as that made by *plumosus,* though Johannsen (letter of Jan. 4, 1912) writes me: "All of those with which I am familiar produce the humming noise when sufficiently abundant and produce specks." Though unacquainted with most of the 800 species (Johannsen 1908, 76) known, I am sure that many compact swarms of a dozen smaller species by the lake near Milwaukee produce barely audible buzzing so far as could be detected at the distance of a dozen feet or so.

In Prof. Williston's Manual of the North American Diptera (1908, 111; quoted by Comstock 1910, 441; Howard 1908, 111; Johannsen, 1905, 77; Washburn, 1905, 52) so nearly similar swarms are mentioned that I propose the question whether Williston's midges could have been the same species. He says "these midges are often seen, especially in the early spring or in the autumn, in immense swarms, dancing in the air, and have doubtless in many cases given rise to exaggerated stories of mosquitoes. Over meadows in the Rocky Mountains the writer has seen them rise at nightfall in the most incredible numbers, producing noise like that of a distant waterfall, and audible for a considerable distance." In a letter of Jan. 22, 1912, he gives the basis for this statement as "in May or June, 1878, at Lake Como, Wyoming. I can remember only that the species was a very large one [*C. plumosus* is largest], and how very distinct the noise was they made. The railroad men called them 'skeeters,' but I demonstrated to them that they were not!" Owing to the lack of waterfalls in the vicinity of these observations, I have likened the humming to an exaggerated singing of telephone wires as the more available comparison, without an outfit of tuning forks to make an exact record (Miall & Hammond, 1900, 96-9 and 183-4). Burmeister, circa 1832, was among the first to note the noise of flies made during flight, Westwood (1840, 496) quoting him from Taylor's Sci. Memoir, pt. 3. The first scientific account is perhaps that of Baron C. R. Osten Sacken in 1861 (quoted by Knab, 1906, 132), but I do not find that any one has before connected the American *plumosus* definitely with this musical habit. This has been done in Germany by Schuster (1904, 344) who compares the sound to "a loud humming noise as is made by swarming bees." The antennal sounding board, as we may call the sound-receptive forks of the much-branched antennæ and their basal organs, is touched on by Child (1894) and Miall & Hammond (1900, 96-9, 183-4).

ENEMIES OF THE GIANT MIDGE.

Birds.—On the way to Oshkosh every one remarked the thousands of midges, all one species so far as my sight could discover, covering the trees, fences, mail boxes, plowed ground, and even the dusty road along Lake Winnebago, like a mantle of brown debris, as all-pervading as dust or winter snow. For a few days previous to March 28, 1889, similar overwhelming swarms in Iowa of the little gnat *C. nigricans* are reported by Riley (1889, 351; quoted by Tutt, 1902, 106), so that *plumosus* is not unique in this respect, the former "coming from the Mississippi and forming in the air in immense clouds, covering everything with which they come in contact." Likewise, Tutt (1902, 107) reports accounts of *C. lugubris* (not Williston, 1896?) in March, 1852, all over the district about the railway station at Leyden (?) and of *C. occultans* Meig. (=*lugubris* Fries.) along a quay for more than a quarter of an hour's walk," London (?).

Some miles from the last camping ground of the troop, we began to notice the many swallows coming towards us along the fields near the lake, slowly advancing and busily feeding in the fields and flying low over all the country as they do on cloudy days. Three different flocks of these swallows must have numbered into thousands each (we counted over 800 before tiring and getting out of range ahorse). Without other proof it seems evident they were eating midges, undoubtedly gorging their stomachs with this fly as the only adequate food supply visible for such legions of mostly white-bellied tree swallows (*Tachycineta bicolor* (Vieill.)), one solitary barn swallow (*Chelidon crythrogaster* (Bodd)), and possibly one bank swallow (*Riparia riparia* (L.)). Lot necessarily accompanying these, but apparently attracted at the same time, in the same way, was a kingfisher (*Ceryle alcyon* (Linn.)) and several sandpipers undetermined. The midges had capital roosting vegetation in the great numbers of grapevines, draping the trees along the shore road.

In the afternoon trip about Oshkosh, I repeated observations as to the work of the birds. There were some flocks of swallows and a few red-winged blackbirds passing northwards in the direction of Neenah, still busily feeding on such midges as dared to fly during broad daylight. Later as dusk began to come on, the midges began to fly in greater numbers again, so that I expected to see the flocks of birds discontinue their northward movement, especially in the season of the year when such bird flocks are supposed to be migrating southwards. They, however, continued northward, still feeding. So remarkable a northward movement of birds over a considerable local area must be correlated with the swarming of *plumosus*. Although so correlating a northward movement for a half dozen bird species seen in one day, I am not unaware that ornithologists have interpreted short northward migrations of certain birds as practise flights previous to their main southward migration,—thus the snowy heron formerly.

Other Enemies.—Miall & Hammond (1900, pp. 4-7) speak of a long list of aquatic creatures besides the vertebrates mentioned in the first pages and bibliography of this paper, to say nothing of birds other than those recorded in the present account, which prey upon Chironomids in different stages from the larval to the imaginal (sparrows, Judd, 1901, pp. 9, 32, 52, 65, 84). Mrs. Treat (1876, p. 386) notes that even aquatic plants feed on the larvæ: "Upon two occasions I have found a dead Chironomus larva held fast in the valve, and while I was looking, the valve suddenly opened and ingulfed the larva with sufficient force to send it to the opposite side of the utricle." P. 387, "But the Chironomus larva not only swims and wriggles (into such positions as does the mosquito larva), but it uses its brush-like feet, and crawls along the leaves and stems of the plants, and often feeds on the hairs or bristles about the entrance of the utricle which I find in all of the species except in *Utricularia purpurea.*" In turn Chironomids are thought to be parasites or inquilines of the water snail (*Limnea peregra*) at least for one species *C. niveipennis* (Barnard, 1911, 76-8).

Fungus Diseases.—For about a week from August 11, 1912, during a prolonged wet spell, a fungus disease broke out on all species of midges, and moored them to the tree trunks and other outdoor resting places. On August 18th, I repeated this observation at South Oshkosh where a considerable swarm of *C. plumosus* was fast perishing from this fungus disease, considered by Dr. E. W. Olive (letter, August 20, 1912) as *Empusa culicis,* which was common in 1905-6 about Madison.

ECONOMIC IMPORTANCE.

Nuisance to Summer Resorts.—In a discussion of these observations before the Wisconsin Natural History Society, June 8th, 1911, the following points were brought out: Mr. E. E. Teller stated that a friend was forced to give up a cottage at Oshkosh Beach due to these flies in 1909, being so thick that year that they were brushed up by the shovelful indoors. It was well-nigh impossible to exclude them with screening as they swarmed in with every person using the doorways. Miss F. Elmer related similar conditions in the same region in 1908, when the lake algæ again made the lake green for many square miles, as seen from the deck of a steamer.

Nuisance about Lights.—The trouble from midges putting out wharf lights and so interfering with evening trips on the lake by summer resorters should be referred to. As to data of this sort, I assume that evidence based on qualitative and quantitative determinations of the insects would show from midges quite as much mischief to beacon lights such as lighthouses, as from mayflies, mosquitoes or moths along water fronts. The keeper of the second-class light at Lake Park, Milwaukee, Wis., complained to me in 1909 of the great trouble he had with the countless swarms of lake flies on some warm nights in spring, as they interfered greatly with the keeping of the glass surfaces in perfect polish for light transmission. Midges of the specking type like *plumosus* were referred to. I have considered that the lack of scientific identification of species connected with each complaint was sufficient warrant for not reciting a long list of instances here, nor for researching for such data extensively.

