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ENTOMOLOGICA AMERICANA

After a lapse of 36 years, this veteran journal of American entomology emerges from its hibernaculum to take its place once more as a vehicle for the progress of our branch of science. Thanks to the generosity of a friend the Brooklyn Entomological Society is enabled to revive this journal to render, we hope, as good service and fill as worthy a place as its predecessor of long ago.

The Society has long felt that a medium was needed for the appearance of those longer papers—monographs, synopses of smaller groups, biological studies, morphology, embryology, revisions, and the many excellent technical productions too long and too special, perhaps, for our regular journals yet too short for a book—emanating from many workers not connected with institutions which publish the results of the research of their staffs. The opportunity has at length presented itself; and the Society has taken the positive step.

Entomologica Americana once more takes its place among our current journals.

The publication will be issued in four numbers a year, and will average approximately 50 to 60 pages to the number, or a total of 200 to 240 pages per volume. Each number will carry *one* paper; or possibly two, but not more, in view of its purpose. The annual subscription price is set at $4.00 a volume. Single numbers will sell on an approximate basis of $1.50 for 50 pages; subscriptions will be received per volume—*not* for four consecutive numbers—payable strictly in advance. The edition for the first of the new volumes will be limited to 200 copies; and those intending to subscribe, particularly institutions and libraries, should do so promptly to ensure possession of complete sets.

Authors are invited to submit contributions, bearing in mind that such contributions must be of the required length and represent original work advancing our knowledge of the taxonomy, biology, ecology, anatomy or embryology of insects. Arrangements with regard to illustrations will be discussed for each case. Papers should be sent direct to the Editor, Entomologica Americana, 11 North Broadway, White Plains, N. Y.; subscriptions (with check) to Geo. P. Engelhardt, Treasurer, Brooklyn Entomological Society, Brooklyn Museum, Eastern Parkway, Brooklyn.

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Studies on the Pleuropodia of *Belostoma flumineum* Say and *Ranatra fusca* Palisot de Beauvois,

with a Discussion of These Organs in Other Insects[1]

By

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[1] Contribution from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 251. Thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Science, Radcliffe College.

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[ABSTRACT]

[The Hemipterous insects *Belostoma* and *Ranatra* possess rudimentary embryonic appendages on the first abdominal segment, serially homologous with the thoracic legs and the mouth-parts. These pleuropodia arise early in embryonic life as minute ectodermal evaginations, later sink beneath the body-wall ectoderm to form large bowl-shaped masses which communicate with the exterior through small circular orifices, reach their greatest development near the end of embryonic life, and degenerate very soon after the insect hatches.

Each pleuropodium is composed of greatly lengthened ectodermal cells whose bases form the inner wall of the organ and whose apices continue in the form of thread-like prolongations for some distance beyond the pleuropodial orifice. The nuclei of these cells are correspondingly enlarged, increasing three-fold in length during the development of the organ.

The function of the pleuropodia is obscure, but their appearance suggests that they are glandular. They may be secretory or possibly excretory.

Pleuropodia occur in divers groups of insects, but appear to be best developed in the less specialized orders, such as the Blattoidea, Mantoidea, Orthoptera, and some Coleoptera. In other Coleoptera and in the Hemiptera they are much less highly developed, and in the Hymenoptera and Lepidoptera pleuropodia are vestigial or wanting entirely. The accounts of pleuropodia of other orders of insects are unsatisfactory.]

I. INTRODUCTION

The following paper embodies the results of my studies on the pleuropodia of *Belostoma flumineum* Say and *Ranatra fusca* Palisot de Beauvois (Hemiptera), with brief notes on the structure of these organs in *Dineutes* (?) sp., *Carabus auratus* L., and *Calosoma sycophanta* L. (Coleoptera), and a review of the literature treating of the pleuropodia of insects from the time of their discovery by Rathke in 1844 to the close of the year 1922.

These investigations were made during the years 1921 and 1922 at the Bussey Institution, Harvard University, under the direction of Professor W. M. Wheeler and Professor C. T. Brues. I wish to express my deep appreciation of the many courtesies extended to me by Professor Wheeler and Professor Brues. I am also indebted to Dr. R. F. Hussey for assistance in the collection of material and for the photographing of slides and plates, and to Mrs. Lilian H. Farlow and Smith College for financial assistance which made possible the investigation.

I use throughout this paper the term *pleuropodia* which was first proposed and defined by Wheeler (1890) to designate the appendages of the first abdominal segment of embryo insects. As Wheeler states on page 87, it is "a name both suggestive of their origin from foot-like organs and their tendency, when fully developed, to take up a position on the pleural wall of the embryo." While I believe the pleuropodium to have a secretory or possibly an excretory function, I have not used the term *adenopodium* suggested by Wheeler as a substitute for *pleuropodium* should the organ prove to be glandular in function. A great many further investigations, both biological and chemical in nature, must be made, on living and freshly fixed embryos, before the exact status of these organs can be determined.

My own studies of the embryos and young nymphs of *Belostoma* and *Ranatra* have demonstrated the structure of the pleuropodium, the time and place of its first appearance in the embryo, its relation to other structures, and its degeneration and disappearance in the nymph; but the very nature of the material examined, namely embryos preserved for several months in 82 per cent alcohol, has prevented my drawing any very definite conclusions as to the specific function of this interesting and problematical organ in the living embryo.

II. MATERIAL AND METHODS

The material used for the study of the pleuropodia of *Belostoma flumineum* Say was collected during the summers of 1921 and 1922 near Ann Arbor, Michigan. Male specimens bearing eggs upon their backs were collected, on July 30, 1921, in Fleming Creek, at Geddes, about four miles east of Ann Arbor; on July 1, July 6, and July 15, 1922, in Pittsfield Pond, about half-way between Ann Arbor and Ypsilanti; and on July 19, and August 9, 1922, in Fleming Creek, as well as in a shallow pond in White's Woods, about two miles west of Ann Arbor. Eggs of *Ranatra fusca* Palisot de Beauvois (= *americana* Mont.) were collected at Pittsfield Pond on June 16, June 20, and July 9, 1921, and July 1, July 6, and July 15, 1922.

The eggs were removed from the collecting net and carried in glass jars, partly filled with water and a little grass, to the laboratory where they were submitted to a superficial examination. Some eggs were killed and fixed at once, and others after they had been allowed to continue their development for one or more days after they were collected.

The period elapsing between the time of collection and the time of fixation of eggs of *Belostoma* varied from six hours to five days, depending upon the stage of development in which the eggs appeared to be when they were collected. As it was my intention to secure embryos in all stages of development, I fixed a few eggs from a batch on the first day, a few eggs from the same batch on the second day, and so on until the entire batch was exhausted or until the eggs hatched.

The period elapsing between the time of collection and the time of fixation of eggs of *Ranatra* varied from three hours to twelve days. The eggs collected on any one day were usually of many different stages, but I followed the same plan of procedure as in the case of *Belostoma* eggs, namely, killing and fixing a few of each lot each day, in order to obtain embryos in various stages of development.

Six different killing and fixing fluids were used, with not very satisfactory results from any of them. They were usually brought to the boiling point before using them. Kahle's fluid (few minutes to 28 hours) gave excellent fixation of the embryo but caused the yolk granules to coagulate so that dissection of the embryo from the yolk, and subsequent sectioning were made rather difficult. Bouin's fluid (4 to 17 hours) had about the same effect as Kahle's fluid. It was quite a simple matter to dissect the yolk from very young embryos in eggs which had been fixed in hot water (few minutes) or in corrosive sublimate (27 hours), but in older embryos fixation was not so successful and the coagulation of the yolk caused a great deal of trouble. Gilson's fluid (27 hours) caused the yolk to become very gummy and Zenker's fluid (27 hours) had a similar effect. The latter, however, had the peculiar effect of making the chorion of the egg highly transparent, and the yolk granules dark brown, so that it was possible to study the white embryo on the dark yolk, enveloped by its membranes and its chorion. Kahle's fluid and Bouin's fluid were by far the most satisfactory for fixing embryos for histological study.

The material was left in 82 per cent alcohol for four to six months before any dissection and study were begun. No. 000 insect pins stuck into the ends of matches and sharpened down to a fine point on a whetstone placed under a binocular microscope were used for dissecting the eggs. Dissection was done in 82 per cent alcohol under a binocular microscope.

Several different stains were tried on embryos intended for whole mounts. Carbol-fuchsin and säurefuchsin proved unsatisfactory; Ehrlich's acid hematoxylin was quite good; alum cochineal and borax carmine were excellent stains for embryos about ready to hatch. By far the best method of staining young embryos, before the chitin has been formed, is that of Wheeler (1893: p. 141). Euparal proved very satisfactory as a mounting medium for entire embryos.

Embryos intended for histological study were imbedded in paraffin, and sections were cut five, six, seven, eight, nine, and ten micra in thickness, with the majority cut eight micra thick. Several methods of staining sections were tried out. Ehrlich's acid hematoxylin proved most unsatisfactory, as well as did iron hematoxylin and orange G. Iron hematoxylin and eosin, eosin and methylene blue, acid Delafield's hematoxylin and acid fuchsin, and haemalum and erythrosin gave rather good results. The best combinations were Delafield's hematoxylin and erythrosin, and Heidenhain's iron hematoxylin and erythrosin, which gave excellent results. Euparal was found unsatisfactory for mounting sections because it showed a tendency to extract stains soluble in the higher alcohols.

I have included in this paper outline drawings of embryos which have been removed from the chorion, envelopes, and yolk, schematized sketches of sections of embryos, omitting the mesoderm, muscles, and other internal structures; and unretouched photomicrographs of the pleuropodia represented in the schematized sketches. An apparatus utilizing monochromatic light from Zettnow's color filter was used in making the photomicrographs.

III. INVESTIGATIONS

1. Belostoma flumineum Say

The pleuropodia of *Belostoma flumineum* Say (Order Hemiptera, Family Belostomatidae) have a very interesting history. They arise, simultaneously with the appearance of the mandibles, as a pair of minute evaginations on the first abdominal segment, one on either side of and adjacent to the median ganglion. They soon become invaginated, develop a very unique structure and acquire a secretory or excretory function. They persist throughout embryonic life and increase in size up to the time of hatching, but degenerate and disappear in the first instar nymph and cannot be found in the older forms.

The time of incubation for *Belostoma* has been generally supposed to be one to two weeks. As the eggs used for my study of the pleuropodia of this species were not laid in the laboratory I have no means of knowing the precise age of each embryo which I studied. An exact age record for each embryo with its pleuropodia would be highly desirable, but under the circumstances under which my material was collected it was impossible to secure such data.

The pleuropodia may be best described in relation to the changes in form and size through which the insect passes in its embryonic and early larval development. In *Belostoma* these changes may be referred to four periods: before the revolution of the embryo, during revolution, after revolution, and after the hatching of the nymph. The pleuropodia will therefore be described under these headings.

The pleuropodia which were selected for the figures and whose measurements are given in the description were selected from the slides of many embryos, and may be considered as typical of the organ at the given stages of development.

A. Before Revolution

[Figures 1, 2, 3, 4, 5, 6, 41, 42, 43.]

Before revolution the embryo lies on the dorsal side of the yolk, with its head directed toward the posterior pole of the egg and the tip of its abdomen toward the anterior pole. It is enveloped by two membranes, the amnion (Figs. 4 and 6, *am*), which is proliferated by the lateral margins of the ectoderm of the body wall, and the serosa (Fig. 4, *se*), which also envelopes the yolk.

Although many embryos of earlier stages were examined, the youngest in which pleuropodia could be made out is that represented in Fig. 1. This embryo measures 2.090 mm. in length and its first abdominal segment (*ab 1*) is 0.260 mm. wide. The cephalic lobes (*cph*) are relatively large as compared with the width of the rest of the body. The pre-oral appendage (*pr o*) is a median oval plate; the mandibles (*md*) are small laterally directed evaginations; the first maxillae (*1 mx*) are about twice the size of the mandibles, while the second maxillae (*2 mx*) are about twice the size of the first: both pairs of maxillae are directed laterally. The thoracic appendages are likewise directed laterally, the prothoracic (*t 1*) being the largest, the metathoracic (*t 3*) the smallest, and the mesothoracic (*t 2*) intermediate in size between the other two pairs. These appendages are stout and unsegmented. The abdomen is segmented and flexed ventrally at its tip.

The pleuropodia (Fig. 1, *pl*) are visible in surface view as slightly evaginate, more heavily stained areas lying in the same place where the pleuropodia are clearly distinguishable in older embryos. In a transverse section of an embryo of the age of that shown in Fig. 1, the pleuropodium (Figs. 4, *pl*, and 41) is seen to be a small, rounded solid evagination adjacent to the ganglion, and of about the same size and shape as the latter. The amnion (*am*) and serosa (*se*) do not come near the organ. The third thoracic appendages (*t 3*) project backward on each side of the first abdominal segment. The right pleuropodium measures 0.050 mm. in length, 0.044 mm. in width, and is evaginated 0.026 mm. above the level of the surrounding and underlying ectoderm. It consists of ectodermal cells with small oval nuclei lying parallel to one another. These nuclei measure 0.003 mm. in length and 0.002 mm. in width, and are of the same size, shape, and appearance as the nuclei of the ectodermal cells of the body wall. The nuclei are scattered uniformly throughout the appendage. They undergo considerable changes in size and shape as the pleuropodium develops. Mesodermal cells line the ectoderm of the body wall and the pleuropodium.

In an embryo (Fig. 2) which is somewhat older than that represented in Figs. 1 and 4, the body has broadened and shortened.

It measures 1.847 mm. in length, and its first abdominal segment is 0.405 mm. wide. The head is conspicuously smaller in relation to the rest of the body; the antennae (*ant*) are present as narrow digitiform appendages behind the cephalic lobes; the other cephalic appendages have increased in length; the thoracic legs are larger, have become segmented, and no longer are directed laterally. The tips of the prothoracic and mesothoracic legs are directed anteriorly and the tips of the metathoracic legs are directed backward.

The pleuropodia (Figs. 2, 5, *pl,* and 42) are present as nearly circular structures, partly evaginated and partly invaginated. The right pleuropodium of Fig. 2 is 0.067 mm. long and 0.063 mm. wide, while the right pleuropodium shown in Figs. 5 and 42 measures 0.048 mm. in length, 0.070 mm. in width, and 0.033 mm. in depth, with its cluster of cell prolongations extending 0.015 mm. above the level of the adjacent ectoderm. The pleuropodia are a little further removed from the ganglion (*gn*) than they were in the embryo shown in Fig. 4.

Each pleuropodium is a shallow bowl-shaped structure. While in the preceding stage (Figs. 4 and 41) the organ consisted of cells which were in no way different from those of the surrounding ectoderm, it is now (Figs. 5, *pl,* and 42) composed of distinctly modified cells, narrowly triangular in outline, with the broadest (basal) portion of each forming a part of the inner margin of the organ and the narrower portion directed outward. The nuclei are oval, measuring 0.005 mm. in length and 0.003 mm. in width; they are no longer scattered throughout the organ, but are grouped in the center and base of the pleuropodium, with their longer axes perpendicular to its base. The distal end of each cell is prolonged into a thread-like structure which, with the similarly constructed distal ends of the other pleuropodial cells, forms a cluster or tuft of lightly staining cell tips. In this stage the tuft portion of the organ is the only part which is elevated above the surface of the body. The nuclei of the ectodermal cells of the body wall are unchanged in shape and size. It is probable that the pleuropodium begins its secretory function at this time, though what it secretes, or indeed whether it secretes or excretes, is a matter for conjecture.

A still older embryo than the preceding is shown in Fig. 3. The embryo has decreased in length and increased slightly in width, measuring 1.620 mm. in length and 0.454 mm. in width at the first abdominal segment. The cephalic appendages have enlarged somewhat, and the thoracic appendages have lengthened considerably.

The metathoracic legs now are directed caudally and obscure the appendages on the first abdominal segment.

Fig. 6 (*pl*) and Fig. 43 represent a pleuropodium of an embryo which is somewhat younger than that shown in Fig. 3 and somewhat older than that represented in Fig. 5. The pleuropodia are plainly invaginated at this stage, with only the tufts of cell tips showing above the surface of the body, and are still further removed from the median ganglion.

The right pleuropodium measures 0.056 mm. in length, 0.037 mm. in width, and 0.037 mm. in depth, with its cluster of cell tips protruding a distance of 0.011 mm. above the surface of the body. In Figs. 6 and 43 there appears to be a slight constriction of the cell tips near their extremities. No such constriction would be apparent in a true transverse section. This line, apparently marking off the extremities of the cells from the basal portions, is mentioned by Wheeler (1890) and represented in his figures. On page 100 he writes as follows:

> "Each cell-tip is capped by a refractive thread, which nearly or quite equals the cell in length and may often be split into two or three branches. Usually the line which separates the cell-tips from the threads which cap them is distinctly marked as in Fig. 17 and at *z* in Fig. 18. I have, however, found numerous cases where no such line could be detected, the hyaline cell-tips passing without interruption into the long refractive threads."

From the fact that Wheeler was not always able to find this separating line I judge that his experience was the same as mine, but our conclusions differ as regards its nature. When the embryo has been correctly oriented before it is sectioned, so that perfectly true transverse, frontal, or sagittal sections of the pleuropodium are obtained, this line cannot be found. In cases where somewhat oblique sections of the pleuropodium are made, it is quite distinctly present. But instead of interpreting this line as a separation between the cell tip and the basal portion, I believe it to represent the margin of a circular orifice formed by the ectodermal cells of the body wall, through which the hyaline cell tips of the pleuropodium protrude, carrying with them their secretion or excretion. Somewhat oblique sections of the pleuropodia of *Ranatra* represented in Figs. 57 and 58 also show this line, which is really the margin of the aperture.