The midges are disgusting to the better class stores in Neenah, since the fly specks the windows all over and the store entry globe lights with green spots larger than typhoid fly specks (*Musca domestica*). This is a worriment to the window cleaners every morning of midge season in the several cities along this large Lake Winnebago. Similarly, light attracts such myriads of midges and two-winged tiny Mayflies at the pier lights of Green Lake, Wisconsin, as to put them out, making dangerous the evening boating parties. (Aug. 27, 1911, observation with Dr. Victor Kutchin, specimens at the State Entomologist's office, Madison, Wis.)

It is not my intention to insist that *plumosus* in particular is of as much economic injury as it is of economic value as food for other creatures, yet it appears necessary that the evidence should be weighed for and against the species. After the varied evidence presented throughout the paper, the author could hardly add much weight to a decision on the insect's status by offering a personal opinion. Therefore, a summary of points will suffice: at times of extreme abundance, the larvæ in water-troughs and rain barrels, but especially in drinking water reservoirs and mains constitute a menace despite their scavenging value; as adults, their numbers are locally a nuisance to man and beast, causing in one case cited, the abandonment of a summer resort, putting out or clogging night lights, specking store windows, clothing, and the like. The bodies of the alighted or dying flies constitute a befouling mass wherever they occur. They are a chief food of useful food fishes and frogs, but do not occur at a time of year when necessary to the existence of our native birds so far as observed. No one has as yet noted any symbiotic relations between the larva and snails, although a related species seems to cause the death of snails (Barnard 1911, 76-8).

I can not refrain in closing the economic review, from retelling a fairy story of Reaumur's (1737, 179 et seq.) as showing what has since been ascertained that *plumosus* undoubtedly does not do.

He speaks of collecting bloodworms on oak leaves, etc., fallen into lakes of the "bois de Bologne" (the street in Paris, we presume) and quotes a letter published in the Academy in 1666, claiming that these bloodworms bore holes in stones, actually burrow out cavities in the stones and that, likewise, they had been proved dangerous to stone walls of various structures.

This lengthy quotation tries to establish other astounding facts, namely, that the worms get into timbers, comminuting the wood until the floors and walls of houses may cave in. Fortunately, for the long-suffering public and the researcher trying to disentangle truth from fancy, *Chironomus* has not lived up to all these allegations, or it would have gained long since so unenviable a reputation as to have engaged the attention of economic workers to study out its whole life habits.

REMEDIAL MEASURES.

Nature will usually take care of a large part of any epidemic of *plumosus,* as shown in the preceding notes about their enemies and fungus diseases. During the summer of 1911, *plumosus* was seen at Madison in July, August, and September, but only one to six individuals were noted at any one time. So far as known, the May and June swarms of midges did not include many of the *plumosi.* The dry summer of 1911 seems to indicate that *plumosus* makes no such large swarms in this small lake region as about Lake Winnebago. At South Oshkosh, Wis., Aug. 28, 1911, Mr. J. W. Roe informed me of an article of his dealing with this midge nuisance about 1908-10 for the Daily Northwestern, Oshkosh. He claims that the midges were there in August of 1911 in less than usual numbers, the swarms varying greatly from year to year. Midges interfered with his business of small summer resort cottages in that region very little. In most years, a week hardly passes without a west wind springing up and blowing the midges into the lake to drown in myriads. 1910 and one or two years before, no such wind interference disturbed them, and then the swarms plagued lake-side residents for a longer period, over a week. The early death of the adult prevents a prolonged infestation even when westerly winds fail.

There are earlier spring swarmings of other species, but the winds almost proverbially sweep away these early plagues. Mr. Roe suggests that the lake be stocked heavily with chub or other midge-consuming fish—there are plenty of shiners, bullheads, etc., now—and thus turn the nuisance into more profitable fisheries for the growing fishing interest of the region, there being a large local market in the important series of manufacturing cities and towns of the contiguous Fox River Valley.

As regards water tanks and reservoirs, Osborn proposes to prevent deposition of eggs at the outset (1896a, 406-7) by "ordinary mosquito netting or wire gauze." The frequent scraping of horse troughs (Craigin, 1899, 185) may occasionally favor farm stock, though no one has demonstrated the need for such care as a prophylactic measure against any known stock disease.

ANNOTATED BIBLIOGRAPHY.

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88 per cu, meter, while in 1898, in more disturbed conditions, there were 29 occurrences in 52 collections, averaging 124 per cu. meter. There is also a marked seasonal distribution. The larvæ appear in the plankton in Mar.—December through the seasonal extremes of temperature, but the numbers in March and Nov.—Dec. are always small. Only 15% of the occurrences and 5% of the individuals were found at temperatures below 45°. The percentage of occurrences in the collections is highest in March—Sept., the percentages being 53, 73, 80, 47, 78, 52, and 50, respectively, to 8 to 35% during the remaining months."

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NEW SPECIES OF DRAGON FLIES (*ODONATA*).

By Richard A. Muttkowski.

Enallagma lunifera sp. nov.

♂.—Colors pale blue, black, metallic green and yellowish green.

Face pale blue, a fine line at the base of the labrum, a broad band on the rhinarium, and the vertex, black. Occipital spots large, ovoid, pale blue; a fine line on the occiput between the spots interrupted and blue. Eyes brown above, sides yellow with pale sprinkling.

Anterior lobe of the prothorax with a narrow line of blue at its posterior end. Side of the prothorax yellowish green.

Thorax black dorsally, an antehumeral line of blue equal in width to the black humeral. Sides blue, but tinged with greenish toward the venter. First and second lateral sutures with a fine black line

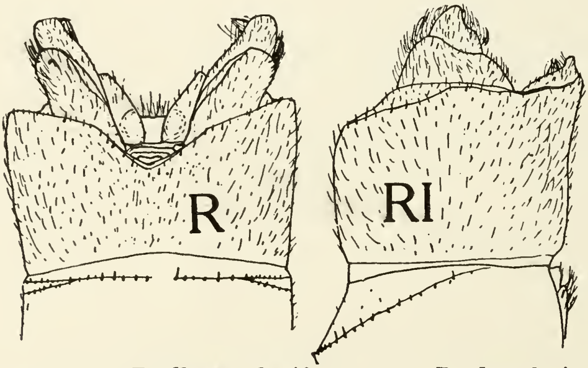


Fig. 1.—R, RI—*Enallagma lunifera* n. sp.; R—dorsal view of appendages, RI—lateral view.

arising below each wing and covering one third of the suture; these sutural lines are connected by a fine transverse line of black, parallel to the base of the wing. Feet black above, greenish beneath; except the tibiæ, which have an external line of greenish and lateral lines of black. Tarsi black.

Abdomen pale blue and metallic green; sides pale yellowish green on 3 to 7, otherwise pale blue. Segment 1 blue, a small spot of black on the basal third; a fine line at the side apically. Segment 2 entirely blue, except for a lunulate spot on the apical third; this dark spot is narrow and shaped exactly like a French circonflex. Appical two thirds of 3, three fourths of 4, four fifths of 5, seven eighths of 6, and 7 practically entirely, dark metallic bronzy green; the metallic green spot on each segment is tridentate, a median dorsal tooth and a lateral tooth tending toward the base of the segment; the median tooth is elongated on the median line on 6 and 7, interrupting the basal ring of pale blue, 8 and 9 entirely blue, 10 black dorsally.

Appendages black laterally, half as long as 10, the superiors thrice the length of the inferiors. The superiors each with a large lobe, which bears an introduced tubercle; in dorsal view they appear as two superimposed tubercles. The inferiors are very short and board flat tubercles. The figures show the form of the appendages better than any description.

♀.—Unknown.

Length: abdomen 22—23 mm.; hind wings 16 mm.

Described from three males, collected at Manning, Iowa, June 21 and 22, 1908, respectively, and at Correctionville, Iowa, June 23, 1908, by Mr. Arthur D. Whedon, from whom the specimens were received and to whom I am indebted for this opportunity to describe this inteersting species. Holotype ♂ in the collection of the Milwaukee Public Museum, the two ♂ paratypes in Mr. Whedon's collection. The three specimens have been preserved in alcohol and their colors appear as fresh as when caught.

This species in its entire habitus recalls the genus *Cœnagrion*, especially the species *C. resolutum*, of which latter Mr. Whedon collected a fair number at the same localities and on the same dates. In the shades of blue and metallic green, and especially in the delicate transitions from pale blue to yellow this species is akin to its prototype *C. resolutum*. For this reason I have placed a query relative to the identity of the species as an *Enallagma*.

As *Cœnagrion* the species would be distinct from all other American species of *Cœenagrion* in that it lacks the lateral lines of black on 2, which makes the spot U-shaped in the other species. There is also no sign of a tendency toward the formation of an antehumeral !-point; the antehumeral is perfectly normal in this respect.

As *Enallagma* the species falls naturally in a group with *E. carunculatum, civile,* and *anna,* i. e., with those species of *Enallag-*

ma in which the male superior appendages are supplied with an introduced tubercle. From either of these it differs in that the colors of 3 to 5 are largely metallic green—more black in its relatives—and in the spot on 2. This spot takes the form of an orbicular in the other species, that of a French circonflex in *lunifera* —hence its name.

As regards the ethology of the species Mr. Whedon writes as follows: "Manning is a small town on the West Nishnabotna river in the southwestern part of Carroll County, Iowa. During a collecting trip through the central, western, and northwestern parts of the state in 1908, two days, June 21 and 22, were spent there. A large part of the lowlands were under water; this threw what was regularly the marginal vegetation of the sloughs out into the water.........The weather was now bright, now cloudy and always very warm.

"Three localities were worked as carefully as time would allow, —a small creek near the town, a slough covering an acre at the Milwaukee bridge and the "Great Western Lake," a large pond formed by a dam in the pleasure grounds of this railroad, a mile and a half south of the town.

"The latter place was visited from 4 to 6 p. m. on June 21. Among the *Zygoptera* obtained in the grasses about the edge of the water were *Ischnura verticalis, Lestes unguiculatus, Enallagma hageni, Enallagma antennatum, Cœnagrion resolutum* and the new *Enallagma* described above. *Enallagma lunifera* Muttkowski was taken as it flew rather close to the surface about the bases of tufts of grass a foot or two from the shore. Its short heavy body and bright blue and black coloration quickly attracted the collector's attention to it. No females were seen in company with the males.

"A single male was also taken at Correctionville in the northwestern part of Woodbury County on June 23, this time about a ditch along the railroad."

It is evident at once from Mr. Whedon's statement that the habits of this new *Enallagma* are remarkably similar to those of *Cœnagrion resoutum.* The habits of the latter I have described in a recent paper (A Synonymical Note, pp. 166-169, 1912) published in this bulletin. *Cœnagrion resolutum* likes to fly in wet places between the blades of grass and also over the shore water between isolated tufts of Iris and grass.

Gomphus whedoni sp. nov.

As this species resembles *Gomphus cornutus* very strongly, I reproduce Tough's description of the latter, especially as the publication in which it originally appeared (Memoirs Chicago Ent. Soc.) was so short lived and is not available in many libraries.

Gomphus cornutus Tough.

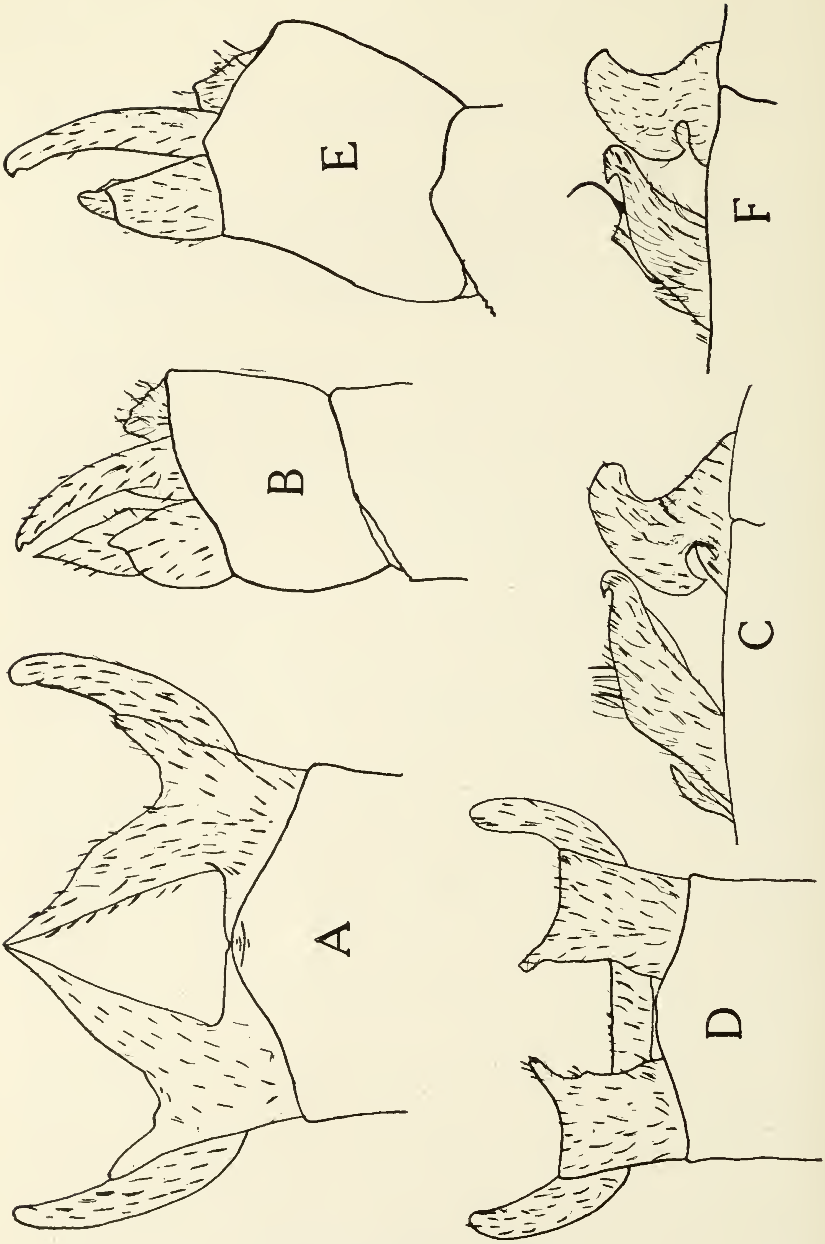
"Length, ♂, 55—57 mm.; abdomen, 40—42 mm.; hind wing, 32—33 mm.