In the pleuropodium represented in Figs. 6 and 43 the nuclei measure 0.006 mm. in length and 0.005 mm. in width, while the nuclei of the body ectodermal cells still measure approximately 0.003 mm. in length and 0.002 mm. in width. The pleuropodial cells are very clearly shown in the section; the nuclei are arranged in a few rows at the base of the organ, leaving the thread-like cell tips to fill the center and the orifice.

B. During Revolution

[Figures 7 and 44.]

During its revolution the embryo migrates around the posterior pole of the egg, from the dorsal to the ventral face of the yolk. All the thoracic appendages become directed backward, and extend considerably beyond the first abdominal segment.

The pleuropodia of an embryo in the process of revolution are represented in Figs. 7 (*pl*) and 44. They are somewhat more bulbiform than in the preceding stage (Fig. 6) and are considerably larger. The space between the median ganglion and the inner margin of the pleuropodium has become greater, showing that the pleuropodium has moved toward the pleural wall as the embryo increased in size.

The left pleuropodium (Fig. 44) is 0.064 mm. long, 0.067 mm. wide, and 0.074 mm. deep, with a tuft extending 0.055 mm. from the orifice and measuring 0.037 mm. in width.

The nuclei in this pleuropodium are beautifully stained and show a fine chromatin pattern. They are somewhat rectangular in shape, and measure 0.008 mm. in length by 0.003 mm. in width, and each contains a round central nucleolus less than 0.002 mm. in diameter. They are grouped at the basal third of the organ, and many small vacuoles have appeared in the inner ends of the cells. Large oenocytes now appear for the first time, clustered in the pleural fold near the outer margin of the pleuropodium. They are roughly circular in outline, measuring 0.015 mm. in diameter, with large oval nuclei which are 0.010 mm. long and 0.008 mm. wide.

C. After Revolution

[Figures 8, 9, 10, 11, 12, 13, 14, 15, 16, 45, 46, 47, 48, 49, 50, 51, 52, 53.]

After the embryo has passed around the posterior pole it comes to lie on the ventral face of the yolk with its head directed toward the cephalic pole of the egg and the tip of its abdomen toward the posterior pole. During this period the dorsal wall of the embryo becomes completed, enclosing the yolk mass.

A transverse section of an embryo which has just passed the posterior pole of the yolk is represented in Fig. 8, and its pleuropodium in Fig. 45. The walls of the embryo are commencing to grow dorso-laterally but have not yet joined in the median dorsal line. In this embryo the pleuropodium, which has moved further away from the ganglion, is again more bowl-shaped in outline; this shape is retained, with various changes in its dimensions, until the time of hatching.

The left pleuropodium (Figs. 8, *pl,* and 45) measures 0.060 mm. in length, 0.070 mm. in width, and 0.048 mm. in depth below the surface of the body; its tuft of cell tips extends 0.048 mm. from the orifice and has a greatest width of 0.052 mm. The nuclei, which occupy the basal half of the organ, measure 0.006 mm. in length and 0.005 mm. in width; interspersed between them are small clear vacuoles. The nuclei of the ectodermal cells of the body wall have not increased in size.

The pleuropodium of an embryo somewhat older than that represented in Figs. 8 and 45 is shown in Figs. 9 (*pl*) and 46, in a fronto-sagittal section through the first abdominal segment. The pleuropodium is covered by the third thoracic leg (*t 3*). It measures 0.100 mm. in length, 0.072 mm. in width, and 0.070 mm. in depth below the surface of the body. The cluster of cell tips is very large, being 0.056 mm. long by 0.074 mm. wide; it projects 0.037 mm. above the level of the body ectoderm and spreads out against the inner margin of the metathoracic leg, which covers the organ. The nuclei are situated in a roughly median belt around the pleuropodium, and are 0.014 mm. long by 0.005 mm. wide, with a spherical central nucleolus about 0.002 mm. in diameter. Many vacuoles, approximately twice the size of the nucleoli, are present; they occur principally in the basal part of the organ.

The pleuropodium of an embryo of about the age of that shown in Figs. 9 and 46 is represented in Figs. 10 (*pl*) and 47, in a fronto-sagittal section through the first abdominal segment. It measures 0.100 mm. in length, 0.088 mm. in width, and 0.059 mm. in depth below the surface of the body. The cluster of cell tips is forced to split into two parts by the presence of the third thoracic leg (*t 3*) which lies above the organ. The tuft extends a distance of 0.015 mm. before it divides, then extends forward a distance of 0.022 mm.

and backward 0.041 mm. The nuclei are somewhat rectangular in shape, and are 0.010 mm. long by 0.005 mm. wide. They lie perpendicular to the bases of the cells, arranged in two irregular rows near the inner wall of the organ, and contain rather uniformly distributed chromatin granules. The vacuoles are not as evident as in the pleuropodium shown in Fig. 46.

A transverse section of an older embryo is represented in Fig. 11, and its pleuropodium in Fig. 48. The dorsal wall of the embryo has closed; the yolk is enclosed in a membrane and now fills the yolk cavity (*yc*) within the body of the embryo. The pleuropodia are quite far removed from the median line of the first abdominal segment, and occupy a position on the pleura near the outer margin of the third thoracic legs.

The right pleuropodium (Fig. 48) is 0.088 mm. long, 0.100 mm. wide, and 0.059 mm. deep. The tuft of cell tips extends 0.078 mm. from the orifice and is split into three parts at its distal end. In shape, size, and arrangement the nuclei resemble those of the pleuropodium represented in Fig. 47; vacuoles are not as conspicuous as in Fig. 46. A cluster of oenocytes in the bend of the pleural fold of the ectoderm is very striking.

A somewhat older embryo is represented in transverse section in Fig. 12, and its pleuropodium in Fig. 49. A chitinous membrane (*ch*) now envelops the entire embryo. The right pleuropodium (Fig. 49) is 0.088 mm. long, 0.100 mm. wide, and 0.059 mm. deep; the tuft of cell tips is roughly triangular in shape, extending outward 0.048 mm. and spreading laterally 0.096 mm. The nuclei seem to be more numerous than those shown in Figs. 47 and 48, are somewhat more elongate, being 0.011 mm. long and 0.003 mm. wide, and are quite densely packed into the basal half of the organ. A cluster of large oenocytes lies near the pleuropodium.

An older embryo is represented in transverse section in Fig. 13. Its right pleuropodium (Fig. 50) is 0.064 mm. long, 0.085 mm. wide, and 0.052 mm. deep. Its tail-like tuft of cell tips is very long, and is bent back upon itself. The tuft of the left pleuropodium is straight and extends 0.078 mm. above the surface of the body; it is 0.018 mm. wide where it emerges from the orifice and 0.037 mm. wide at its distal end. The right tuft is directed laterally, with a small number of cell tips separated off and lying between the body wall and the margin of the third thoracic leg. The nuclei are 0.008 mm. long and 0.003 mm. wide; they are densely packed in two irregular rows in the basal half of the pleuropodium. A cluster of oenocytes lies lateral to the pleuropodium and is separated from it by a bend in the pleural wall.

The embryo shown in transverse section in Fig. 14 is of nearly the same age as that shown in Fig. 13. The right pleuropodium (Fig. 51) is 0.080 mm. long, 0.089 mm. wide, and 0.070 mm. deep. Its tuft is broken into several strands at the distal end; it is 0.074 mm. long and its greatest width is 0.033 mm. Large vacuoles at the apices of the nuclei and interspersed between them give a mottled appearance to the basal region of the pleuropodium. The nuclei are 0.012 mm. long and 0.005 mm. wide; the vacuoles are approximately 0.005 mm. by 0.004 mm. in size.

A fronto-sagittal section through the first abdominal segment of a somewhat older embryo than that shown in Fig. 14 is represented in Fig. 15, and its pleuropodium in Fig. 52. A second chitinous cuticle has been secreted and closely envelops the thoracic legs. The pleuropodium has come to occupy a position on the pleural wall of the first abdominal segment, close up under the insertion of the metathoracic coxa and concealed by it. The left pleuropodium (Fig. 15) appears to lie with its orifice directed upward instead of outward, but this is not substantiated by the pleuropodia shown in Fig. 16.

The greatest length of the left pleuropodium is 0.074 mm., its greatest width 0.111 mm., and its depth 0.056 mm. Its tuft of cell-tips, which is split into two parts, has a lateral expansion of 0.111 mm., and extends 0.022 mm. above the orifice. It appears to be fused at one point with the chitin of the metathoracic leg. The nuclei are more darkly stained and less densely packed into the basal third of the organ; they are 0.008 mm. long and 0.003 mm. wide.

Fig. 16 represents a transverse section through the first abdominal segment of an embryo just before hatching. The second chitinous envelope (*cu*) is closely applied to the thoracic legs. The yolk cavity has given way to the mid-intestine (*int*). The pleural region increases greatly in width before the insect hatches, and in the confined space within the egg shell it is thrown into several folds such as those shown lateral to the pleuropodia in Fig. 16.

The right pleuropodium (Fig. 53) is 0.080 mm. long, 0.096 mm. wide, and 0.059 mm. deep. The tuft is split into two uneven parts, due to the presence of the third thoracic leg; its greatest length is 0.096 mm. It narrows down to a fine thread which seems to fuse with the chitinous cuticle of the metathoracic leg. The pleuropodial nuclei are 0.011 mm. long and 0.003 mm. wide; they are arranged in two rows in the basal third of the organ, the nuclei of one row alternating with those of the other.

D. After the Hatching of the Nymph

[Figures 17 and 54.]

A sagittal section through the first abdominal segment of a first instar nymph is represented in Fig. 17 and its pleuropodium is shown in Fig. 54. The left pleuropodium (*pl*) is now pyriform with a narrow neck and a bulbous basal portion. The narrow neck is formed by the extension of the lateral margin of the ectodermal body wall over the orifice of the pleuropodium. The organ measures 0.092 mm. long, 0.064 mm. wide, and 0.055 mm. deep; its longitudinal axis is now at right angles to the surface of the body, instead of being parallel to the body as in earlier stages.

The pleuropodium is now undergoing absorption. The body wall has covered it completely, making useless the temporary duct leading into the cavity of the bulbous portion. The cluster of cell tips is entirely gone: the precise time of its disappearance is uncertain, though it probably occurred during the process of hatching. The cell walls have disappeared, leaving the organ a syncytium, and the enormous nuclei have degenerated into small spherical or ellipsoidal deeply staining bodies measuring 0.002 mm. or less in diameter.

2. **Ranatra fusca** Palisot de Beauvois

For reasons given under *Belostoma,* I have been unable to ascertain the precise ages of the eggs of *Ranatra fusca* Palisot de Beauvois (Order Hemiptera, Family Nepidae) used in my studies of the pleuropodia. The period of incubation for this species has been said to be two or three weeks.

As in the case of *Belostoma,* the pleuropodia of *Ranatra* arise at the time of the first appearance of the mandibles, as a pair of minute evaginations (Figs. 18, *pl,* 21, and 55) on the first abdominal segment, one on each side of and adjacent to the median ganglion. They become invaginated and seem to produce a secretion which is carried to the surface of the body by the elongated cell tips; they increase in size up to the time of hatching; but, as in *Belostoma,* their degeneration and dissolution take place in the first instar nymph.

The pleuropodia will be described under five headings, each representing a distinct period in the early history of the insect. The periods are the following: before the revolution of the embryo, during revolution, after revolution, during the hatching of the nymph, and after hatching.

A. Before the Revolution of the Embryo

[Figures 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 55, 56, 57, 58, 59, 60, 61, 62.]

Before the embryo begins its revolution around the posterior pole of the yolk, it lies on the dorsal side of the yolk, with its head directed toward the posterior pole of the egg and the tip of its abdomen toward the anterior pole. It is covered by the amnion and by the serosa (Figs. 23 and 24).

Although I examined many stages younger, Fig. 18 represents the youngest embryo in which I found pleuropodia. The head is short and wide; the cephalic appendages are small and directed laterally; the thoracic legs are unsegmented and directed laterally and somewhat backward; the abdomen is segmented and its tip is flexed ventrally. The embryo is 2.106 mm. long and its first abdominal segment is 0.243 mm. wide. The pleuropodia appear like little buds, somewhat more lateral than the pleuropodia in the same stage in *Belostoma* (Fig. 1).

Fig. 21 represents a transverse section through the first abdominal segment of an embryo of about the same age as Fig. 18, and Fig. 55 represents the left pleuropodium of the section shown in Fig. 21. The pleuropodium is 0.064 mm. long, 0.048 mm. wide, and elevated 0.037 mm. above the surface of the body ectoderm. The nuclei measure 0.006 mm. long by 0.005 mm. wide and are grouped irregularly throughout the median portion of the organ. The cells are roughly oblong in shape, with their basal ends forming the floor of the structure. The nuclei of the ectodermal cells forming the body wall are oval, measuring 0.005 mm. long by 0.003 mm. wide. The body wall extends under the pleuropodium and it is bordered within by mesodermal cells. The distal ends of the short pleuropodial cells are clear, and in this stage are separated from each other, though in outline they form a small cluster. The cell tips are rather blunt and not drawn out into the fine thread-like structures which develop in later stages.

An older embryo is shown in surface view in Fig. 19. The head is longer and narrower; the cephalic appendages are somewhat more slender; the thoracic legs are longer, are segmented, and are directed further backward; the abdomen is shorter and broader at its caudal end. The pleuropodia (*pl*) are nearly circular in outline with a median aperture; they are shown in transverse section in Fig. 22 and the right pleuropodium is shown in detail in Fig. 56.

The pleuropodium (Fig. 56) is 0.056 mm. long, 0.063 mm. wide, by 0.041 mm. in thickness. It lies level with the surface of the body with its base sunken below the surface and the cluster of cell tips projecting above it. The nuclei are of the same size and shape as those in the preceding stage (Fig. 55), and have about the same arrangement. The cell tips are about the length of those shown in Fig. 55.

An older embryo is represented in oblique transverse section in Fig. 23, and its right pleuropodium in Fig. 57. The pleuropodium is 0.060 mm. long, 0.059 mm. wide, and 0.052 mm. deep. The nuclei have the same size and shape as those shown in Figs. 55 and 56, but owing to the increase in size of the entire organ they are less closely crowded and therefore appear larger. They are arranged in two rows at the base of the pleuropodium, one row alternating with the other in elevation. The cell tips are long, but appear to be cut off from the basal portions of the cells by a constriction—which is really the margin of the orifice formed by the ectoderm of the body wall. The amnion and serosa enclose the embryo but do not come into contact with the pleuropodium.

The first abdominal segment of an embryo of the same age is represented in transverse section in Fig. 24 and its pleuropodium in Fig. 58. The right pleuropodium is 0.070 mm. long, 0.059 mm. wide and 0.041 mm. deep. In size, shape, and position the nuclei resemble those shown in Fig. 57, though the pleuropodium is more shallow. Here also a constriction seems to cut off the distal ends of the cells but really represents the margin of the orifice. This figure suggests that a secretion from the cell tips may actually be present at their distal extremities, as there is shown in this section a cloudy homogeneous substance which does not appear in later stages when the amnion is lost. It is quite possible that this substance is held after fixation, with the amnionic secretion, between the amnion and the embryo, though what its function may be is problematical.

An older embryo is shown in surface view in Fig. 20 and in transverse section in Fig. 25; its right pleuropodium is shown in Fig. 59. The embryo has shortened and broadened, being now 1.993 mm. long while its first abdominal segment is 0.535 mm. wide. The pleuropodium is 0.080 mm. long, 0.078 mm. wide, and 0.048 mm. deep. The nuclei are nearly spherical, with a diameter of 0.008 mm. and grouped at the base of the organ, but the chromatin seems to have been limited to a narrow zone around the periphery of the nucleus, leaving a clear space between it and the small central nucleolus. The cell tips form a bushy cluster and may still contain their secretion.

An older embryo than those previously described is shown in transverse section in Fig. 26, and its left pleuropodium in Fig. 60. The thoracic legs have changed their direction from lateral to backward and they now extend down the ventral face of the embryo. The pleuropodia have moved away from the median line and have taken up a position on the pleural wall near the margin of the metathoracic leg. The left pleuropodium (Fig. 60) is 0.064 mm. long, 0.067 mm. wide, and 0.052 mm. deep. The nuclei are oval bodies 0.011 mm. long and 0.005 mm. wide, grouped in the basal third of the organ. The cell tips form a tuft of nearly uniform width, projecting 0.048 mm. beyond the orifice.

Two embryos which are just about ready to make their revolution around the posterior pole of the egg are represented in Figs. 27 and 28. Fig. 27 represents a transverse section of the first abdominal segment; the left pleuropodium is shown in Fig. 61. Fig. 28 shows a sagittal section of another embryo with its left pleuropodium shown in Fig. 62. There is a surprising similarity between the pleuropodia shown in these two figures—surprising because the pleuropodia are from different embryos and because Fig. 61 represents a transverse section while Fig. 62 represents a sagittal section. One may conclude, therefore, that the organ is radially symmetrical, so that any plane which passes through the center of its orifice and the median point of its basal region divides it into two equal parts.

The left pleuropodium (Fig. 61) is 0.088 mm. long, 0.081 mm. wide, and 0.078 mm. deep. Its nuclei are 0.008 mm. long by 0.006 mm. wide and seem to lie in a single row around the base. If one thinks of the organ as a bowl-shaped structure, then this row is seen to be a layer of nuclei lining its cavity. Several large vacuoles are present between the cell boundaries. The largest one visible in this section measures 0.008 mm. in length and 0.003 mm. in width. The cell tips form a particularly compact structure, the shape of which is partly determined by the proximity of the metathoracic leg. The tuft extends 0.033 mm. beyond the orifice of the pleuropodium and at its greatest width measures 0.042 mm.

The left pleuropodium shown in Fig. 62 is 0.096 mm. long, 0.072 mm. wide, and 0.078 mm. deep. The nuclei are 0.010 mm. long by 0.008 mm. wide and are arranged in a uniform layer lining the cavity of the organ. Vacuoles are also visible as in the pleuropodium shown in Fig. 61. The tuft of cell tips is more pointed at its median part. Apart from a difference in the size and shape of the tuft, the two pleuropodia shown in Figs. 61 and 62 might easily be mistaken for one another. The nuclei of the ectodermal cells of the body wall are small oval bodies, 0.003 mm. long by 0.002 mm. wide.

B. During Revolution

[Figures 29, 30, 63, 64.]

During revolution the embryo leaves its former position on the dorsal face and moves around the posterior pole to a new position on the ventral face of the yolk. An embryo in the act of passing around the pole is shown in transverse section in Fig. 29, and its left pleuropodium is represented in Fig. 63. The thoracic legs are pressed close against the ventral body wall, and their ventral margins form nearly a straight line.

The left pleuropodium (Fig. 63) is 0.064 mm. long, 0.085 mm. wide, and 0.037 mm. deep. Its nuclei are 0.010 mm. long by 0.005 mm. wide, and are grouped in irregular rows at the base of the organ. The organ is quite compressed, being considerably wider than it is deep, and the tuft of cell tips slants abruptly toward the space between the body wall and the thoracic appendage. The aperture is very wide.

A transverse section of the first abdominal segment of an embryo of about the same age is shown in Fig. 30, but in this case the embryo has assumed a triangular shape during its revolution. The body wall forms the base of the triangle and the prothoracic legs form the apex. The amnion is still intact, but does not touch the pleuropodia. The right pleuropodium of Fig. 30 is shown in Fig. 64. It is 0.080 mm. long, 0.085 mm. wide, and 0.044 mm. deep. Its nuclei are 0.010 mm. long by 0.005 mm. wide; they are very deeply stained bodies arranged in a regular row at the base of the organ. The aperture is narrower than that shown in Fig. 63, while the tuft of cell tips is longer and more pointed distally, and shows a median flexure.

C. After Revolution

[Figures 31, 32, 33, 34, 35, 36, 37, 38, 65, 66, 67, 68, 69, 70, 71, 72.]

After its revolution around the posterior pole the embryo comes to lie on the ventral face of the yolk with its head directed toward the cephalic pole and the tip of its abdomen toward the posterior pole of the egg. The lateral margins of the body wall are extended upward to join in the median line and surround the yolk mass.

A transverse section of an embryo just after revolution is represented in Fig. 31, and its left pleuropodium in Fig. 65. The pleuropodia have moved further away from the median ganglion. The one figured is 0.090 mm. long, 0.085 mm. wide, and 0.063 mm. deep. It is very lightly stained, and the dark-stained nucleoli and chromatin threads stand out in bold relief. The nuclei are nearly round, with a diameter of 0.008 mm., and each contains a spherical, very darkly stained central nucleolus with a diameter of 0.001 mm. The chromatin is thread-like, and much of the nucleus is hyaline. The aperture is narrow, and the cluster of cell tips long and flexed distally, where it is crowded between the body and the metathoracic leg.

A transverse section of an older embryo is represented in Fig. 32 and its left pleuropodium in Fig. 66. The dorsal body walls are still incomplete; the first chitinous envelope has been proliferated; the pleuropodia have moved farther to each side and are now almost lateral in position.

The left pleuropodium (Fig. 66) is 0.072 mm. long, 0.107 mm. wide, and 0.044 mm. deep. The nuclei are 0.011 mm. long by 0.005 mm. wide, and are more irregular in outline than those in previous stages. The divisions between the cell boundaries are particularly well marked and indicate that the organ is composed of triangular cells whose narrow bases form the inner wall of the bowl-shaped organ and whose greatly prolonged and attenuated apices are protruded as a cluster of cell tips forming a passage-way for the exit of the material which the embryo secretes or perhaps excretes through the pleuropodium.

The cluster of cell tips of the pleuropodium shown in this figure is quite brush-like and asymmetrical, curving laterally somewhat to pass the margin of the metathoracic leg.

An embryo in which the dorsal wall is closed over and the first chitinous envelope is completed is shown in transverse section in Fig. 33, and its left pleuropodium is shown in detail in Fig. 67. The pleuropodium is 0.064 mm. long, 0.104 mm. wide, and 0.044 mm. deep. The nuclei are 0.008 mm. long by 0.005 mm. wide, and are arranged in several irregular rows at the base of the organ. The aperture is small; the tuft of cell tips is very large, and is broader than long. It approaches but does not come into contact with the chitinous membrane. It seems to be fused with the lateral margin of the metathoracic leg, which is close to the body at this point.

A transverse section of an older embryo is shown in Fig. 34 and the right pleuropodium in Fig. 68. The yolk has become enclosed in a membrane, and now lies in a distinct yolk cavity (*yc*) within the body. The right pleuropodium is 0.080 mm. long, 0.089 mm. wide and 0.048 mm. deep. The nuclei are 0.022 mm. long by 0.005 mm. wide; they are no longer grouped at the base of the organ but are radially disposed in a median belt. The cell tips form a tremendous mass, which splits into two parts and seems to fuse with the metathoracic leg along its inner margin. Though I searched each preceding stage for oenocytes, I found none until they were seen in this section. They are very pale bodies situated laterad to the pleuropodia and not in contact with it; they measure 0.018 mm., and their spherical nuclei 0.008 mm. in diameter. Due probably to faulty technique, the left pleuropodium in this section seems to be torn halfway out from the body wall.

A transverse section of an embryo of the same age is shown in Fig. 35, and its left pleuropodium is shown in detail in Fig. 69. The pleuropodium is 0.104 mm. long, 0.100 mm. wide, and 0.048 mm. deep. The nuclei are 0.011 mm. long by 0.003 mm. wide, and, as in the stages represented in Figs. 68 and 70, they are grouped band-like about the organ as though they radiated from the orifice. The aperture is small and through it emerges the slender tuft of cell tips which splits into two narrow portions, one of which seems to fuse with the chitinous membrane (not shown in Fig. 35) which is closely applied to the metathoracic leg.

An older embryo is shown in transverse section in Fig. 36 and its right pleuropodium in Fig. 70. The second chitinous cuticle (*cu*) has now appeared, and completely envelops the legs and the body, except for the cluster of cell tips from the pleuropodia. This remains exposed, but in some places seems to be fused with the chitin of the third thoracic appendage. The pleuropodium is 0.080 mm. long, 0.078 mm. wide, and 0.067 mm. deep. The nuclei are 0.013 mm. long by 0.005 mm. wide, with their distal apices pointing directly toward the orifice. The cell tips are very long, some of them measuring 0.148 mm. from the apex of the nucleus to the extreme distal tip of the cell. The tuft is split into two parts, a very small strand turning back along the median wall of the body while the great mass turns outward. A conspicuous feature of this pleuropodium is the manner in which the ectoderm of the body wall has turned in to form a distinct rim instead of merely a margin around the orifice.

A sagittal section through the first abdominal segment of an embryo of about the same age is represented in Fig. 37, and its left pleuropodium is shown in oblique section in Fig. 71. The pleuropodium in this embryo is 0.111 mm. long, 0.056 mm. wide, and 0.081 mm. deep. In Fig. 71 the orifice of the pleuropodium is shown in nearly frontal section, with the circular cell prolongations cut in slightly oblique transverse section, while a portion of the tuft appears in longitudinal section with the cell tips shown horizontally. The cell tips have a diameter of 0.001 mm. as they emerge from the orifice of the organ. Other sections show a number of small vacuoles present around the outer wall of the organ, though they are not conspicuous in the sections of most stages.

A frontal section through the first abdominal segment of an embryo which is nearly ready to hatch is shown in Fig. 38, and its right pleuropodium is represented in Fig. 72. The pleuropodium is 0.063 mm. long, 0.104 mm. wide, and 0.055 mm. deep; it is set off from the ectoderm of the body wall by a rim around the orifice as in Fig. 70. The nuclei are 0.011 mm. long by 0.003 mm. wide, and are arranged as in Fig. 70. The cells are very long, if one is to judge by the length of their prolongations; the tuft extends 0.084 mm. beyond the orifice, and as the bowl-shaped portion is 0.055 mm. in depth, a maximum length of 0.139 mm. may be assigned to the cells comprising the pleuropodium at this stage. Part of the tuft appears to fuse with the chitin of the metathoracic leg (not shown in Fig. 38).

D. During Hatching

[Figures 39 and 73.]

During the process of hatching the body and appendages of the nymph are much shrivelled as the air has not yet entered the tracheae and inflated the body, and the chitin has not yet hardened.

A transverse section of the first abdominal segment of an embryo in the process of hatching is shown in Fig. 39, and its left pleuropodium is shown in detail in Fig. 73. The ectoderm of the body wall is elevated in a fold on each side of the pleuropodium, forming a duct leading into its interior. The pleuropodium is 0.040 mm. long, 0.070 mm. wide at its median portion, and 0.067 mm. deep, including the duct formed by the ectodermal cells of the body wall. The long cell prolongations have disappeared some time between the stage represented in Fig. 72 and that shown in Fig. 73, though when or by what means this interesting structure was lost is unknown. The nuclei are 0.008 mm. long and 0.005 mm. wide, and are quite irregular in shape and size. The body wall seems about to close over the pleuropodium, which will later be absorbed inside the body. Its period of usefulness is apparently almost ended.

E. After Hatching

[Figures 40 and 74.]

A transverse section of the first abdominal segment of a first-instar nymph is shown in Fig. 40 (the legs are omitted), and its left pleuropodium in Fig. 74. The pleuropodium is 0.081 mm. long, 0.065 mm. wide, and 0.037 mm. deep, with a narrow duct 0.037 mm. long, formed by the ectoderm of the body wall, leading part way into it but ending blindly, showing that the ectoderm has now begun to cover the pleuropodium. The nuclei are 0.008 mm. long and 0.003 mm. wide, and apparently the cell boundaries are still present. The organ has not degenerated to the same extent as that in the first-instar nymph of *Belostoma* (Fig. 54), but no trace of the pleuropodium is to be found in older nymphs of *Ranatra*.

3. **Dineutes** (?) sp., **Carabus auratus** L., **Calosoma sycophanta** L.

I have examined a small series of embryos of each of these three species of adephagous beetles, but have been unable to give them the attention and time which they deserve, as the material came into my hands only recently.

The embryos of *Dineutes* (?) sp. (Family Gyrinidae) which I have examined were considerably past revolution, with the dorsal wall completed and the appendages well developed. The pleuropodia are shallow invaginations at the surface of the body on the pleura of the first abdominal segment. It is possible that they represent later stages in the development of pleuropodia which were evaginated in younger embryos. On each of the succeeding abdominal segments is a pair of curved digitiform appendages which represent tracheal gills.

A series of eggs of *Calosoma sycophanta* L. and *Carabus auratus* L. (Family Carabidae) was given me by Mr. C. W. Collins. In surface view the pleuropodia of *Calosoma* and *Carabus* are very similar; in both species they occur as a pair of circular evaginations on the pleural wall of the first abdominal segment. In general shape they resemble the pleuropodia of *Meloë scabriusculus* Brandt as figured by Graber (1891).

IV. HISTORICAL REVIEW

1. CLASS PTERYGOGENEA

Before proceeding with descriptions of the pleuropodia of those insects in which they have been found, it may be well to give a list of the insects for which no pleuropodia have been described. With the exception of the references to Carrière (1891), Tutt (1894), Craven (1909), and Nelson (1915), the citations below are those given by Wheeler (1890). The specific names used are those employed by the authors cited.

List of Insects for Which No Pleuropodia Have Been Described

Order Hymenoptera.

Apis mellifica L. [Bütschli (1870), Grassi (1884), Nelson (1915)].

Order Coleoptera.

Clythra laeviuscula [Carrière (1891)].
Doryphora decemlineata Say [Wheeler (1889c)].

Order Lepidoptera.

Telea polyphemus Cram. [Wheeler (1890)].
Hyperchiria io Fabr. [Wheeler (1890)].
Callosamia promethea Drury [Wheeler (1890)].
Gastropacha quercifolia L. [Graber (1888)].
Platysamia cecropia L. [Wheeler (1890)].
Orgyia leucostigma A. and S. [Wheeler (1890)].
Tortrix ferrugana Treit. [Tutt (1894)].

Order Diptera.

Chironomus sp. [Weismann (1863), Craven (1909)].
Tabanus atratus Fabr. ? [Wheeler (1890)].
Musca sp. [Weismann (1863), Voeltzkow (1889)].

Order Homoptera.

Aphis pelargonii [Will (1888)].
Aphis rosae L. [Will (1888)].
Aphis saliceti [Will (1888)].

I have revised and brought up to date the nomenclature of the species of insects for which pleuropodia have been described. In this work I have consulted the following references:

General classification.
Brues and Melander (1915).
Order Orthoptera.
Kirby (1904–1910).
Burr (1910).
Rehn and Hebard (1915).
Morse (1920).
Order Dermaptera.
Burr (1916).
Order Mantoidea.
Kirby (1904–1910).
Burr (1910).
Hebard (1920).
Order Blattoidea.
Morse (1920).
Order Isoptera.
Banks (1919).
Order Hymenoptera.
Dalla Torre (1894).
Wheeler (1910).
Friese (1911).
Order Coleoptera.
Heyden, Reitter, and Weise (1906).
Leng (1920).
Order Strepsiptera.
Pierce (1909).
Order Embiidina.
Selys Longchamps (1912).
Order Megaloptera.
Banks (1907).
Order Trichoptera.
Banks (1907).
Order Lepidoptera.
Barnes and McDunnough (1917).
Order Homoptera.
Van Duzee (1917).
Order Hemiptera.
Oshanin (1912).
Van Duzee (1917).
Hungerford (1924).

Order Orthoptera

FAMILY ACRIDIDAE

Stauroderus biguttulus L.

Stenobothrus of Wheeler (1890).
Stenobothrus variabilis of Graber (1888, 1889).

The pleuropodium is a flattened, biscuit-shaped, dark-brown body, measuring about 1 mm. in diameter, and occupying, at the time of its greatest development, a position on the pleural wall of the first abdominal segment. It opens into the body cavity through a short, rather broad passage, in which are sometimes seen blood (?) cells. The enormous cells of the outer wall, which are not covered by a chitinous cuticle, are filled with yellowish granules, similar to those contained in a fine brown coagulum which partly adheres to the skin and legs adjacent to the pleuropodium. This coagulum is probably, at least in part, secreted by the pleuropodial cells.

FAMILY LOCUSTIDAE

Conocephalus brevipennis (Scudd.)

Xiphidium ensiferum Scudd. of Wheeler (1890, 1893).

The pleuropodium arises as a nipple-shaped elevation on the first abdominal segment. It becomes bulbous and constricted into a peduncle at its base. Its contour is somewhat angular, and its distal end terminates in a point. The cavity of the organ is very large, while the cells forming the walls are reduced to short broad prisms, with pale granular cytoplasm and nuclei which stain less deeply than the smaller nuclei of the surrounding ectoderm. A canal through the peduncle at first connects the large cavity of the pleuropodium with that of the body, but later becomes closed.

The pleuropodia attain their maximum size during the revolution of the embryo, and advance toward the pleural wall of the segment. Later they decrease in size and their peduncles become attenuated. When the embryo is ready to escape from its envelopes, the pleuropodium occupies a position close to the insertion of the third thoracic leg. It is loosely attached to the body and adheres to the serosa and the first chitinous cuticle. A dark brown granular substance fills the space between the embryo and its membranes, and adheres to the latter. The abundance of this granular substance seems to indicate that it may be a secretion of the pleuropodium or of one of the embryonic envelopes. The organ becomes a syncytium in its later stages; the nuclei lose their regular arrangement, and often their oval contours; the cytoplasm stains more deeply. The pleuropodium is probably shed by the embryo just before hatching.

Meconema thalassina De G.

Baillon (1920) states that the pleuropodia are present until the moment of hatching, when they separate from the amniotic membrane and are cast off with the chorion. Free cells, having all the characters of amebocytes, occur within their cavities. The chorion has a very special structure which renders the circulation of air very difficult, and it is possible that the pleuropodia are respiratory organs.

FAMILY GRYLLIDAE

Oecanthus niveus (De G.)

Oecanthus niveus Serville of Ayers (1884) and Wheeler (1890).

Ayers assigns a respiratory function to the pleuropodium, a conclusion which Wheeler questions. According to Ayers, each pleuropodium is a single-layered sac connected with the pleural region of the first abdominal segment by a much constricted neck. It grows to the length of the mature mandibles before atrophying, and varies in shape from a finger-like to a lobed outgrowth. In the later stages it is covered by the third thoracic leg. He describes, without seeing their relationship to pleuropodia, "gill-pads," organs which Wheeler identifies with the late stages of the pleuropodia.

Gryllus sp.

Heymons (1895) states that the first abdominal appendages agree in their general aspect with the pleuropodia of *Oecanthus niveus* (De G.).

FAMILY GRYLLOTALPIDAE

Gryllotalpa gryllotalpa (L.)

Gryllotalpa vulgaris L. of Rathke (1844), Patten (1884), Korotneff (1885), Wheeler (1890), Graber (1888, 1891).

Rathke records the first discovery of pleuropodia in any insect embryo. He describes them as mushroom-shaped bodies and ascribes to them a respiratory function. Patten assigns them some sensory (?) function, on account of the peculiar structure and development of the ectoderm cells, or possibly a glandular function, because of the longitudinal duct leading into the cavity of each pleuropodium. Korotneff states that they arise as button-shaped prominences laterad to the other appendages; that they resemble mushrooms and consist of succulent cells; and that they fall off and disappear completely when the dorsal wall of the embryo closes over. Wheeler believes that the pleuropodia arise at each side of the median line and close to it, as they do in other insects. Graber refers to the pleuropodia of this species.

Order Dermaptera

FAMILY FORFICULIDAE

Forficula auricularia L.

Heymons (1895) describes and figures the pleuropodia as conical evaginations of the same shape and size as the other abdominal appendages.