"Yellowish green, with black and brown markings. Face and occiput yellowish green, eyes posteriorly black above, yellowish below, occiput distinctly convex, notched in center and fringed with black hairs, vertex and antennae black. Prothorax black, with a geminate spot in center and a patch on each side yellowish. Thorax yellowish green, except a narrow band, indistinct or absent anteriorly, on each side of the mid-dorsal carina, also except humeral and antehumeral hands, and margins of first and second lateral sutures, all of which are brown. Legs black, front femora yellowish green below. Wings hyaline, with veins black, pterostigma yellowish, and costa yellowish green. Abdomen of uniform thickness, black, a dorsal stripe or spot on segments 1—8, small and basal on 9, and a small quadranular spot on 10, yellowish; dorsum of 9 entirely black.

"Appendages, ♂, see ......, Superiors, dull yellowish; seen from above, internal branches produced inward and backward until they meet, acute and spinose at tip; external branches short, rather broad, and tipped with a blunt spine. Inferior appendages, seen from above, slightly longer than superiors, spreading, the distance from tip to tip of outer extremities being more than twice the width of the tenth abdominal segment at base. From side view the internal branches of superiors are seen to bear a conical tooth about midway between base and apex; the inferior curving upward gradually and each branch bearing a curved spine at tip."

A description of *Gomphus whedoni* n. sp. would be practically identical with that just cited for *G. cornutus*. The only color difference that can be mentioned is that the hastate dorsal marks on the abdominal segments are wider in *G. whedoni*.

As regards the genitalia, the difference is trifling as can be seen from comparison of the figures. The appendages, however, are so strongly different that I do not hesitate to name this species as new and distinct by itself. Originally I had supposed the species to be a variety of *G. cornutus*, at best a subspecies; later



EXPLANATION OF PLATE.

A, B, C—*Gomphus cornutus* Tough; A dorsal view of appendages.
B—lateral view, C—lateral view of genitalia.

D, E, F—*Gomphus whedoni* n. sp.; D,—dorsal view of appendages.
E—lateral view, F—lateral view of genitalia.

comparison, however, with actual specimens of the latter (specimens in the Milwaukee Public Museum) convinced me of its distinctness.

Viewed from above the main feature of *G. cornutus* is that the superior appendages have two angles, the inner process being elongated and meeting on a level with the tips of the outer processes. In *G. whedoni* the superior appendage appears cut short with a small inner tubercle left in place of the long process of the other. This is shown very well in the figures.

Described from a ♂ collected at Iowa City, June 9, 1908, by Mr. Arthur D. Whedon. Holotype in the collection of Milwaukee Public Museum. Measurements the same as for *G. cornutus.*

The nearest relative of this species, as already stated, is *Gomphus cornutus* Tough. I take great pleasure in dedicating this species to its discoverer, Mr. Arthur D. Whedon.

Mr. Whedon writes of it as follows: "The spring of 1908 was extremely cold and rainy, interfering constantly with collecting. The dragon flies had no chance to transform as the sloughs and ponds were abnormally flooded and the streams were roily torrents. Especially was this true of the first week of June. On the 9th, however, the skies cleared, the sun came out and the insects again began to move.

"About the middle of the forenoon on this date the writer took a little run out to the ponds along the R. C. I. & P. Railway, a mile or so west of Iowa City. So cold was it that scarcely anything was on the wing until after 10:30, when a few benumbed *Libellulidæ* were put to flight by sweeping the vegetation and a *Gomphus fraternus* ♀ was captured as she sunned herself on the short grass of the pasture adjoining the slough.

"At 11 o'clock I crossed the railroad embankment to a small pond between steep hills covered with hazel brush and other shrubs. There was no wind here and the sun beat in warmly. Many male *L. pulchella* were patrolling the shores, dashing around my net or rustling their wings in encounters with *P. lydia* at the point of some little promontory. A few *Ischnura* and *Enallagma* skimmed the marginal waters.

"Suddenly a medium sized *Gomphus* shot across the pond and appeared to dart without diminution of speed into a tall shrub near by. On an attempt to discover its position the insect darted out again and off up the valley. Thinking it lost, I turned my attention to some large snails that were creeping about over the leaves of the bush. A moment later the *Gomphus* returned and lit almost under the net and was taken. No other *Gomphi* were seen on this date."

Here again a remarkable similarity of the hunting grounds of two related species is noticeable. *Gomphus cornutus* was taken by me at Milwaukee in a locality precisely the same as that described by Mr. Whedon.

Zoological Laboratory, University of Wisconsin, Oct. 13, 1912.

RECORDS OF WISCONSIN DIPTERA.

By S. Graenicher.

The records given in this paper are based mainly on specimens in the collection of the Public Museum of Milwaukee. Besides, I have had the opportunity of examining quite a number of flies from Tenderfoot Lake, Vilas County, and various other localities in the state, contained in the collection of Prof. Wm. S. Marshall of Madison, Wis., as also some Tabanids taken by Dr. Geo. P. Barth of Milwaukee, at Spider Lake, Vilas County, and elsewhere. To both of these gentlemen I herewith express my thanks for the kind loan of the specimens for study.

TABANIDÆ.

At the present time the biting insects are receiving a larger share of attention than ever before, owing to the fact that quite a number of them figure as disease-carriers between individuals of the same or of different species of Vertebrates. It has not been shown, so far, that any of the horse-flies *(Tabanidæ)* are dangerous to man in this particular respect, but they may be of greater importance in the spread of infectious diseases among domestic animals than our present knowledge would indicate.

Chrysops.

C. callidus Osten-Sacken. In the western part of Wisconsin it has been collected at various points along the St. Croix and Mississippi rivers. Specimens are on hand from the St. Croix dam in Douglas Co., the Nemakagon river and Yellow river in Burnett Co., Hudson in St. Croix Co., Genoa in Vernon Co., and Wyalusing in Grant Co. Taken in the southeastern part of the state at Army Lake in Walworth Co., and at Milwaukee.

C. carbonarius Walker. This is very close to *C. mitis* O. S., and Prof. Hine[1] has considered the possibility of both representing one species only; he refers to the presence *(carbonarius)* or absence *(mitis)* of a hyaline spot at the base of the fifth posterior cell as a

1) James S. Hine. *Tabanidæ* of the western United States and Canada. Bull. Ohio St. Univ. Series 8, No. 35, pp. 217-248 (December 1904.)

distinguishing character, and states that, as a rule, specimens of *carbonarius* are smaller than those of *mitis*. In specimens taken on Isle Royale in Lake Superior[2] he found a marked difference in size between the two species.

11 specimens from Solon Springs in Douglas County and the Yellow river in Burnett Co., both of these localities in the northwestern corner of Wisconsin, are small, ranging from 7 to 8 mm in length: 6 from Divide, Vilas Co., situated in the northeastern part of the state are about 10 mm long, and agree in size with the specimens of *mitis* mentioned below, while 18 specimens collected by Prof. Wm. S. Marshall at Trout and Tenderfoot Lakes in the same County run from 7 to nearly 11 mm. The hyaline spot in the fifth posterior cell is more or less visible in every case.