Order Mantoidea

FAMILY MANTIDAE

Mantis religiosa L.

Mantis sp. (European) of Wheeler (1890).
Mantis religiosa L. of Graber (1877, 1888, 1891).

The pleuropodia are most obviously leg-like and even show signs of segmentation, the finger-like processes being apparently divided into two parts by transverse constrictions. They are neither as long nor as broad as the thoracic legs, though they resemble them in shape. They probably never become bulbous or sac-like.

Stagmomantis carolina (Joh.)

Mantis carolina L. of Wheeler (1890).
Stagmomantis of Hagan (1917).

Wheeler states that the pleuropodia are narrowly pyriform evaginations, homostichous with the metathoracic legs and partly covered by them, with laterally directed tips. They are shorter and more narrow than the legs or cephalic appendages. The thickened walls are made up of a single layer of cells enclosing a narrowly linear cavity. The cells are shaped like curved pyramids with broad bases forming the outer surface, and gradually tapering apices converging toward the central cavity. The cells differ only in shape from other ectodermal cells adjacent to them. The appendage was probably hollow in an earlier stage of development, and became closed off from the body cavity by the intrusion of ectoderm cells from the body. Hagan states that the pleuropodia are conical finger-like processes resembling those of *Tenodera.*

Tenodera sinensis Sauss.

Paratenodera sinensis of Hagan (1917).

The pleuropodia consist of a pair of finger-like processes which appear during the revolution of the embryo. In an older embryo they are still relatively long and project diagonally outward.

Order Blattoidea

FAMILY BLATTIDAE

Blattella germanica (L.)

Phyllodromia germanica L. of Cholodkovsky (1888, 1889, 1890, 1891).
Blatta germanica L. of Patten (1884) and Wheeler (1889c, 1890).

Patten states that the pleuropodia are pear-shaped structures attached to the abdomen by constricted stalks which increase in length and become fine ducts leading into the small cavities in the expanded distal extremities of the organs. The sac-like distal extremity is made up of very high ectodermal cells. No mesoderm makes its appearance in the cavity. In the later stages of embryonic development the pleuropodia disappear entirely. Their function is problematical.

Cholodkovsky does not distinguish the pleuropodia, either in size or shape, from the appendages of the succeeding abdominal segments of the embryo.

Wheeler (1889c) refers briefly to Patten's observations and to his own paper "On the Appendages of the First Abdominal Segment of the Embryo Cockroach (Blatta germanica). Proceed. Wisc. Acad. Science, Arts and Letters. Vol. VIII. 1888." On investigation I find that this paper was read at the annual meeting of the Wisconsin Academy of Science, Arts, and Letters, on December 28, 1888, but was not published until 1890, when it was incorporated in Wheeler's paper "On the Appendages of the First Abdominal Segment of Embryo Insects." In the latter paper Wheeler gives a very detailed description and several figures of the pleuropodia of this insect.

An embryo which is eleven days old has nipple-shaped pleuropodia. An embryo which is twelve days old has pleuropodia which are twice as long as the appendages of any of the succeeding abdominal segments, and about half as long as the third pair of thoracic legs. The cells forming the wall of the pleuropodium swell enormously, become shaped like prisms, and begin to grow inward, pushing the mesoderm near them back into the body cavity. The finely granular cytoplasm of the cells is somewhat vacuolated. The nuclei increase in size, assume a centrifugal position in the fan-shaped sections of the pleuropodium, and become arranged in several rows.

In an embryo fourteen days old the cells of the basal part of the pleuropodium lengthen somewhat and clasp the inner ends of the large prismatic cells of the now nearly solid structure, thus forming a broad tubular peduncle whose lumen communicates with the body cavity of the embryo. An embryo which is nineteen days old has a long, narrow, tubular peduncle connecting the pleuropodium with the body. The pleuropodium, with the part of the first abdominal segment to which it is appended, has been carried up to a position somewhat dorsad to what will become the coxa of the metathoracic leg. A superficial constriction has divided the bulbiform organ into two segments. The nuclei have moved back from the surface of the organ and lie in several rows near the region of constriction. The contour of the inner ends of the prismatic cells is distinct and the cavity of the organ has increased in size. Large vacuoles fill the peripheral ends of the prismatic cells, indicating perhaps that the structure of the outer part of the pleuropodium is more sensitive than the inner part.

On the twentieth day of development the pleuropodium has a more or less irregular outline; the peduncle is longer and thinner; the cavity is irregular and bounded by ragged prismatic cells; the constriction is disappearing; the vacuoles have either increased in length and migrated from within the cells to between the cells, or have completely disappeared; and the lateral walls of the cells have been replaced by elongate vacuoles.

On the twenty-fourth or twenty-fifth day of the development of the embryo the pleuropodium is the only part of the body whose surface is not covered by a chitinous cuticle; it has become irregular in outline; and the apical cells have migrated toward the body cavity. In an embryo of twenty-six days the pleuropodium is merely a slightly elevated remnant of what it had been, and in an embryo a few hours older it can not be found at all.

Blatta orientalis L.

Periplaneta orientalis L. of Wheeler (1890).

The pleuropodia are pear-shaped, as in *Blattella,* but with somewhat truncated distal ends and short broad peduncles. In older embryos they undergo degeneration similar to that which takes place in the pleuropodia of *Blattella.* Many of the large nuclei lie in the proximal ends of the cells, thus determining their shape to some extent. The broad ends of the cells are directed toward the body, and the narrow ends meet in a point at the distal end of the organ. Vacuoles occur within and between the cells. At the distal end of the organ the protoplasm, in the form of an irregular granular mass, leaves the organ and perhaps joins the coagulum of the amnion. The disappearance of the pleuropodia is due to their absorption into the body cavity and their dissolution between the body and its membranes. The pleuropodium is the only part which is not covered by the chitinous cuticle secreted before the embryo hatches.

Order Isoptera

FAMILY TERMITIDAE

Nasutitermes ripperti (Ramb.)

Eutermes (*Ripperti* ?) of Knower (1899).

The pleuropodia are at first mere rounded projections which later become pear-shaped in outline and somewhat longer than the appendages on the succeeding abdominal segments. They appear in an embryo just before its revolution, reach their greatest size during revolution, and disappear when revolution has been completed.

Order Hymenoptera

Family Hylotomidae

Hylotoma berberidis Schrank.

Graber (1890) figures and describes the pleuropodia as tiny rounded evaginations, similar in size and shape to those on succeeding abdominal segments. They disappear before the embryo hatches.

Family Formicidae

Camponotus herculaneus L. var. *ferrugineus* Fabr.

Tanquary (1913) figures and describes the pleuropodia as very small paired tubercles or papillae which have a brief period of development in the young embryo.

Myrmica scabrinodis Nyl.

Tanquary (1913) figures and describes the pleuropodia as being similar to those of *Camponotus*. They are merely rounded prominences resembling those of the other abdominal segments. They disappear early in the development of the embryo.

Formica fusca L. var. *gnava* Buckley

Wheeler (1910) figures and describes the pleuropodia as being evanescent appendages which disappear before the embryo hatches. He suggests that they may be mere vestiges of the legs of

> "ancient larval types like the caterpillar, or eruciform larvae of the sawflies, or even . . . the Palaeodictyopteroid ancestors of all insects."

Family Megachilidae

Megachile (*Chalicodoma*) *muraria* (Retz.)

Chalicodoma muraria Fabr. of Carrière (1890), and Carrière and Burger (1897).

The pleuropodia are rudimentary structures very similar to appendages on other abdominal segments.

Order Coleoptera

FAMILY DYTISCIDAE

Acilius sp.

Wheeler (1890) quotes Patten's unpublished description of the pleuropodia of this insect. They

> "arise on the first abdominal segment of the young embryo, as a pair of ectodermic evaginations, homostichous with the thoracic legs. Later, the distal end of each bulbous appendage, consisting of large columnar cells, is invaginated in the form of a cup. The nuclei are situated in the inner ends of the cells, each of which secretes at its tip a short refractive thread, which, with those of the neighboring cells, goes to form over the invaginated area a thick, striated, cuticula-like layer . . . this form of secretion may be compared with the pleuropodial secretion of *Zaitha*, the only difference being that the individual threads secreted are so short as to form together a continuous sheet instead of a penicillate bundle.
>
> "These peculiar appendages, which of all described species most closely resemble the pleuropodia of Meloë, do not fall off during their period of degeneration but are pushed into the yolk and absorbed."

Dytiscus marginalis L.

According to Korschelt (1912) the pleuropodium appears as a conical appendage attached by its broad base to the first abdominal segment. It is somewhat variable in form, but has much the appearance of a leg, and even undergoes a sort of segmentation due to the appearance of superficial ring-like constrictions. This condition is only temporary. The appendage soon increases in bulk, especially at its distal end, where a shallow invagination makes its appearance. At this time the pleuropodial ectoderm becomes greatly thickened as the individual cells increase in depth.

The succeeding abdominal segments undergo similar changes in the corresponding places, forming distinct epithelial elevations. These soon disappear, and the appendages of the first abdominal segment change from pyriform bodies to structures having the shape of a mushroom cap. Sections show them to consist of a rather thick cell plate on a narrow stalk; the stalk is not always well developed.

The organ now increases in circumference and a cup-like invagination develops on its upper surface. It is still leg-like in appearance, both as regards its position and its attachment to the body. Later it sinks below the surface of the body. The pleuropodium is now formed of deep cylindrical cells with large heavily staining nuclei. These cells have a glandular aspect and produce an obvious secretion. Later stages show a clear margin, sharply delimited without, having the appearance of a row of minute rods set side by side. This may be either a secretion or a cuticular structure.

The pleuropodium is retained for a long time after its leg-like appearance is lost, and it is still well developed in nearly mature embryos, though its circumference has decreased somewhat. In later stages it appears to be united in some way with the embryonic membranes, which now show no trace of cellular structure. The part of the clear mass attached to the membrane appears somewhat distorted, whence it seems to be plastic and of secretory origin.

After reviewing Selys Longchamps' theory of the function of the pleuropodium in *Tenebrio,* Korschelt points out that in *Dytiscus* there is no union between the chorion and the pleuropodium, and that further the union between the latter and the embryonic membranes is of very brief duration. These facts, together with the previously noted decrease in size of the pleuropodium, make it seem improbable that these organs are developed to suspend the embryo from the membranes—an end which could be accomplished much more easily by other means. He suggests that probably the secretion given off by the pleuropodium renders the embryo flexible. Toward the end of embryonic life the pleuropodium is overgrown by the hypodermis and soon disintegrates. No external indication of it may be found in recently hatched larvae.

Blunck (1914) finds that the mass contained in the gland cavity of the pleuropodium is a secretion, and agrees with Korschelt in supposing that it serves to render the embryo flexible and finally to facilitate the hatching of the larva. Thus the pleuropodium is comparable to the exuvial glands of Verson, which facilitate larval moults. As long as the embryonic membranes are intact their secretion is sufficient to keep the surface of the embryo softened. At the time when these membranes are ruptured during the process of revolution the pleuropodium begins to function as a glandular organ. Its secretion then takes up the rôle formerly played by the secretions of the embryonic membranes, thus preventing injury to the germ band during revolution.

As evidence for this hypothesis Blunck points out that the pleuropodia secrete a glandular product which penetrates into the amnionic cavity and later into the space between the embryo and the chorion, and that furthermore no other dermal glands are known to occur in the embryo. The theory of Selys Longchamps is held to be untenable, since the embryonic membranes disintegrate at the very time when the pleuropodium reaches its highest development, and since the thoracic legs lie between the two structures concerned.

FAMILY HYDROPHILIDAE

Hydroüs piceus L.

Hydrophilus piceus L. of Kowalevsky (1871), Heider (1889), Wheeler (1890), and Graber (1891).

Kowalevsky figures the pleuropodia of a young embryo as digitiform processes shorter than the third thoracic legs. In an older embryo they are represented as smaller protuberances inserted on the pleura near the bases of the metathoracic legs.

Heider figures them as small bulbous organs with spherical contour, developed from a pair of small mammillary processes. At the time of the rupture of the embryonic envelope, they are but little larger than the terminal metameres of the metathoracic legs and show but little tendency to move apart from the places where they arise. The beginning of a differentiation of the cells may be observed in the last stages described by Heider, but the pleuropodia do not attain their greatest differentiation until a later stage of development.

Graber describes and figures other stages in the development of the pleuropodia. In a younger stage they are obviously composed of two lobes, the median one of which is longer than the other and is more pointed at its apex. The lateral portion soon disappears and the median one alone undergoes further differentiation. Thus the pleuropodia of other insects may represent only a portion of the original rudiment.

Sections through the pleuropodium show it to be composed of two parts, or segments, separated from one another by a rather deep constriction. The basal part consists of a low ectodermal elevation while the distal part has the form of a small sac borne by the former. The base of the structure lies at the middle of the abdominal segment, while the apex extends slightly beyond its posterior margin. The basal portion later becomes shortened so that the distal part, instead of extending backward, now lies directly over it. Sections show that the organ is composed of a circular plate of nearly uniform thickness, made up of narrow cylindrical cells whose nuclei occupy their original peripheral position. These nuclei are about four times as large as the other ectodermal nuclei.

At the time when the dorsal organ has become closed over the pleuropodia can no longer be called appendages, since the cellular plate lies at the level of the surrounding ectoderm. At this time it is slightly concave on the outer surface and projects strongly into the interior of the body. The nuclei have migrated from the periphery toward the middle of the cells. The most striking part of these cells is now their apical portion. This is not granular, but hyaline, does not stain with carmine, and shows very fine longitudinal striations. These apical portions of the cells may be compared in their appearance to the strongly refractive terminal retinal rods of larval eyes. It is very probable that these hyaline cell-tips indicate a gland-like function.

The high point of development occurs somewhat after revolution. In mature embryos the pleuropodia still occur in their original places, appearing as knob-like projections firmly attached to the integument of the segment. In sections it is seen that the entire structure is now overgrown by the ectoderm. The external concavity has disappeared and given place to a slight convexity. In the outermost zone of the cellular plate there occur many vacuoles of various sizes.

Hydrophilus caraboides L.

Carrière (1891) discusses and figures the pleuropodia of the later embryonic stages of this insect. They are very large, flat, more or less circular organs with very broad external orifices, sunken below the surface of the body and lying laterad to the line between sternite and pleuron. The large prismatic cells which form the floor of the organ fill its cavity completely. As in *Tenebrio* and *Meloë,* the basal and distal portions of the cells differ in structure. The former contains the nucleus and the granular cytoplasm, while the latter is composed of a strongly refracting mass of secretion surrounded by a very thin protoplasmic sheath, so that superficially the outer portion of the organ has the appearance of a mass of short rods lying upon a layer of thick cells. Occasionally one finds also a greater number of much finer threads in the outer ends of the cells, so that possibly the secretion is of two kinds. This furnishes a transition to the type of abdominal gland found in *Belostoma.*

FAMILY LAMPYRIDAE

Photuris pennsylvanica (De G.)

The quotation given below is from Williams' (1916) description of the pleuropodia.

"In a Photuris embryo about one-third developed and before the developing amnion has been ruptured . . . , the appendage, . . . , is a knob-like process with a short, stout peduncle, and, like the thoracic legs, with its axis somewhat inclined caudally. It is a little less in diameter than the length of the segment from which it originates. In a sagittal section through the organ, its cells, which are of course hypodermal, are in large measure strongly differentiated in that they are columnar, with larger, very elongate nuclei, three or more times as long as wide, the whole forming a somewhat convex layer or disc. . . . At the distal extremity of the pleuropod there is already much granular secretion, which is evidently extra cellular and held *in situ* by the thin enveloping membrane, . . .

"A somewhat later embryo . . . shows the organ . . . , considerably enlarged, its disc broader and flatter and the neck proportionally shorter. The cells are four to six times as long as wide and form a flat disc. The nuclei occupy an approximately central position in the cells which may already be vacuolated just below the nuclei, but elsewhere well filled with a granular secretion which largely obscures the cell boundaries. The thin capping membrane is here frequently separated from the apices of the cells. Fat cells largely occupy the base of the peduncle.

"A later stage, such as occurs in larvae nearly ready to hatch . . . , shows that the gland has already largely performed its function. The cap . . . may be depressed, irregular or wavy, the gland cells, . . . , now well below and separated from the cap, form a concave disc or crater, and seem almost to have exhausted the secretion, for very little of it is in evidence. The now spherical or subspherical nuclei, of the same height in each cell, strongly augment the crater-like appearance of the layer. Each cell has the walls closely applied to those of its neighbors, but the dividing line, . . . , between is usually discernible. Extending from just above the nucleus is the large conspicuous gland duct, . . . , flaring somewhat distally and often saccate at the base, so that the whole glandular structure, distally, has a papillose aspect. The basal portion of each cell, *i.e.*, immediately below the nucleus, is marked by a large space or vacuole, . . . , beyond which are smaller indefinite vacuoles and protoplasmic strands. No muscle was found to connect with the organ, and in but one case what seemed to be a duct, leading from the distal portion of the gland into the body cavity, could be made out. The unmodified hypodermis, . . . , extends well up the sides of the cup where it passes off rather abruptly into the outer gland-cells. Viewed from above, the tips of the gland-cells form a network, the ducts constituting the circular or subangular spaces, the meshes the cell walls.

"It is quite evident that these large gland-cells are hypodermal and modified by elongation, etc., and form the jointed appendage which, at first bilaterally symmetrical, becomes perfectly radial and extends somewhat pleurally of the thoracic appendages.

"A larva quite near hatching shows the gland in the process of collapsing and of sinking into the body cavity. A freshly hatched larva, *i.e.,* one a day old, has already lost the first abdominal appendages, remnants of which can be found in the body cavity. (According to Patten the pleuropods in *Acilius* are absorbed, while in the June beetle, *Melolontha vulgaris,* they are probably pushed off (Graber). In other cases they seem to be in part cast off and in part absorbed.) The gland-cell nuclei are now clearer, show scattered large pieces of chromatin; the cells themselves are breaking down, and the whole is forming a rather deep U-shaped mass. Large phagocytes occur in the vicinity; the cuticle and unmodified hypodermal cells are present above the organ, so that it is probable that they have spread over and covered the void made by the retracted gland-cells."

Photinus consanguineus Lec.

The quotation given below is from Williams' (1916) description of the pleuropodia.

"In both Photuris and Photinus, the pleuropods, so named by Wheeler ('90), are very conspicuous by reason of their size and structure. In neither genus was the organ observed in the first stages of development."

"The pleuropod of Photinus is somewhat different morphologically from that of Photuris. It is more convex and elongate, the cells form a convex instead of a, later, flat disc, their nuclei are distal, and correlated with this is the apparently internal basal secretion instead of the largely distal one as occurs in the pleuropod of Photuris. A conspicuous receptacle of non-glandular cells, . . . , calling to mind the cup of an acorn, surrounds and constitutes the basal portion of the pleuropod." . . . "In Photuris and Photinus embryos, stained in toto with borax carmine, the pleuropodia took the stain more deeply than the general body wall and more conspicuously than the other appendages, thus showing the more permeable character of their membrane."

FAMILY TENEBRIONIDAE

Tenebrio molitor L.

Carrière (1891) describes the pleuropodia as invaginated flattened spheroids with secretion cavities. A summary of the long description by Selys Longchamps (1904) is given below:

A four day old embryo has a pleuropodium with an epiblastic disc of considerable thickness at the distal end, and at the proximal end it is connected to the body with a slender epithelial tube. Part of the coelomic sac penetrates into the proximal end of the pleuropodium.

An embryo which is six days old has pleuropodia well differentiated into distal and proximal parts. The coelomic cavity has disappeared and has become transformed into lacunae; the mesenchyme has replaced the primitive mesoblast, but there are still present masses of deeply staining cells which resemble muscular elements in the process of formation. A tracheal trunk, similar to those in the thoracic appendages, is found in the proximal part of the organ.

The distal portion of the appendage has become deeply modified; the ectodermal cells have increased considerably in volume. The form of the cells has changed: they have increased in length; the nucleus has moved from the periphery to the deep part of each cell and has become large and pale. The protoplasm of the organ has become fibrillar. The proximal part has a median circular constriction.

In an embryo of seven days the pleuropodium is concave instead of convex. The proximal part of each cell, in which the nucleus is situated, has become more voluminous. The cells have become triangular in shape with the top of each cell directed towards the exterior. The deeper part of the organ has become enlarged. The fibrillar structure has become apparent; dark fibrillar cones with points directed toward the exterior alternate with clear cones with external base and internal summit. A fine refracting cuticle covers the cavity of the cup. Laterally and superiorly, at the surface of the organ, are a certain number of small dark nuclei, belonging to the ectodermic cells which originally formed the lateral wall of the pleuropodium. At the time of the excessive development of the cells in the distal extremity of the appendage, these cells were compressed and flattened; the assumption of a triangular form by the glandular cells caused an invagination of the terminal part of the appendage, and consequently the ectodermic cells, which originally formed the lateral wall, completely cover the mass of glandular cells and delimit the boundaries of the cavity of the cup. At this stage the pleuropodium becomes intimately applied to the embryonic membranes and adheres firmly to them. The amnion disappears and the product resulting from its degeneration occupies the cavity of the cup of the appendage; the serosa has become thinner and is no longer nucleated.

In an embryo which is ten days old the relatively long pedicel which connects the cup of the pleuropodium to the body has begun to shrink, so that the appendage begins to go under the surface of the body, though it maintains its adherence to the egg shell.

In an embryo which is twelve days old the dorsal walls have completely closed over the yolk. In this stage the pleuropodium has become completely invaginated. The distal and proximal parts are no longer differentiated, and one can hardly call the organ an appendage. The envelopes and shell still adhere to the organ and are present in its external cavity.

The cells delimiting this cavity have changed in appearance. The cellular boundaries are more distinct; the fibrillar appearance of the protoplasm tends to disappear and to be replaced by a granulation, especially conspicuous in the deeper part of the cells. The nuclei are more voluminous and paler, and contain but few irregular peripheral nucleoli. Certain ectodermic cells that earlier delimited the opening of the cavity of the cup of the pleuropodium have undergone considerable development. The external part of these cells is darker and seems even to present a cuticularization. Superimposed on a double row they form a sort of circular tooth intimately applied to the shell. Even an organ which has been accidentally detached from the surface of the embryo shows the imprint of this cuticular tooth.

The internal face of the organ is compressed by a series of longitudinal muscles. A trachea accompanies it, and just above the group of longitudinal muscles is a group of three or four nuclei of voluminous pale cells which are possibly nerve cells. Independent of the longitudinal muscles are transverse lateral muscles, fixed on one side to the ectodermal cells bordering the margin of the opening of the cavity, and on the other to ectodermal cells which are situated a little above.

This condition persists during the last days of embryonic life. At the time of hatching the organ is detached from the shell. The large cells become more and more flattened and the external cavity disappears; the pleuropodium becomes completely covered by the epidermis. Later the large cells degenerate and finally no trace of this very interesting organ can be found.

The first abdominal appendage plays an important part in the rupture of the embryonic membranes and in the closure of the dorsal wall of the embryo. In an embryo of seven days, when the appendage has attained its maximum development, it is intimately united to the membranes and to the shell. At this stage the existence of glandular elements at the extremity of the appendage is certainly indisputable: the glandular epithelium at this time plays a physiological rôle which brings about the destruction of first the amnion and later the serosa. This change in function is effected by the retreat of the median portion of the organ. The appendage adheres to the superior part of the shell and its function changes from that of a gland to a sort of sucking organ. The distal end, rather than the proximal, is the part which is transformed into glandular epithelium which acts chemically on the membranes.

FAMILY MELOIDAE

Meloë proscarabaeus L.

I reproduce below the main points of Nusbaum's (1889) description, as given by Wheeler (1890):

Before the embryo is eight days old the pleuropodia have the form of roundish cylindrical sacs consisting of a single layer of cylindrical ectoderm forming a cavity. Within the cavity may be seen a few isolated mesoderm cells.

In an eight day embryo the pleuropodium becomes differentiated into a cylindrical basal part and a distal part which is spherical in contour and pointed at its terminal end. The cavity of the distal end disappears and is replaced by large cylindrical cells which arise by invagination of part of the ectodermic layer at the pole of the organ. The invaginated cells increase in size and narrow clear slits appear between them. The edges of the invagination begin to close in, until only a small aperture leads into a roundish cavity.

In an embryo of ten days each pleuropodium is divided into three or four superficial segments.

In an embryo of twelve days the plasma of the invaginated cells, whose roundish oval nuclei lie near the basal ends, becomes very distinctly and very finely fibrillated and resembles the epithelium of many excretory glands. A homogeneous sticky secretion collects in the cavity and gradually swells out of the aperture in abundance. Delicate threads of the secretion run from the large cells surrounding to the secretion in the cavity. The roundish terminal joint of the pleuropodium is very probably cast off, while the basal part gradually becomes shorter, flattens out, and eventually disappears completely.

A summary of Nusbaum's (1891) later description of the pleuropodia is given below:

On the first abdominal segment are a pair of small, club-shaped, bud-like protrusions, larger than the appendages on the succeeding abdominal segments and about half as long as the third thoracic legs.

The pleuropodium is composed of two parts, a more or less cylindrical base and a widened, rounded or spherical distal part. The interior of the spherical distal end is visible through an aperture bordered by high cylindrical cells.

On the ninth day of development the ectoderm at the apex of the distal end begins to invaginate. The invaginating cells very rapidly grow larger, and assume the form of big cylindrical elements, somewhat broader at their lower ends than at their apices, with their nuclei situated near their bases. These large invaginating cells are more than twice as long as the ectoderm cells which form the outer wall of the appendage. Later a spherical cavity appears at the apex, and the small ectoderm cells advance over it until only a narrow aperture remains to connect the cavity with the outside.

As the external cells advance toward this orifice, the large internal cells, responding apparently to internal pressure, become more and more flattened and their cytoplasm diminished in quantity. The protoplasm is somewhat granular in the region surrounding the nuclei; near the apices of the cells it is thinner and homogeneous. As the embryo develops, the outer ectodermal wall of the pleuropodium diminishes until it resembles a thin nucleated membrane.

In an embryo of ten days the invaginated cells begin to emit a secretion from their apices, which are directed toward the cavity. The apices of the cells pass directly, without any visible line of division, into a colorless, homogeneous, strongly refracting substance. The cytoplasm of the cells is granular only in the basal part, near the nuclei: elsewhere it has a distinctly fibrillar structure.

The organ reaches its highest degree of development on the twelfth day. It then contains an abundance of the secretion, which escapes to the outside through the apical aperture. At this time filaments of the secretion can be traced directly into the apices of the cells. The cells now become loosely associated; large vacuoles or interstices appear between them, so that they seem to be isolated from one another.

The appendages of the second to the seventh abdominal segments likewise undergo a similar invagination at their apices and also emit a clear homogeneous secretion, but they do not reach nearly the same degree of development as does the appendage of the first segment.

Meloë scabriusculus Brandt

Graber (1891) states that the pleuropodium is a small conical evagination which exceeds somewhat in size the rounded tuberculate appendages of the succeeding abdominal segments.

FAMILY CHRYSOMELIDAE

Donacia crassipes Fabr.

Hirschler (1909) states that each pleuropodium enlarges considerably and becomes a pyriform structure, the basal part of which is cellular and the distal part chitinous. Sections show it to be calyculate with outer walls formed of normal ectodermal cells, while the interior is composed of very deep cells with large nuclei; the cytoplasm of these cells is filamentous in structure and contains many vacuoles. The entire lumen is filled with a thread-like secretion which exudes to the outside in a globular mass. The pleuropodium has therefore a secretory function. It is located at the border of sternite and tergite.

Later the abdominal appendage loses its pyriform shape and appears flattened and button-like. Sections show the cup partly sunken below the level of the ectoderm, its outer margin passing into the surrounding epithelium without a distinct angle. In older stages the entire structure lies below the hypodermis and the external situation where it formerly lay is indicated only by a slight swelling and the mass of secretion. The pleuropodium resembles an invaginated sac, the wall of which is composed of cylindrical cells with large, homogeneous, degenerating nuclei. In still older stages the ectoderm extends over the glandular sac and the excretory aperture disappears completely. Then the whole structure undergoes complete degeneration, so that in young larvae no trace of it remains.

Lina tremulae (Fabr.)

Graber (1888) states that he finds no pleuropodia. Later (1890) he states that they are occasionally present in young embryos. They are narrowly digitiform appendages with pointed distal ends, situated near the lateral boundaries of the first abdominal segment and directed medially and anteriorly.

FAMILY SCARABAEIDAE

Melolontha melolontha L.

Melolontha vulgaris Fabr. of Graber (1888, 1890, 1891) and Wheeler (1890).

I give below the main points of Graber's (1888) description of the pleuropodia, as given by Wheeler (1890):

The pleuropodia first appear in an embryo which is twelve days old. On the twenty-second day they reach their maximum size and are then large flattened sacs attached to the body by peduncles. They are about three times as broad as the thoracic legs and also exceed them in length. Nearly all the cells in the pleuropodium, especially those forming the outer wall, are very large and have nuclei which are twice as large as those of the remaining ectoderm. A nucleus of one of the pleuropodial cells measures approximately 0.014 mm., while a nucleus of one of the cells of the body wall measures about 0.006 mm. At the time when the pleuropodium first appears the nucleus of a body wall cell measures 0.008 mm. This fact indicates that the cells of the body wall ectoderm decrease in size, and that the cells of the pleuropodium increase in size. In the cavity of the organ are to be found loose cells originating from the evagination of the mesoderm, which may or may not be blood cells.

The pleuropodium begins to degenerate in an embryo of thirty days of age. It diminishes considerably in size. In a thirty-four day embryo the appendages are merely minute scales, hardly as long as a body segment, and half hidden in a coagulum. They fall away from the body when the least pressure is applied to them: they probably are rubbed off during the process of hatching, as only the healed scar of the peduncle is to be seen in the larva.

Order Strepsiptera

FAMILY XENIDAE

Achroschismus wheeleri Pierce

Xenos peckii Kirby of Brues (1903).

The pleuropodia are considerably longer than the appendages on the succeeding basal abdominal segments.

Order Embiidina

family embiidae

Oligotoma texana (Mel.)

Embia texana of Melander (1903).

The pleuropodia are larger than the appendages on the second, third, and fourth abdominal segments, and disappear before the embryo hatches.

Order Megaloptera

family sialididae

Sialis infumata Newm.

Wheeler (1890) makes the following statement concerning the pleuropodia:

> "The embryos are so small that it is difficult to obtain good surface views; still, I have been able to satisfy myself that the first abdominal segment, at about the time of revolution, presents a pair of conical evaginated pleuropodia, which lie somewhat outside of the line of the thoracic legs. In my sections I could detect neither a differentiation of the cells nor diverticula of the body-cavity extending into these appendages. The apparent solidity of the organ may have been due to the thickness and the plane of my sections."

Order Trichoptera

family phryganeidae

Neophylax concinnus McLach.

Patten (1884) states that the pleuropodia are conical in shape and considerably larger than the appendages of the two succeeding segments of the abdomen. Wheeler (1890) states that the cells of the pleuropodia differ in structure from the unmodified cells of the body wall and the other appendages.

Order Lepidoptera

family bombycidae

Bombyx mori L.

Wheeler (1890) states with Tichomiroff (1882) that the silkworm has no pleuropodia. Toyama (1902) figures them as minute rounded structures similar to the other abdominal appendages, and makes the following statement concerning them:

> "The abdominal appendages now also make their appearance on the first ten segments with the exception of the anal, as Kowalevsky ('71) and Tichomiroff ('82) long ago observed in Lepidopterous insects. Graber ('88), however, doubts the observations of Kowalevsky and erroneously states that Tichomiroff did not discover them. But, as is stated above, we are not only able to say that abdominal appendages do really exist in silk-worms, but we can also confirm the statement made by Packard on this point, that 'these structures appear in the embryos of certain Lepidoptera and Hymenoptera, though they are much less distinct and more evanescent than in the lower orders of insects.' "

Order Homoptera

FAMILY CICADIDAE

Tibicina septendecim (L.)

Cicada septemdecim Fabr. of Wheeler (1889a, 1889b, 1890) and Heymons (1899).

The following account is taken from Wheeler's paper of 1890. Each pleuropodium arises as an orange-shaped ectodermal thickening near the median line. The long axes of the cells forming the thickening are directed dorso-ventrally. The pleuropodium reaches its maximum size during the revolution of the embryo.

> "The ectodermic elements increase greatly in length and assume the form of curved pyramids with their tapering apices attaining the surface of the body and their broadened nuclear ends projecting into the body cavity. The outer and attenuated ends of the cells are uniformly hyaline and stain very faintly in borax carmine. The cytoplasm of the inner ends is granular like that of the remaining ectoderm. The nuclei of the pleuropodium seem not to differ in their finer structure from the nuclei of the general ectoderm. They are frequently triangular or violin-shaped both in the pleuropodium and in the undifferentiated ectoderm. The only difference is one of position: the nuclei of the body wall lie at right angles to their former position. A granular mass, the amniotic secretion, fills the space between the body walls and the egg membranes. In one place, however, this mass is replaced by one of a different nature, a glairy, homogeneous

and vacuolated substance of irregular though rounded outline, firmly attached to the attenuated tips of the pleuropodial cells. This homogeneous mass, which stains pink in borax carmine, is often more globular than is represented in the figure, and is often separated from the granular amniotic secretion by a clearly defined space, proving that one or both of the secretions contract under the influence of the reagents employed. From the constancy of its occurrence and the manner of its adherence to the outer surface of the pleuropodium, I do not hesitate to regard the homogeneous mass as a secretion of the pyramidal cells. It seems to consist of an albuminoid substance; the vacuoles which it contains may be artefacts. Not having examined it in fresh embryos, I was unable to learn anything more concerning its physical or chemical nature.''

After revolution the pleuropodium moves to a position near the insertion of the metathoracic leg. In an embryo nearly ready to hatch the pleuropodium cannot be found. ''The pyramidal cells grow pale and irregular, finally fall asunder and are probably absorbed.''

Wheeler uses the following facts to enable him to homologize the invaginated ectodermal thickenings of *Cicada* with the evaginated pleuropodia of the Orthoptera:

''1. The pleuropodia of *Cicada* are of purely ectodermic origin.

''2. They appear only on the first abdominal segment.

''3. They are at first homostichous with the thoracic and cephalic appendages.

''4. Their cytological structure closely resembles that of some evaginate pleuropodia; the shapes of the component cells with reference to the surface of the body being merely reversed. . . .

''5. Their greatest development is attained during the revolution of the embryo.

''6. They move away from the median ventral line of the embryo and take the same position on the pleurae as the evaginated pleuropodia of the Orthoptera and Coleoptera.

''7. They atrophy and disappear before the embryo hatches.''

Order Hemiptera

Family Naucoridae

Naucoris cimicoides L.

Heymons (1896 and 1899) refers to the pleuropodia as paired bud-like processes, which first appear at the side of the ganglion rudiments and which, at first, resemble in form the mandibles of the early germ-band. Later these rudiments are converted into glandular organs, and in older germ-bands they sink beneath the surface of the body and give out a natural secretion. They remain there and are recognizable even in young larvae in the indicated places.

FAMILY BELOSTOMATIDAE

Belostoma flumineum Say

Nepa cinerea of Wheeler (1889a, 1889b).
Zaitha fluminea Say of Wheeler (1890).

The account given below is from Wheeler (1890).