C. mitis Osten-Sacken. 4 Specimens from Solon Springs, Douglas Co., 1 from Mercer, Iron Co., and 2 from Two Rivers, Manitowoc Co., are from 10 to 11 mm long, and do not show a hyaline spot in the fifth posterior cell.

C. celer Osten-Sacken. Taken in the northern part of the state at the Nemakagon river in Burnett Co., and Mercer in Vilas Co.; in the southern part of the state in Milwaukee Co., and Waukesha Co.

C. excitans Walker. A species of northern distribution that has been taken as far south as Pennsylvania and Illinois. The 23 specimens in our collection are all from the northern part of the state, from the following localities: Solon Springs, Gordon and the St. Croix dam in Douglas Co.; the Yellow river in Burnett Co.; the Apostle Islands in Lake Superior, Ashland Co., and Divide in Vilas Co. I have also seen 3 from Tenderfoot Lake in Vilas Co.

C. frigidus Osten-Sacken. Specimens on hand from Solon Springs and Gordon in Douglas Co., Washington Co., and Milwaukee Co.

C. indus Osten-Sacken. The St. Croix dam in Douglas Co.; Nemakagon river and Yellow river in Burnett Co.; Washington Co.; Milwaukee Co. and Walworth Co.

C. moerens Walker. 1 specimen from Milwaukee and 1 from Army Lake, Walworth Co.

C. niger Macquart. In northern Wisconsin this species has been taken at Solon Springs and the St. Croix dam in Douglas Co., and on the Apostle Islands in Ashland Co.; in southern Wisconsin, at Milwaukee, in Waukesha Co. and Dane Co.

C. obsoletus Wiedemann. Specimens from the St. Croix dam in

2) James S. Hine. Diptera of the 1905 Museum Expedition to Isle Royale, Michigan Survey 1908. Ecology of Isle Royale, pp. 308-316.

Douglas Co., the Nemakagon river in Burnett Co., Washington Co. and Milwaukee Co.

C. sackeni Hine[3]. Type locality; Sandusky, Ohio. I have come across this species in the dune region at Two Rivers, Manitowoc Co., Wis., as also in the dune region in Lake Co., Ill., north of Waukegan. All of the specimens on hand agree with the description, except that in one of them from Illinois the apical spot is hardly wider than the marginal cell.

C. striatus Osten-Sacken. One of our most common species of *Chrysops*. Solon Springs and the Copper Mine dam in Douglas Co.; the Nemakagon river and the Yellow river in Burnett Co.; Waupaca; Two Rivers in Manitowoc Co.; Cedar Lake in Washington Co.; Army Lake in Walworth Co., and Dane Co.

C. univittatus Macquart. This species, which according to Prof. Hine is common in Ohio, seems to be one of the rarer ones with us. In our collection there are only two specimens from the state. both from the Yellow river in Burnett Co.

C. vittatus Wiedemann. This is, like *C. striatus*, a very common species in Wisconsin, and has been collected at the following localities; Solon Springs, Gordon and the St. Croix dam in Douglas Co.; the Nemakagon river, the Yellow river, and Randall in Burnett Co.; Fountain City in Buffalo Co.; Oostburg in Sheboygan Co.; Cedar Lake in Washington Co.; Army Lake in Walworth Co., and Waukesha Co.

Pangonia.

P. rasa Loew. The original description was based on material collected in Wisconsin. The only specimen from this state seen by the writer is a male taken at Milwaukee.

Tabanus.

T. affinis Kirby. There are 18 specimens in the collection of the Public Museum of Milwaukee from the following localities in the state: Solon Springs in Douglas Co.; the Yellow river in Burnett Co.; the Apostle Islands in Lake Superior, Ashland Co.; Divide in Vilas Co., and Two Rivers in Manitowoc Co. I have also seen 13 specimens from Tenderfoot Lake in Vilas Co., collected by Prof. Wm. S. Marshall. The largest of these reaches a length of about 19 mm, while the smallest specimen (from the Yellow river) is hardly 13 mm long. This is as small as any of our specimens of the closely related *T. epistatus* (the next species considered), although, as a rule, *affinis* is the larger of the two. They differ in the form of the palpi, which are long and slender in *affinis*, short and robust in *epistatus*.

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3) James S. Hine. Tabanidæ of Ohio. Bull. Ohio St. Univ. Series 7 No. 19 pp. 3-57, plates 2 (May 1903).

T. epistatus. Osten-Sacken. Specimens from Fox Lake in Dodge Co., Dane Co., Golden Lake, in Waukesha Co., and Milwaukee Co., range from 13 to 15 mm. in length.

T. astutus Osten-Sacken. A female from Winchester, Vilas Co., is nearly 15 mm long. The gray stripes on the thorax, as also the gray markings on the abdomen are quite conspicuous, and answer the description.

T. atratus Fabricius. Prescott in Pierce Co., Genoa in Vernon Co., and Milwaukee Co.

T. carolinensis Macquart. 5 male specimens taken in July and August at Cedar Lake, Washington Co., hovering in the air, on the summit of a high hill (called "Fox Hill"). The median white triangular markings of the abdomen are very distinct, especially so on segments 2 and 3; they are decidedly more conspicuous than on some specimens from Cincinnati, Ohio, in the collection of the Public Museum of Milwaukee.

T. costalis Wiedemann. Milwaukee Co. and Racine Co.

T. flavipes Wiedeman. One female from Tenderfoot Lake, Vilas Co., in the collection of Prof. Wm. S. Marshall. Length about 18 mm. Differs from the original description as follows: face and front yellowish pollinose (not grayish); on the pleurae the hairs are black instead of yellow; the black on the middle and hind femora covers at least the basal two-thirds. The type locality is Labrador; it occurs also in East Siberia, but has, up to the present time, not been reported from any part of the United States.

T. giganteus Degeer. A specimen from Tower Hill, Sauk Co. (Prof. Wm. S. Marshall).

T. lasiophthalmus Macquart. One of our most common species. Nemakagon river in Burnett Co.; Hudson in St. Croix Co.; Apostle Islands in Lake Superior, (Ashland Co.); Two Rivers in Manitowoc Co.; Cedar Lake in Washington Co.; Milwaukee Co. and Dane Co.

T. lineola Fabricius. Specimens from Prescott, Pierce Co.; Rutledge in Grant Co.; Cedar Lake in Washington Co.; Milwaukee Co. and Dane Co.

T. mexicanus Linné. This is a species of southern distribution, that has not been reported from any part of the United States north of New Jersey. A female from Fountain City in Buffalo Co. is about 9 mm long, and much smaller than specimens in the collection of the Public Museum of Milwaukee from Florida. It is also more greenish in color, especially on the abdomen, but it agrees otherwise with the description, and runs to this species in Osten-Sacken's key (Prodrome, Part II), as also in Prof. Hine's key to the Louisiana species of the genus Tabanus[4].

T. nivosus Osten-Sacken. A female from Solon Springs in Douglas Co. (length 15 mm), and one from the Yellow river in Burnett Co. (length 12 mm) agree with 2 specimens from Sandusky, Ohio, and 2 from Orono, Maine, in our collection. In each of the Wisconsin specimens the gray thoracic stripes are obsolete posteriorly, and the front is of equal width throughout.