> "The stages which I have studied show only the fully developed pleuropodia: I can, therefore, assert nothing in regard to the process whereby these organs originate and disappear, although their resemblance when fully formed to the pleuropodia of *Cicada* renders it highly probable that the beginning and end of their development are no less similar to those observed in the Homopteron."

The pleuropodium appears as a bulbous, greatly thickened ectodermal structure during the revolution of the embryo.

> "The cells composing it are greatly elongated, being three or four times as long as the thickest ectoderm cells of the ventral body wall. It is also seen that a great number of cells take part in the formation of the *Zaitha* pleuropodium while but very few go to make up the same organ in *Cicada*. In the water-bug the rounded inner face of the pleuropodium projects as far as the yolk and presents at irregular intervals a few flattened mesodermic elements. The inner ends of the long cells are coarsely granular, their outer ends uniformly hyaline. Their nuclei are but little larger than the nuclei of the body walls. The delicate hyaline cell-tips converge to form a flat surface which is covered by a broad pencil of refractive threads which is to be regarded as the secretion of the pleuropodial cells. In Fig. 18 three of these curious cells are represented as they appear under a magnification of about 900 diameters. The inner ends which stain deeply in borax carmine contain a number of very coarse granules among which are interspersed a multitude of finer ones; the granules diminish in number beyond the oval nuclei and have completely disappeared in the gradually tapering outer ends of the cells. These ends are not affected by the stain. Each cell-tip is capped by a refractive thread, which nearly or quite equals the cell in length

and may often be split into two or three branches. Usually the line which separates the cell-tips from the threads which cap them is distinctly marked, as in Fig. 17 and at *z* in Fig. 18. I have, however, found numerous cases where no such line could be detected, the hyaline cell-tips passing without interruption into the long refractive threads. The minute structure of the nuclei resembles that of the pleuropodial nuclei of *Blatta*. Through the faintly staining caryochylema runs a chromatic reticulum, the nodes of which are irregular and much thickened. The nucleolus has little affinity for staining fluids and is probably to be relegated to *Carnoy's* class of 'nucléoles plasmatiques.' "

FAMILY NEPIDAE

Nepa cinerea L.

Heymons (1896 and 1899) refers to the pleuropodium as a circular invagination on the pleural wall of the first abdominal segment, close to the insertion of the third thoracic leg, by which it is partly concealed.

FAMILY NOTONECTIDAE

Notonecta glauca L.

Heymons (1896 and 1899) states that the pleuropodia are at first invaginated but that they later sink into the body and become glandular in function.

FAMILY PYRRHOCORIDAE

Pyrrhocoris apterus L.

Heymons (1899) states that in a young embryo the pleuropodia appear as oval evaginations near the median line.

FAMILY PENTATOMIDAE

Palomena prasina (L.)

Cimex dissimilis Fabr. of Heymons (1899).

The pleuropodia occur in a young embryo as two distinct peg-like cellular elements raised vertically above the ventral surface of the body. In older embryos they sink into the interior of the body and give off a secretion.

2. CLASS APTERYGOGENEA

The most complete embryological study on this class of insects is that of Philiptschenko (1912b), who worked with *Isotoma cinerea* Nic. (Order Arthropleona, Family Entomobryidae). In this form the embryo possesses a pair of appendages on the first abdominal segment which later unite to form the ventral tube. These appendages are much shorter than the legs. They soon develop two segments, of which the distal is much smaller than the proximal. Later their bases approach one another and fuse, the distal ends remaining separated for a time: finally they too unite and the organ assumes its definitive form. The small distal segments supply the essential material for the eversible sac, the proximal section the material for the other parts. The musculature appears very late, and at the same time there also appear certain large cells which some authors have claimed are glandular but which have been shown to be merely large hypodermal cells without special glandular function.

The embryology of Apterygogenea has also been discussed by Ryder (1886), Haase (1889), Wheeler (1890), Heymons (1897, 1905), Uzel (1897a, 1897b), Claypole (1898a, 1898b), Folsom (1900), Hoffmann (1904), and Philiptschenko (1912a). It is beyond the province of this paper to discuss their works here.

3. CLASS MIRIENTOMATA

According to Börner (1910) these forms possess a ventral tube similar to that of Collembola, composed of two free sections and bearing an apical eversible vesicle. Before this tube is located the epimeron-like subcoxa.

V. DISCUSSION

The pleuropodia of insects have been for years a subject of great interest to embryologists. Many observations have been made as to their structure, and many speculations have appeared as to their function. Had it been possible to obtain for each species studied a complete series of embryos showing the entire history of the pleuropodia from the time of their first appearance to the time of their disappearance, we might be better able to compare these organs in the various orders and to make more specific statements in regard to their probable function.

A search of the literature has revealed for many species a mere mention of the presence of appendages on the first abdominal segment, and for other species most extensive statements giving in great detail the structure as well as the history of the pleuropodia.

In addition to the papers cited under the heading of Historical Review, which dealt in more or less detail with the structure of the pleuropodia, there have been a number of works on more general phases of entomology which have included some discussion of their structure, function, and phylogeny. Among these may be cited Fernald (1890), Peytoureau (1892), Packard (1898), Korschelt and Heider (1899), Henneguy (1904), Berlese (1909), Folsom (1914), Tothill (1916), and Comstock (1920).

The papers which treat most extensively of the pleuropodia of insects are the works of Graber (1888), Wheeler (1890), Carrière (1891), Graber (1891), and Selys Longchamps (1904). In addition to a detailed account of the condition of the pleuropodia in the species studied, each of these authors gives a tabulation of the species of the Class Pterygogenea for which these organs have been described.

Selys Longchamps, basing his work on that of the earlier authors, lists eighteen species of insects, representing fourteen families and six orders, in which pleuropodia have been described.

My search of the literature has revealed the fact that pleuropodia have been found in at least forty-six species, representing thirty-two families and fourteen orders.

A study of the insects in which pleuropodia have been found shows that these organs have a common origin. They arise as ectodermal thickenings on the first abdominal segment, homostichous with the thoracic and cephalic appendages. They may all be described as evaginations of the body-wall ectoderm of the first abdominal segment.

After the earliest appearance of the pleuropodia in the form of evaginations, their history differs in different species and different orders. They may remain as evaginations until the time of their disappearance; they may become partly invaginated; they may become wholly invaginated, except for the cell-tips which in some species escape through the orifice.

In the orders Dermaptera (*Forficula*), Hymenoptera (*Hylotoma, Camponotus, Myrmica, Formica,* and *Megachile*), and Lepidoptera (*Bombyx*), the pleuropodia occur as minute papillate evaginations which are evanescent and apparently rudiments of organs which at one time had a longer period of development.

In the orders Isoptera (*Nasutitermes*), Strepsiptera (*Achroschismus*), Embiidina (*Oligotoma*), Megaloptera (*Sialis*), and

Trichoptera (*Neophylax*), the descriptions of the pleuropodia are so fragmentary that it is impossible to say more than that they are conical or pyriform evaginations which probably do not have a very long period of development.

In the orders Homoptera (*Tibicina*) and Hemiptera (*Naucoris, Belostoma, Nepa, Ranatra, Notonecta, Pyrrhocoris,* and *Palomena*), the pleuropodia exist for a very brief time as evaginations and then become invaginated for the greater part of their development.

In the order Orthoptera (*Stauroderus, Conocephalus, Oecanthus, Gryllus,* and *Gryllotalpa*), the pleuropodia are bulbiform evaginations, sometimes with a reniform or subreniform outline. The account of *Meconema* is too fragmentary to permit of placing it in any classification based on structure.

In the order Mantoidea (*Mantis, Stagmomantis,* and *Tenodera*) the pleuropodia are pyriform, digitiform, or conical evaginations.

In the order Blattoidea (*Blattella* and *Blatta*) the pleuropodia are pyriform or broadly pear-shaped.

A variety of forms of pleuropodia are found in the order Coleoptera. In *Carabus, Calosoma,* and *Photinus* they are bulbiform; in *Melolontha* flattened, bag-shaped, and very large; in *Lina* digitiform; in *Donacia* pyriform. The pleuropodia of *Acilius, Dytiscus, Hydroüs, Hydrophilus, Meloë, Tenebrio, Photuris,* and *Dineutes* are at first evaginate, then the distal tip of the structure becomes invaginated, and eventually the whole organ sinks into the body.

If the data concerning the history of the pleuropodia in each species were more complete, the question of their ultimate fate might be settled. Some authors have stated that they reach their point of greatest development during revolution, while others state that they reach their maximum size after revolution. In some cases the appendages of the first abdominal segment are said to disappear after revolution, in others before hatching, in still others at the time of hatching.

In *Belostoma* and *Ranatra* the pleuropodia are still present in a degenerating condition in the first instar nymphs, but are not to be found in older nymphs. It seems to be the consensus of opinion that the pleuropodia which are most large and bulbiform, and which most resemble a true leg, degenerate and finally fall off during the process of hatching. Other pleuropodia, which show a tendency at some time of their development to become invaginated, are covered over by the body wall and are absorbed within the body.

But few theories have been suggested to account for the function of the pleuropodia since the appearance of Wheeler's paper (1890) which deals so extensively with their structure and function, and which establishes the fact that they are neither respiratory, nor sensory, but secretory organs.

Baillon (1920) still clings to the idea that the pleuropodia of *Meconema* may be respiratory. Graber (1891) believes them to be true appendages rather than glands. Selys Longchamps (1904) believes that they have the function of assisting the embryo to escape from its membranes and its egg shell. Korschelt (1912) and Blunck (1914) believe that they secrete a fluid which renders the embryo flexible and keeps it moist so that its movements within the egg shell are facilitated.

The pleuropodia are quite generally believed, however, to have a secretory function. The structure of the pleuropodia of *Belostoma* and *Ranatra* leads one to suspect that some substance is passed from the interior of the embryo to the outside of the body, but what this substance is cannot be determined from the meager data now available as to its chemical constitution. It seems possible that they serve as organs for the excretion of waste products which must necessarily accumulate during the embryonic life of the insect. Throughout this period it is enclosed within the chorion and rather tightly enveloped in its membranes, and has no known method of ridding itself of the waste products of metabolism.

As soon as the nymph escapes from its membranes and the chorion, it possesses a definite and functional excretory system. At the same time the pleuropodia begin to degenerate and finally disappear, as though their period of usefulness were at an end. With the acquisition of the functional system in the nymph the need for a provisional embryonic excretory apparatus, such as the pleuropodia may fulfill, would be eliminated; this would account for their retention throughout embryonic life and their disappearance in the free-living insect.

VI. SUMMARY

1. The pleuropodia of insects are paired appendages of the first abdominal segment which arise from foot-like organs and which tend, as they develop, to take up a position on the pleural wall of the embryo.

2. They always arise as ectodermal evaginations serially homologous with the appendages of the head, thorax, and abdomen.

3. In the orders Dermaptera, Hymenoptera, and Lepidoptera they are present for a very brief period as minute, papillate,

evanescent evaginations, and probably are as short-lived in the orders Isoptera, Strepsiptera, Embiidina, Megaloptera, and Trichoptera.

4. They develop as bulbiform evaginations with a reniform or subreniform outline in the order Orthoptera.

5. They occur as pyriform or digitiform or conical evaginations in the orders Mantoidea and Blattoidea.

6. In the order Coleoptera they may be evaginated, flattened, bag-like, and very large; bulbiform; digitiform; or calyculate with their distal ends invaginated; or they may be quite submerged with a large orifice at the surface of the body.

7. In the order Hemiptera the pleuropodia arise before the revolution of the embryo, as ectodermal evaginations, and in *Belostoma* and *Ranatra* soon sink into the body and become bowl-shaped structures. The ectodermal cells of the body wall form a margin surrounding the orifice of each pleuropodium. The pleuropodial cells increase in size and assume a triangular shape with their distal ends prolonged into long thread-like structures which form a cluster or tuft projecting from the orifice. The nuclei of the pleuropodial cells originally have the same size and shape as the nuclei of the body ectoderm, but increase enormously in size and move toward the bottom and sides of the rounded structure as the pleuropodium increases in size. The pleuropodium in an embryo just before hatching is four times as large as when it first made its appearance. During the same period the nuclei of the pleuropodial cells increase three times in size.

8. The pleuropodia in *Belostoma* and *Ranatra* attain their greatest size just before the nymphs hatch; in the first instar nymph they have lost their tufts of cell tips and are covered over by the ectoderm of the body; in later instar nymphs they are lacking.

9. The pleuropodia probably serve as organs of excretion or secretion during the embryonic life of the insect.

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KEY TO PLATES

ab 1	First abdominal segment.
ab 2	Second abdominal segment.
am	Amnion.
ant	Antenna.
ch	Chitinous envelope.
cph	Cephalic lobe.
cu	Embryonic cuticle.
ec	Ectoderm.
gn	Ganglion.
int	Mid-intestine.
md	Mandible.
1 mx	First maxilla.
2 mx	Second maxilla.
oe	Oenocyte.
pl	Pleuropodium.
pr o	Pre-oral appendage.
se	Serosa.
t 1	Prothoracic appendage.
t 2	Mesothoracic appendage.
t 3	Metathoracic appendage.
y	Yolk.
yc	Yolk cavity.

PLATE I

All the figures of this plate are of *Belostoma flumineum* Say.

1. Surface view of a young embryo, which has been removed from the chorion, envelopes, and yolk, at the end of anatrepsis. × 32.

2. Surface view of an embryo, which has been removed from the chorion, envelopes, and yolk, somewhat older than that shown in Fig. 1. × 32.

3. Surface view of an embryo, which has been removed from the chorion, envelopes, and yolk, shortly before revolution. × 32.

4. Schematized transverse section, slightly oblique, through the first abdominal segment of an embryo of about the same age as that represented in Fig. 1. × 75.

5. Schematized transverse section through the first abdominal segment of an embryo of about the same age as that represented in Fig. 2. × 75.

6. Schematized transverse section, slightly oblique, through the first abdominal segment of an embryo intermediate in age between those shown in Figs. 3 and 5. × 75.

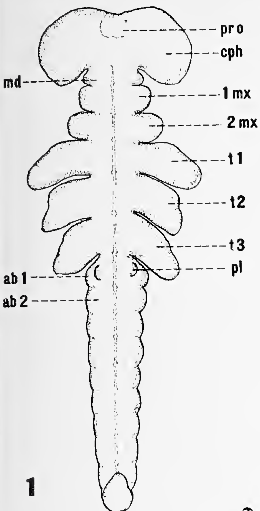
7. Schematized transverse section, through the first abdominal segment of an embryo during revolution, somewhat older than that shown in Fig. 6. × 75.

8. Schematized transverse section, quite oblique, through the first abdominal segment of an embryo just after revolution, older than that represented in Fig. 7. × 75.

9. Schematized fronto-sagittal section through the first abdominal segment of an embryo after revolution, older than that represented in Fig. 8. × 75.

10. Schematized fronto-sagittal section through the first abdominal segment of an embryo of about the age of that represented in Fig. 9. × 75.

11. Schematized transverse section, quite oblique, through the first abdominal segment of an embryo after the closure of the dorsal wall, older than that represented in Fig. 10. × 75.



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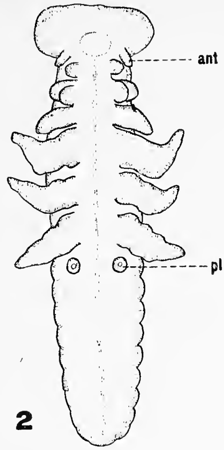

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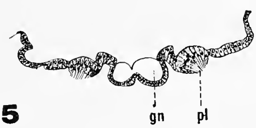

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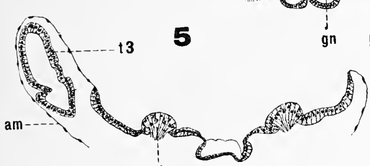

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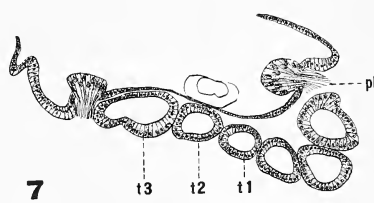

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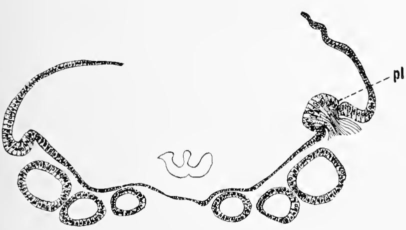

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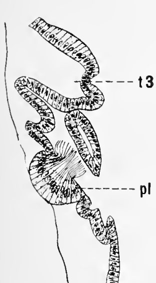

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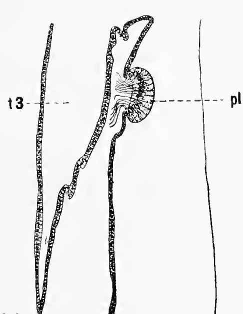

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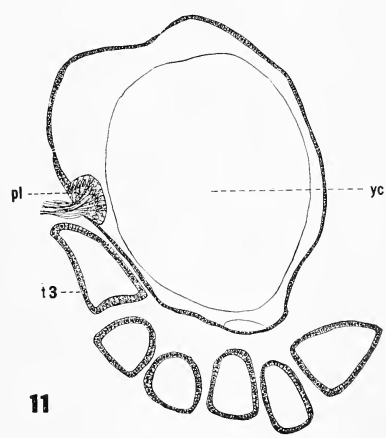

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PLATE II

All the figures of this plate are of *Belostoma flumineum* Say.

12. Schematized transverse section through the first abdominal segment of a somewhat older embryo than that represented in Fig. 11. × 75.