T. reinwardtii Wiedemann. 1 female from Milwaukee. Length about 13 mm.

T. stygius Say. 1 specimen from Sunny Slope, Waukesha Co., (Dr. Geo. P. Barth), and 1 from Milwaukee Co.

T. trimaculatus Palisot de Beauvois. 2 females taken at Sunny Slope, Waukesha Co., by Dr. Geo. P. Barth. One of these has in addition to the median triangular white markings on abdominal segments 3, 4 and 5, a roundish white spot on each side of segment 2, situated midway between the anterior and posterior margins.

T. vivax Osten-Sacken. 2 specimens from the St. Croix dam in Douglas Co.; 1 from Pansy, and 2 from the Yellow river in Burnett Co., and 4 from Tenderfoot Lake in Vilas Co. All of these are females and the smallest one (from Tenderfoot Lake) is 12 mm. long, while the largest one (from the St. Croix dam) reaches 17 mm. in length.

T. zonalis Kirby. A female taken by Dr. Geo. P. Barth at Spider Lake, Vilas Co., in July 1912. This species is unique among the species of *Tabanus* on account of its black and yellow, wasp-like markings. it reminds one of such species as *Temnostoma aequalis* among the Syrphids.

STRATIOMYIDAE.

Most of the species of *Stratiomyia* and *Odontomyia* are conspicuous on account of their yellow or green stripes and bands on a dark ground color, and in connection therewith all the members of the family are called "soldier-flies". Unbelliferous flowers and flowers arranged in flat-topped inflorescences, as in many species of *Cornus*, *Viburnum*, etc., are especially attractive to flies of this family.

Allognosta.

A. fuscitarsis Say. Numerous specimens from Milwaukee Co., Washington Co. (Cedar Lake), Grant Co. (Wyalusing and Rutledge), and Dane Co.

A. obscuriventris Loew. Milwaukee Co.

4) James S. Hine. Second report upon the horseflies of Louisiana. Louisiana Bull. No. 93. Agricult. Exp. St. Louisiana St. Univ. (June 1907.)

Actina.

A. viridis Say. Milwaukee Co. and Dane Co.

Geosargus.

G. cuprarius Linné. Milwaukee Co.

G. decorus Say. Specimens from Milwaukee, Cedar Lake in Washington Co., and Dane Co.

G. viridis Say. Milwaukee Co. and Dane Co.

Microchrysa.

M. polita Linné. 2 males and 1 female from Milwaukee Co., and 1 male from Dane Co.

Chrysochroma.

C. atriventris Loew. 2 females from Milwaukee Co. In these the antennae are testaceous, and not black, as according to description.

Stratiomyia.

S. apicula Loew. Specimens fom Milwaukee and Racine Cos.

S. badius Walker. Specimens from Milwaukee Co., Army Lake in Walworth Co., Wausau in Marathon Co., the Nemakagon river in Burnett Co., and Spider Lake in Vilas Co. The specimens from the last named locality are in the collection of Dr. Geo. P. Barth. I have also seen a number of males and females from Tenderfoot Lake in Vilas Co. and Dane Co., collected by Prof. Wm. S. Marshall. A female from the Nemakagon river in Burnett Co., has the abdomen shorter and comparatively broader, the median facial black stripe broader, and the legs decidedly more reddish than in the other specimens.

S. discalis Loew. Milwaukee, Washington Co., and Dane Co.

S. lativentris Loew. Milwaukee, Dane Co., and Army Lake in Walworth Co.

S. meigenii Wiedemann. Specimens from Milwaukee Co.

S. norma Wiedemann. A male taken in the western part of the state at Maiden Rock, Pierce Co., and specimens from Washington, Milwaukee, Dane and Walworth Cos. in the southeastern part.

S. normula Loew. Rather common. Specimens studied from Gordon in Douglas Co., Genoa in Vernon Co., Cedar Lake in Washington Co., Army Lake in Walworth Co., Dane Co., and Milwaukee Co. Three males from the latter locality have a yellow dorsal triangle on the 5th abdominal segment, but not even a trace of such a marking on the 4th. All the rest have markings on both segments well defined.

S. quaternaria Loew. A male from Milwaukee Co., evidently belongs here. It resembles the male of *apicula* but there is a large indented lateral yellow marking on the third abdominal segment and in addition to this the coloration of the venter of the abdomen answers the description of *quaternaria.*

Odontomyia.

O. cincta Olivier. Specimens from Pierce, Vernon, Dane, Door, Milwaukee, Washington and Waukesha Cos.

O. pubescens Day. 12 specimens from Milwaukee Co., 5 from Racine Co., 7 from Dane Co., 2 from Washington Co. (Cedar Lake), and 1 from Door Co,. (Jacksonport) all have yellow femora and agree otherwise with the description of *pubescens.* Of these 6 are males. 6 males and 3 females from Milwaukee, and 1 female from Racine Co., have the femora black with yellow tips, and the abdominal markings less triangular than in most of the specimens mentioned above (with yellow femora. On account of these characters they run in Johnson's table (Trans. Am. Ent. Soc. XXII. p. 251) to *hoodiana* Bigot, a western species, but at the same time the presence of yellow markings on the front and vertex points to *pubescens*, according to Johnson. The question therefore presents itself whether these specimens represent a black-legged form of *pubescens* or a variety of *hoodiana* with yellow marks on front and vertex. Furthermore it may be asked whether *hoodiana* is specifically distinct from *pubescens.*

O. trivittata Say. Specimens from Milwaukee, Dane and Washington Cos.

O. truquii Bellardi. *(O. binotata* Loew.) Milwaukee Co., Dane Co. and Walworth Co.

O. vertebrata Say. Hudson in St. Croix Co.; Maiden Rock in Pierce Co.; Dodge Co.; Racine Co.; Army Lake in Walworth Co.; Dane Co., and Tenderfoot Lake in Vilas Co.

O. virgo Wiedemann. Numerous specimens from the following localities: Yellow river in Burnett Co., Hudson in St. Croix Co., Prescott and Maiden Rock in Pierce Co., Genoa in Vernon Co., Cedar Lake in Washington Co., Army Lake in Walworth Co., Milwaukee Co., Racine Co., Waukesha Co., and Dane Co.

Euparyphus.

E. atriventris Coquillett. Type locality: Greely, Col. A female from Milwaukee probably belongs here, but the yellow stripe along the side of the mesonotum runs from the hind angle to the suture only; in the described specimens it extends as far as the humerus.

E. mutabilis Adams. 1 female taken at Hudson in St. Croix Co., July 12th, 1910, agrees with the description, except as follows: The frontal medial black line is not produced laterad at its lower end; legs with the exception of the coxae entirely yellow; no yellow bands along the posterior borders of the ventral segments.

E. tetraspilus Loew. Milwaukee Co. and Washington Co. 2 males from Milwaukee have the yellow on the scutellum limited to the tips, while in 2 other males from the same locality the greater portion of the scutellum is yellow.

Nemotelus.

N. unicolor Loew. Milwaukee, Racine Co., Prescott and Maiden Rock in Pierce Co.

RHYPHIDAE.

Rhyphus.

Only 4 species are known from North America. One of these, (*R. scalaris* Wiedemann) is of southern distribution (type locality: Georgia). *R. alternatus* and R. *fenestralis* inhabit the northeastern United States, and the latter has been taken as far north as Quebec. *R. punctatus*, the only species occurring in our region has been reported from Quebec, the White Mountains in New Hampshire and New Jersey in the east; Minnesota and Kansas in the west. It is also an inhabitant of Europe, and according to Schiner (Fauna austriaca, Diptera, vol. 2, p. 495) it is found in Austria mostly at high altitudes.

R. punctatus Fabricius. This is to all appearances a species of rare occurrence in Wisconsin. There are 3 specimens in the collection of the Public Museum of Milwaukee: 2 from Milwaukee Co., and 1 from Grant Co. These agree with Schiner's description based on material collected in Austria, except that the brown spot opposite the spot in the stigma is not confined to the first posterior cell, but invades the second posterior cell on one side, and the sub-marginal cell on the other, thereby uniting with the stigmatal spot. But the latter is much darker than its neighbor, and therefore distinctly outlined. In a specimen from Dane Co. (collected by Prof. Wm. S. Marshall) on the other hand, the spot in the first posterior cell is clearly separated from the stigmatal spot, and both are very light in color.

BOMBYLIIDAE, SYRPHIDAE AND CONOPIDAE.

The following records of flies belonging to these families are added to those given in the preliminary list published in May, 1910 (Vol. VIII of this Bull., pp. 32-44), and the supplement published in April, 1911 (Vol. IX of this Bull., pp. 66-72).

BOMBYLIIDAE.

Spogostylum.

S. albofasciatum Macquart. Waukesha Co., Two Rivers in Manitowoc Co., Genoa in Vernon Co., Wyalusing and Rutledge in Grant Co.

S. anale Say. 1 specimen from Rutledge, Grant Co.

S. oedipus Fabricius. Cedar Lake in Washington Co., Fifield in Price Co., and Tenderfoot Lake in Vilas Co.

S. pauper Loew. 1 from Rutledge, Grant Co.

Exoprosopa.

E. decora Loew. Genoa in Vernon Co., Wyalusing and Rutledge in Grant Co.

E. fasciata Macquart. Genoa in Vernon Co., Wyalusing in Grant Co., and Dane Co.

E. fascipennis Say. Wyalusing and Rutledge in Grant Co., Dane Co., and Tower Hill in Sauk Co.

Anthrax.

A. alternata Say. Genoa in Vernon Co., Two Rivers in Manitowoc Co., and Trout Lake in Vilas Co.

A. fulviana Say. Door Co., Trout Lake in Vilas Co.

A. lateralis Say. **var. gracilis** Johnson. Genoa in Vernon Co., Wyalusing in Grant Co., and Tenderfoot Lake in Vilas Co.

A. morio Linné. Two Rivers in Manitowoc Co., and Dane Co.

A. nemakagonensis Graenicher. One specimen from Genoa in Vernon Co. and one from Army Lake in Walworth Co.

A. sinuosa Wiedeman. Jacksonport in Door Co.; Army Lake in Walworth Co., Dane Co.; Tenderfoot Lake in Vilas Co.

Bombylius.

B. fulvibasis Macquart. Genoa in Vernon Co., Dane Co.

B. major Linné. Dane Co.

Systoechus.

S. vulgaris Loew. Army Lake in Walworth Co., Door Co., and Tower Hill in Sauk Co.

Phthiria.

P. aldrichi Johnson. Genoa in Vernon Co. and Rutledge in Grant Co.

P. punctipennis Walker. Genoa in Vernon Co. and Rutledge in Grant Co.

P. sulphurea Loew. Specimens from the dune region south of Kenosha, and from the dune region at Two Rivers in Manitowoc Co.

Lepidophora.

L. aegeriiformis Westwood. A specimen in Prof. Wm. S. Marshall's collection from Tower Hill in Sauk Co.

Sparnopolius.

S, fulvus Wielemann. Rutledge in Grant Co., and Dane Co.

Systropus.

S. macer Loew. Wyalusing and Rutledge in Grant Co.

Geron.

G. calvus Loew. Genoa in Vernon Co. and Wyalusing in Grant Co.

G. subaurutus Loew. Genoa in Vernon Co. and Rutledge in Grant Co.

Toxophora.

T. amphitea Walker Specimens have been taken in the southwestern part of the state at Genoa in Vernon Co. and Rutledge in Grant Co.; in the southeastern part at Milwaukee and at Army Lake in Walworth Co.

SYRPHIDAE.

Microdon.

M. tristis Loew. A female taken in Dane Co. by Prof. Wm. S. Marshall.

Chrysotoxum.

A number of writers have called attention to the wide range of variation in the markings of the species belonging to this genus.

C. laterale Loew. A female specimen taken by Mr. Hugo Altschwager of Milwaukee at Fifield in Price Co. has a length of 13 mm. It runs in Williston's table (Synopsis of N. Am. Syrphidae, p. 14), to *laterale* but does not answer the description in all respects. The posterior margin of the first abdominal segment is not yellow, and the second segment shows just a slight indication of yellow on the sides of the posterior margin. The legs are yellow, with the exception of the coxae, the trochanters, and the bases of the front and middle femora, which are black. There is a covering of yellow hair on the abdomen, but this does not extend as far as the apical portion of the fifth segment.

Chrysogaster.

C. nitida Wiedemann. Genoa in Vernon Co.; Wyalusing and Rutledge in Grant Co.

C. pulchella Williston. Tenderfoot Lake in Vilas Co.

Pipiza.

P. festiva Meigen. Dane Co.

P. pistica Williston. 1 male from Rutledge in Grant Co.

Paragus.

P. bicolor Fabricius. Genoa in Vernon Co., and Wyalusing in Grant Co.

P. tibialis Fallén. Genoa in Vernon Co., Rutledge in Grant Co., and Two Rivers in Manitowoc Co.

Chilosia.

C. sororcula Williston. Two Rivers in Manitowoc Co.

Baccha.

B. fascipennis Wiedemann. 1 male from Dane Co. in Prof. Wm. S. Marshall's collection. It has "the face and front metallic green, the tubercle and a lunule above the antennae enclosing a small black spot yellow," the same, as two males from Connecticut referred to by Prof. Williston (Synopsis N. Am. Syrphidae, p. 121).

B. lemur Osten-Sacken. A female taken by Prof. Wm. S. Marshall at Tenderfoot Lake, Vilas Co., in July 1912. Length over 13 mm. Face entirely yellowish. There are two yellowish spots, one above the base of each antennae, which are nearly united above, leaving a distinct black spot between them. This character is mentioned in the description of *B. fascipennis* (Synopsis N. Am. Syrphidae, p. 120), but not in that of *B. lemur.* The red cross-bands at the bases of the third and fourth abdominal segments are slightly interrupted. This species has been recorded from California, Nevada, Wyoming, and Colorado.

Pyrophaena.

P. rosarum Fabricius. This boreal species occurs in the northern half of our state, and seems to be rather rare. 1 male and 1 female were taken by Prof. Wm. S. Marshall at Trout Lake, Vilas Co., in August, 1912. The male has two large yellow spots on the 3rd abdominal segment which are barely separated in the middle. In addition to these there are two smaller spots on segment 4, and in this respect the specimen agrees with the male from Elkhart Lake, Sheboygan Co., referred to in Can. Ent. Vol. 42, p. 28 (1910). In the female specimen the usual two spots on segment 3 are united to a single one. There are no markings on segment 4, but an indistinct U-shaped median spot on segment 2.

Platychirus.

P. hyperboreus Staeger. Oostburg in Sheboygan Co.; Two Rivers in Manitowoc Co.; Tenderfoot Lake and Trout Lake in Vilas Co.

P. peltatus Meigen. Fifield in Price Co. and Tenderfoot Lake in Vilas Co.

P. quadratus Say. Dane Co. and Genoa in Vernon Co.

Melanostoma.

M. mellinum Linné. Dane Co. and Two Rivers in Manitowoc Co.

M. obscurum Say. Two Rivers in Manitowoc Co. and Tenderfoot Lake in Vilas Co.

Syrphus.

S. americanus Wiedemann. Dane Co. and Tenderfoot Lake in Vilas Co.

S. arcuatus Fallén var *lapponicus* Zett. Tenderfoot Lake in Vilas Co.

S. ribesii Linné. Dane Co.; Two Rivers in Manitowoc Co.; Tenderfoot Lake in Vilas Co.; Fifield in Price Co.; Rutledge in Grant Co.

Allograpta.

A. obliqua Say. Dane Co.; Tenderfoot Lake in Vilas Co.; Genoa in Vernon Co.; Wyalusing in Grant Co.

Xanthogramma.

X. flavipes Loew. 1 female, Dane Co.

Mesogramma.

M. geminata Say. Tenderfoot Lake in Vilas Co.; Genoa in Vernon Co.: Wyalusing and Rutledge in Grant Co.

M. marginata Say. Tenderfoot Lake in Vilas Co.; Genoa in Vernon Co.; Wyalusing and Rutledge in Grant Co.; Army Lake in Walworth Co.

Sphaerophoria,

S. cylindrica Say. Genoa in Vernon Co.; Wyalusing and Rutledge in Grant Co.; Two Rivers in Manitowoc Co., and Tenderfoot Lake in Vilas Co. Among those from the latter locality one specimen, a small female, represents Williston's var. d (Synopsis N. Am. Syrphidae, p. 105). The face has a median black stripe, the lateral thoracic stripe does not surpass the suture, and the slender abdomen is black with three yellow bands.

Sphegina.

S. campanulata Robertson. A female from Tenderfoot Lake, Vilas Co., taken in July, 1912, by Prof. Wm. S. Marshall. In a general way this specimen answers Robertson's description of the male (Can. Ent. vol. 33, p. 284; type locality: Carlinville, Ill.), but it differs as folows: Abdomen very much darker than the thorax; in the hind tibiae there is an incomplete brown ring near the base in addition to the small brown apical one; the second abdominal segment does not surpass the remaining segments in length, and the broadest part of the abdomen is near the base of the third segment instead of near the apex of the fourth. All of these differences may be due to sex, and for the present

I do not hesitate to consider this specimen the female of *S. campanulata* Robertson. Johnson (Psyche, vol. 17, p. 230) has recorded this species from the New England states Maine, New Hampshire and Connecticut.

Rhingia.

R. nasica Say. Tenderfoot Lake in Vilas Co. and Fifield in Price Co.

Volucella.

V. evecta Walker. Cedar Lake in Washington Co.

Sericomyia.

S. chrysotoxoides Macquart. Two Rivers in Manitowoc Co. and Tenderfoot Lake in Vilas Co.

S. militaris Walker. Fifield in Price Co. and Tenderfoot Lake in Vilas Co.

Eristalis.

E. bastardi Macquart. Tenderfoot Lake in Vilas Co.

E. dimidiatus Wiedemann. Dane Co. and Tenderfoot Lake in Vilas Co.

E. meigenii Wiedemann. Dane Co.

E. tenax Linné. Rutledge in Grant Co.

E. transversus Wiedemann. Two Rivers in Manitowoc Co.; Dane Co.; Genoa in Vernon Co.; Wyalusing and Rutledge in Grant Co.

Tropidia.

T. quadrata Say. Genoa in Vernon Co.

Helophilus.

H. chrysostoma Wiedemann. Dane Co.

H. conostoma Williston. 3 specimens from Dane Co.

H. distinctus Williston. A female from Cedar Lake in Washington Co., has the black stripes on the thoracic dorsum very much narrower than the gray ones, and answers the description of *H. distinctus* in this respect. But the face and the first two joints of the antennae are yellow, and not black as in the type specimens from Connecticut and the scutellum is also yellow.

H. laetus Loew. Dane Co.

H. latifrons Loew. Army Lake in Walworth Co.

H. similis Macquart. Dane Co.; Two Rivers in Manitowoc Co.; Tenderfoot Lake in Vilas Co.

Mallota.

M. cimbiciformis Fallén. Two Rivers in Manitowoc Co., and Tenderfoot Lake in Vilas Co.

M. posticata Fabricius. Dane Co.

Xylota.

X. curvipes Loew. Male from Tenderfoot Lake in Vilas Co. (Prof. Wm. S. Marshall). This is the only known record for Wisconsin.

X. ejuncida Say. Two Rivers in Manitowoc Co. and Tenderfoot Lake in Vilas Co.

X. fraudulosa Loew. Dane Co.

X. pigra Fabricius. A female from Tenderfoot Lake in Vilas Co. agrees entirely with the description. It was taken by Prof. Wm. S. Marshall in July, 1912, and is the only record for the state.

Criorhina.

C. analis Macquart. Dane Co.

Spilomyia.

S. longicornis Loew. Dane Co.

S. quadrifasciata Say. Sauk Co.

Temnostoma.

T. aequalis Loew. Two Rivers in Manitowoc Co.; Oostburg in Sheboygan Co., and a single specimen from Milwaukee Co. In the St. Croix river region this species was not met with south of Douglas Co. In the eastern part of the state it occurs along Lake Michigan as far south as Milwaukee, but is extremely rare in the latter named locality.

T. bombylans Fabricius. Two Rivers in Manitowoc Co.

CONOPIDAE.

Conops.

C. brachyrhynchus Macquart. Genoa in Vernon Co.

C. xanthopareus Williston. Rutledge in Grant Co.; Kenosha Co.

Physocephala.

P. affinis Williston. Genoa in Vernon Co.

P. furcillata Williston. Fifield in Pierce Co. and Tenderfoot Lake in Vilas Co.

P. tibialis Say. Genoa in Vernon Co. and Wyalusing in Grant Co.

Zodion.

Z. bicolor Adams. 7 specimens from Genoa, Vernon Co., are all of the same length (4 mm.) as the specimen reported from the Yellow river in Burnett Co. (vol. VIII. of this Bull. p. 43) and fall somewhat short of the type, the length of which is given as 5 mm. They have the first abdominal segment gray and not black as in the types, but otherwise they answer the description.

Z. fulvifrons Say. Genoa in Vernon Co.; Wyalusing and Rutledge in Grant Co.; Army Lake in Walworth Co.; Dane Co.; Tenderfoot Lake in Vilas Co.

Z. pygmaeum Williston. Genoa in Vernon Co.; Wyalusing and Rutlelge in Grant Co.

Eccemyia.

E. abbreviata Loew. Genoa in Vernon Co.; Rutledge in Grant Co.; Army Lake in Walworth Co.

Myopa.

M. pilosa Williston. A female from Dane Co. in the collection of Prof. Wm. S. Marshall.

Public Museum, Milwaukee, Wis.

Dec. 4, 1912.

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