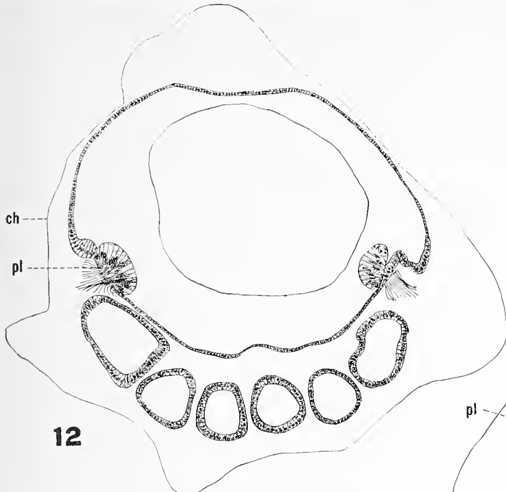
13. Schematized transverse section through the first abdominal segment of a somewhat older embryo than that represented in Fig. 12. × 75.

14. Schematized transverse section through the first abdominal segment of an embryo of about the age of that represented in Fig. 13. × 75.

15. Schematized fronto-sagittal section through the first abdominal segment of a somewhat older embryo than that represented in Fig. 14. × 75.

16. Schematized transverse section through the first abdominal segment of an embryo just before hatching. × 75.

17. Schematized parasagittal section through the first abdominal segment of a first-instar nymph. × 75.



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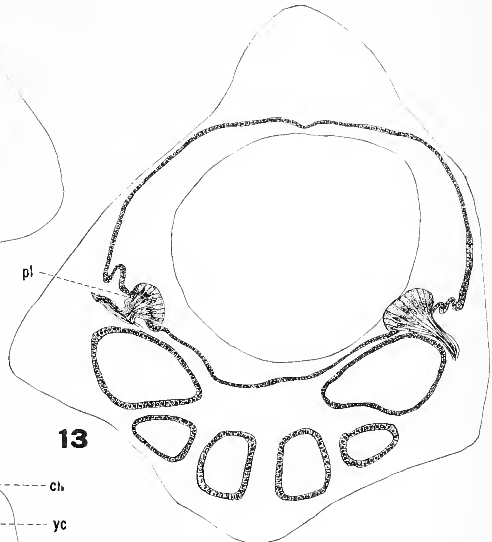

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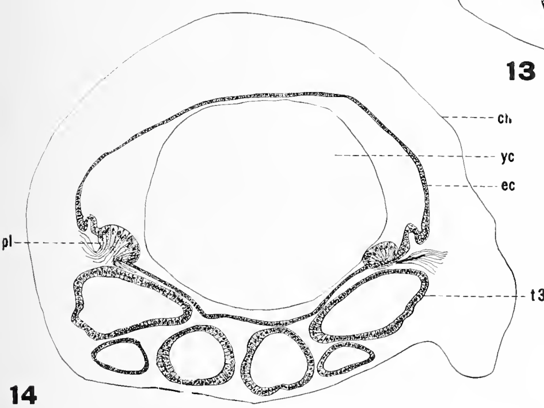

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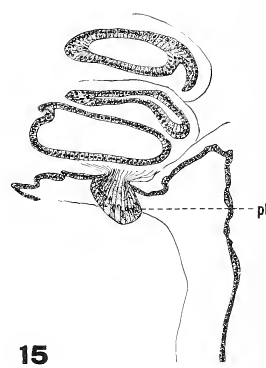

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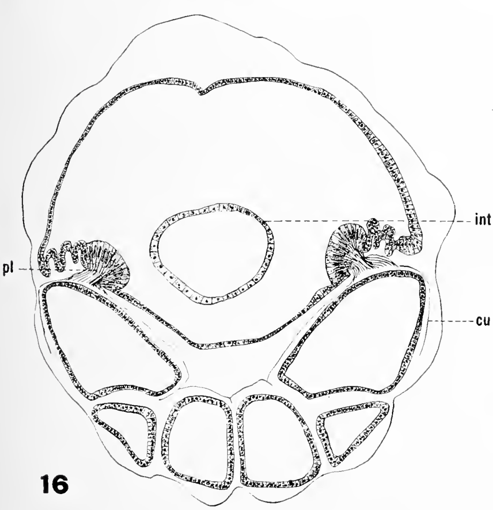

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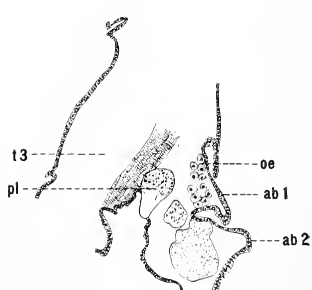

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PLATE III

All the figures of this plate are of *Ranatra fusca* Palisot de Beauvois.

18. Surface view of an embryo, which has been removed from the chorion, envelopes, and yolk, at the end of anatrepsis. × 32.

19. Surface view of an embryo, which has been removed from the chorion, envelopes, and yolk, somewhat older than that shown in Fig. 18. × 32.

20. Surface view of an embryo, which has been removed from the chorion, envelopes, and yolk, between anatrepsis and revolution. × 32.

21. Schematized transverse section, quite oblique, through the first abdominal segment of an embryo of about the age of that represented in Fig. 18. × 75.

22. Schematized transverse section through the first abdominal segment of an embryo of about the age of that represented in Fig. 19. × 75.

23. Schematized transverse section, quite oblique, through the first abdominal segment of a somewhat older embryo than that represented in Fig. 22. × 75.

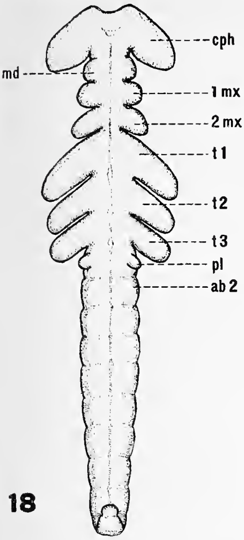
24. Schematized transverse section, somewhat oblique, through the first abdominal segment of an embryo of about the age of that represented in Fig. 23. × 75.

25. Schematized transverse section, somewhat oblique, through the first abdominal segment of an embryo of about the age of that represented in Fig. 20. × 75.

26. Schematized transverse section through the first abdominal segment of a somewhat older embryo than those represented in Figs. 20 and 25. × 75.

27. Schematized transverse section through the first abdominal segment of an embryo just before revolution. × 75.

28. Schematized sagittal section through the first abdominal segment of an embryo of about the age of that shown in Fig. 27. × 75.



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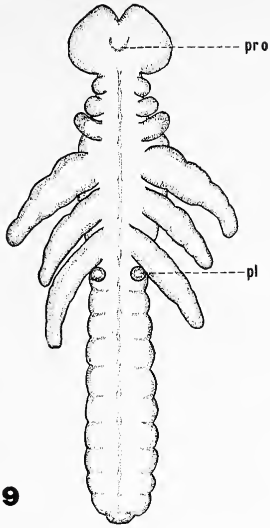

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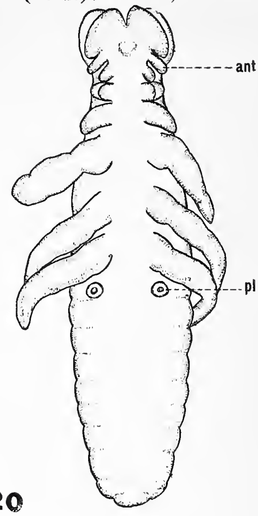

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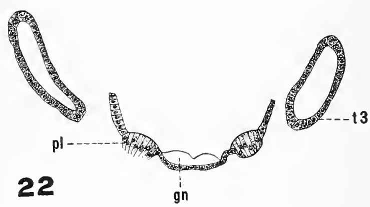

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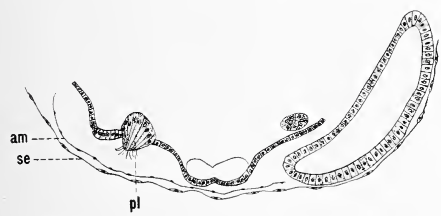

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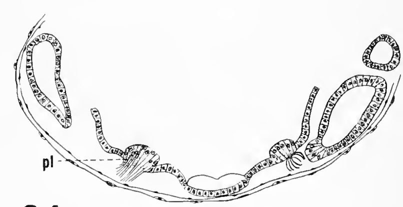

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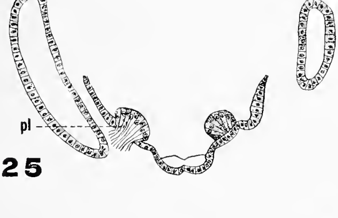

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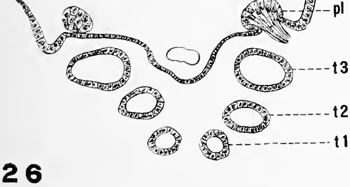

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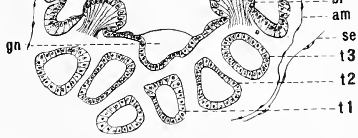

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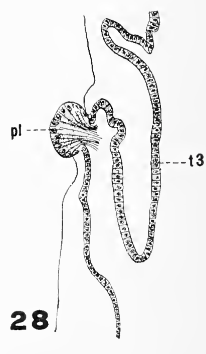

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PLATE IV

All the figures of this plate are of *Ranatra fusca* Palisot de Beauvois.

29. Schematized transverse section through the first abdominal segment of an embryo during revolution. × 75.

30. Schematized transverse section through the first abdominal segment of an embryo of about the age of that represented in Fig. 29. × 75.

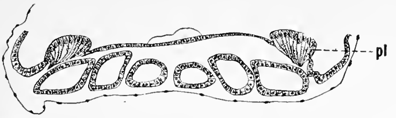
31. Schematized transverse section, somewhat oblique, through the first abdominal segment of an embryo just after revolution. × 75.

32. Schematized transverse section through the first abdominal segment of a somewhat older embryo than that represented in Fig. 31. × 75.

33. Schematized transverse section through the first abdominal segment of a somewhat older embryo than that represented in Fig. 32. × 75.

34. Schematized transverse section through the first abdominal segment of a somewhat older embryo than that represented in Fig. 33. × 75.

35. Schematized transverse section, somewhat oblique, through the first abdominal segment of an embryo of about the age of that represented in Fig. 34. × 75.



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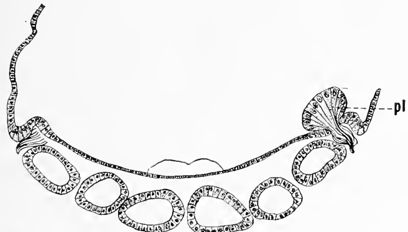

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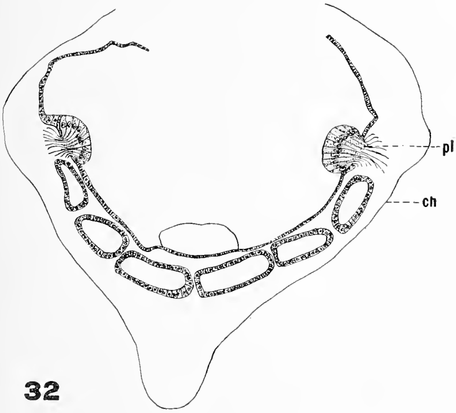

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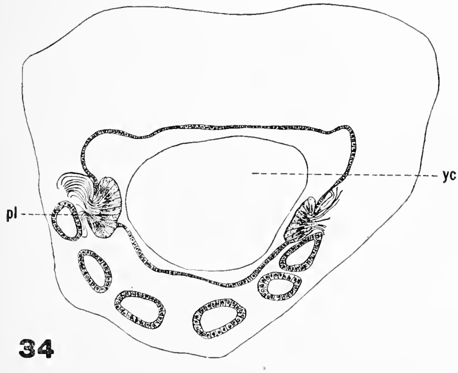

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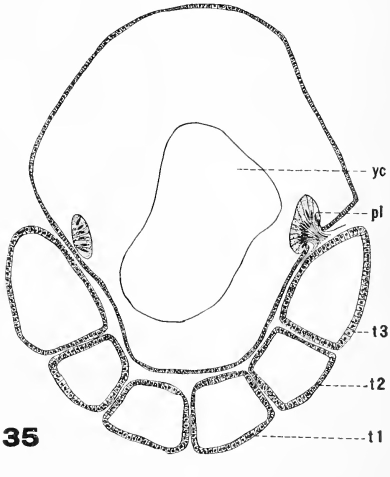

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PLATE V

All the figures of this plate are of *Ranatra fusca* Palisot de Beauvois.

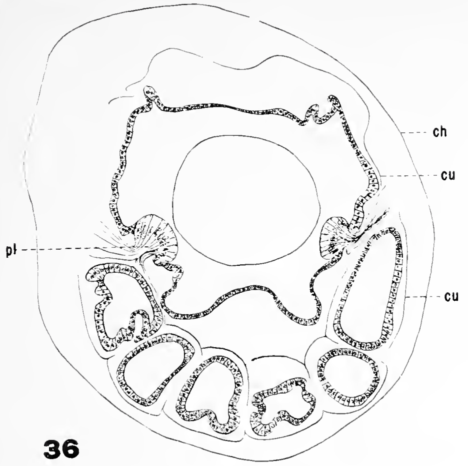
36. Schematized transverse section through the first abdominal segment of a somewhat older embryo than that represented in Fig. 35. × 75.

37. Schematized sagittal section through the first abdominal segment of an embryo of about the age of that represented in Fig. 36. × 75.

38. Schematized frontal section through the first abdominal segment of an embryo just about to hatch. × 75.

39. Schematized transverse section through the first abdominal segment of a nymph in the process of hatching. × 75.

40. Schematized transverse section through the first abdominal segment of a first instar nymph. (The legs are omitted.) × 75.



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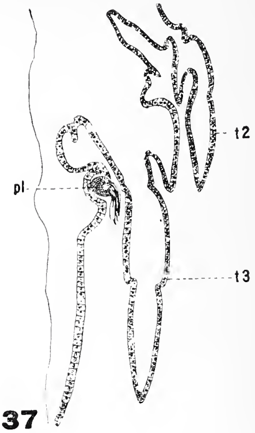

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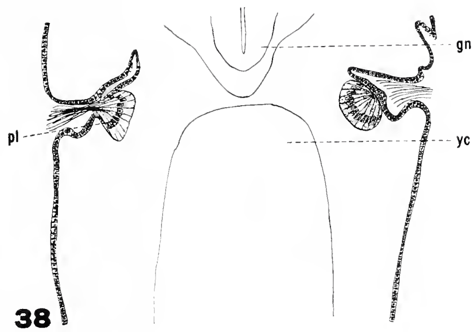

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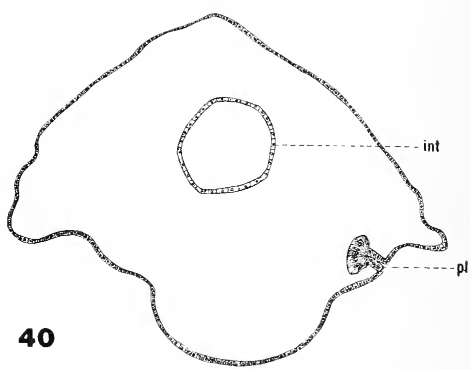

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PLATE VI

All the figures of this plate are of *Belostoma flumineum* Say.

41. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 4. Hot Kahle; iron hematoxylin, erythrosin. × 500.

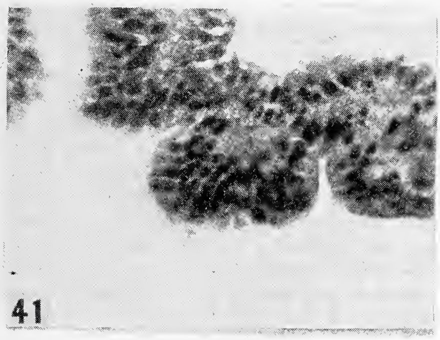
42. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 5. Hot corrosive sublimate; Delafield's hematoxylin, erythrosin. × 500.

43. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 6. Hot Kahle; Delafield's hematoxylin, erythrosin. × 500.

44. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 7. Hot Kahle; Delafield's hematoxylin, erythrosin. × 500.

45. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 8. Hot Kahle; iron hematoxylin, eosin. × 500.

46. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 9. Hot Kahle; Delafield's hematoxylin, erythrosin. × 500.



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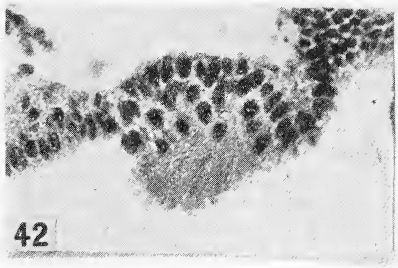

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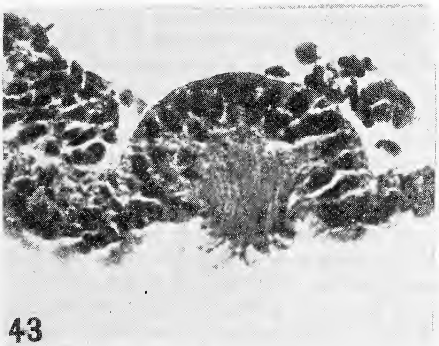

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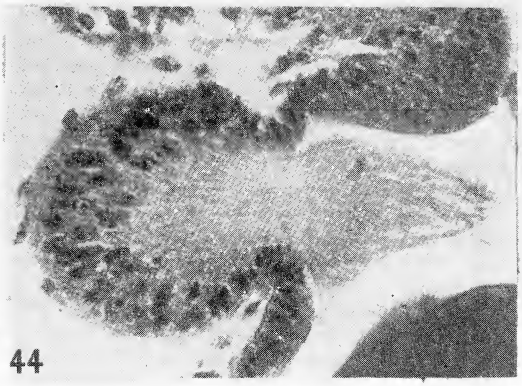

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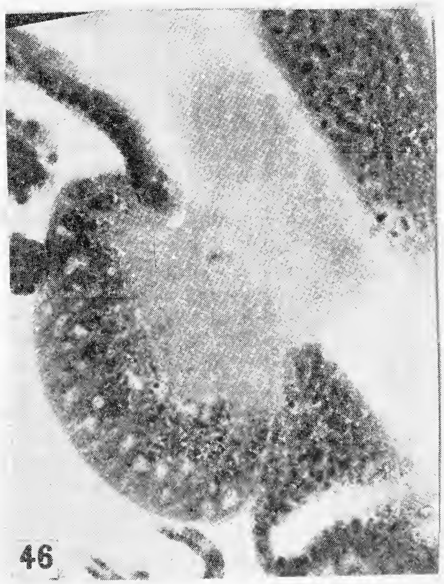

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PLATE VII

All the figures of this plate are of *Belostoma flumineum* Say.

47. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 10. Hot Kahle; Delafield's hematoxylin, erythrosin. × 500.

48. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 11. Hot Kahle; Delafield's hematoxylin, erythrosin. × 500.

49. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 12. Hot Kahle; Delafield's hematoxylin, erythrosin. × 500.

50. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 13. Hot Kahle; Delafield's hematoxylin, erythrosin. × 500.

51. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 14. Hot Kahle; Delafield's hematoxylin, erythrosin. × 500.

52. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 15. Hot Kahle; eosin, methylene blue. × 500.


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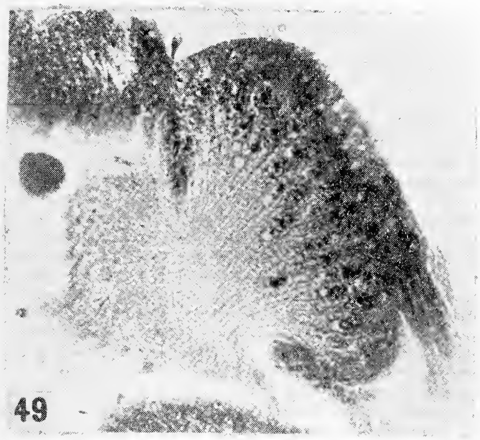
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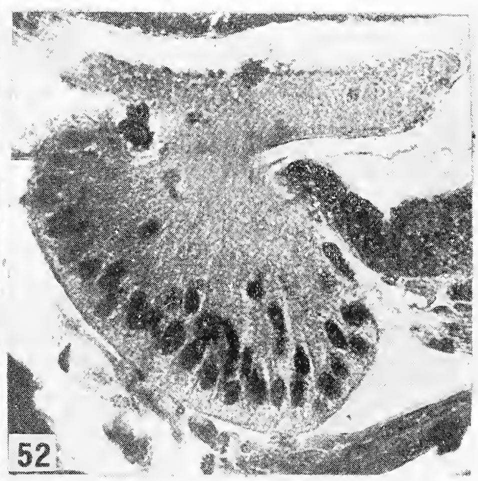
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PLATE VIII

Figures 53 and 54 are of *Belostoma flumineum* Say.

Figures 55 to 58 inclusive are of *Ranatra fusca* Palisot de Beauvois.

53. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 16. Hot Kahle; Delafield's hematoxylin, erythrosin. × 500.

54. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 17. Hot Kahle; Delafield's hematoxylin, erythrosin. × 500.

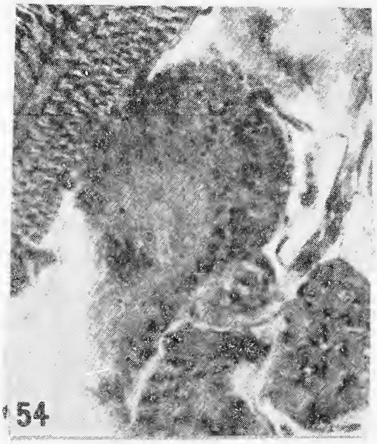
55. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 21. Hot water; Delafield's hematoxylin, erythrosin. × 500.

56. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 22. Hot water; Delafield's hematoxylin, erythrosin. × 500.

57. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 23. Hot Bouin; iron hematoxylin, erythrosin. × 500.

58. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 24. Hot Bouin; iron hematoxylin, erythrosin. × 500.


53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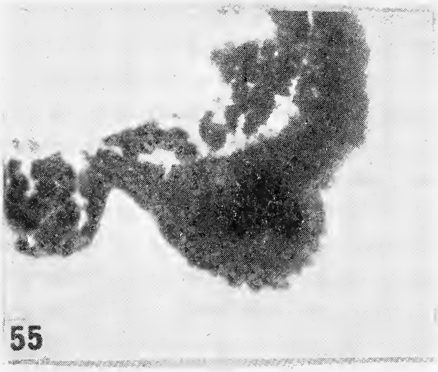
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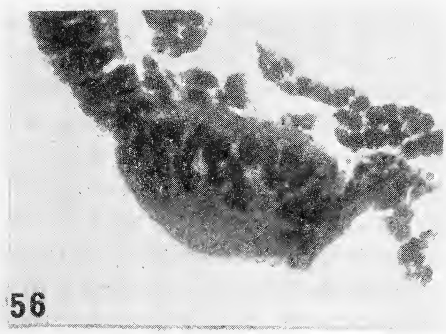
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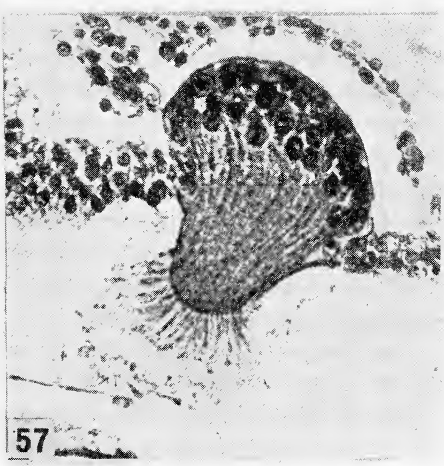
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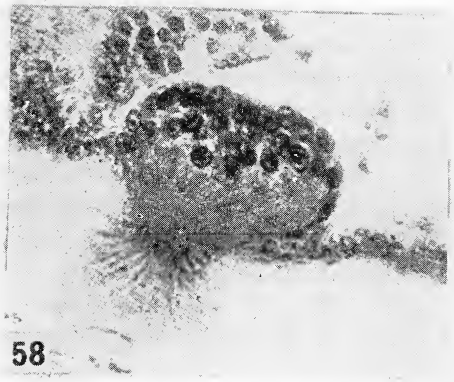
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PLATE IX

All the figures of this plate are of *Ranatra fusca* Palisot de Beauvois.

59. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 25. Hot Kahle; iron hematoxylin, erythrosin. × 500.

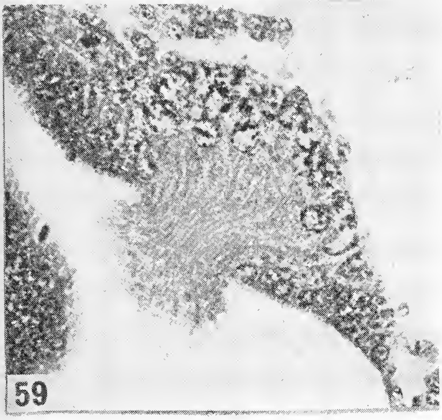
60. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 26. Hot water; Delafield's hematoxylin, erythrosin. × 500.

61. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 27. Hot water; Delafield's hematoxylin, erythrosin. × 500.

62. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 28. Hot water; Delafield's hematoxylin, erythrosin. × 500.

63. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 29. Hot corrosive sublimate; Delafield's hematoxylin, acid fuchsin. × 500.

64. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 30. Hot corrosive sublimate; Delafield's hematoxylin, acid fuchsin. × 500.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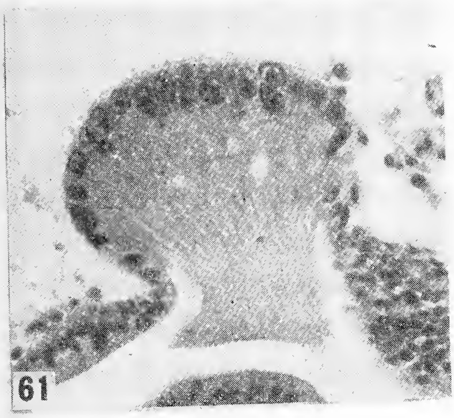
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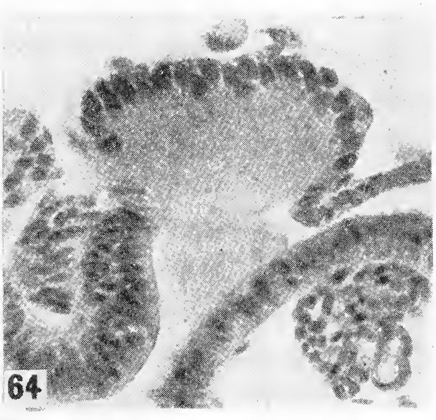
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PLATE X

All the figures of this plate are of *Ranatra fusca* Palisot de Beauvois.

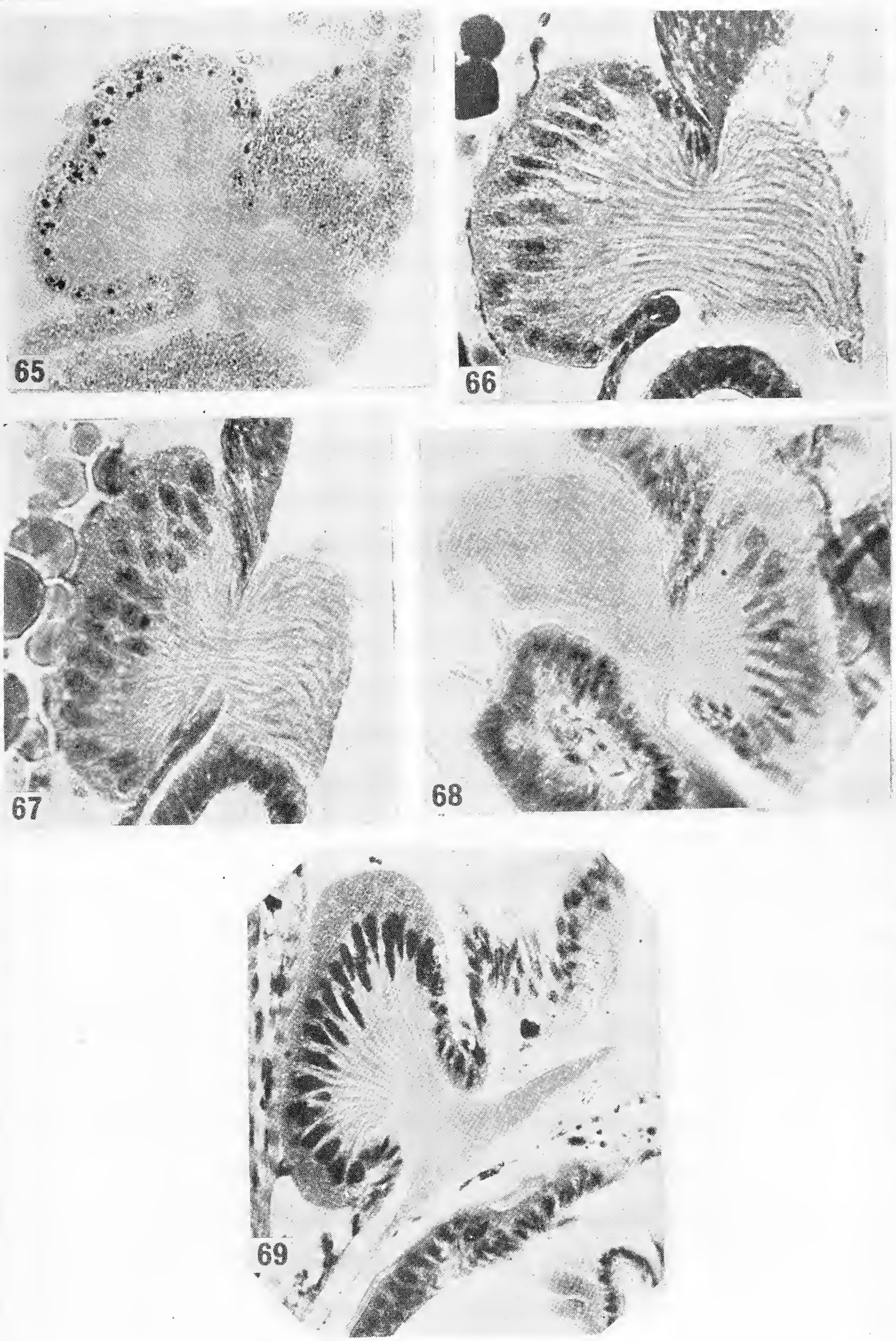
65. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 31. Hot Kahle; iron hematoxylin, erythrosin. × 500.

66. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 32. Hot water; Delafield's hematoxylin, acid fuchsin. × 500.

67. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 33. Hot water; Delafield's hematoxylin, acid fuchsin. × 500.

68. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 34. Hot corrosive sublimate; Delafield's hematoxylin, acid fuchsin. × 500.

69. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 35. Hot water; Delafield's hematoxylin, erythrosin. × 500.


65
66
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68
69

PLATE XI

All the figures of this plate are of *Ranatra fusca* Palisot de Beauvois.

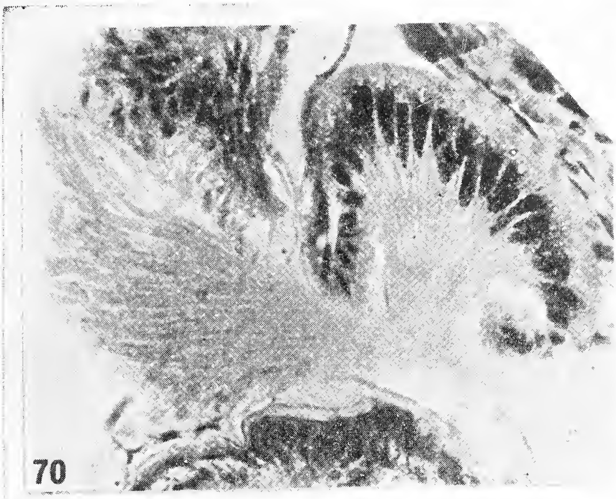
70. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 36. Hot water; Delafield's hematoxylin, erythrosin. × 500.

71. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 37. Hot water; Delafield's hematoxylin, erythrosin. × 500.

72. Unretouched photomicrograph of the right pleuropodium of the section shown in Fig. 38. Hot corrosive sublimate; Delafield's hematoxylin, erythrosin. × 500.

73. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 39. Hot water; Delafield's hematoxylin, erythrosin. × 500.

74. Unretouched photomicrograph of the left pleuropodium of the section shown in Fig. 40. Hot corrosive sublimate; Delafield's hematoxylin, erythrosin. × 500.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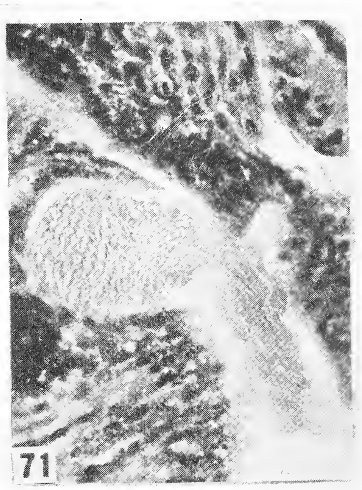
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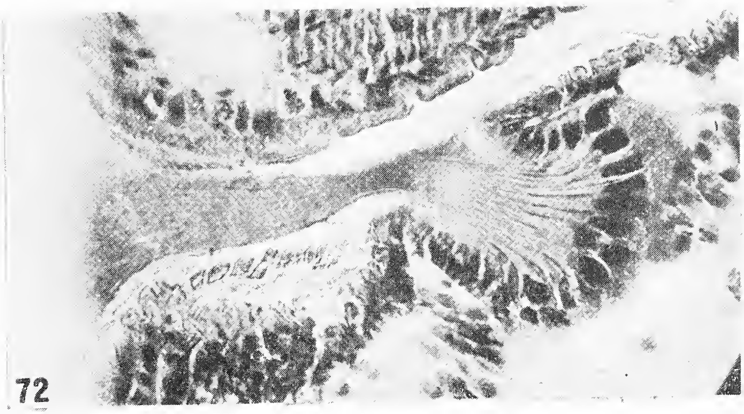
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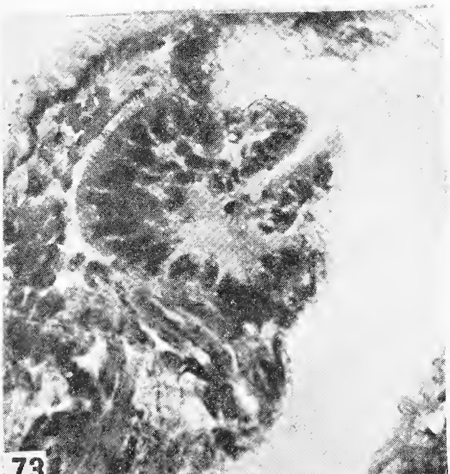
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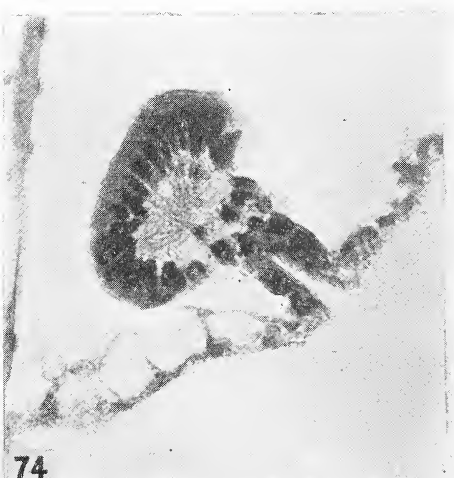
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A JOURNAL OF ENTOMOLOGY

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ENTOMOLOGICA AMERICANA

After a lapse of 36 years, this veteran journal of American entomology emerges from its hibernaculum to take its place once more as a vehicle for the progress of our branch of science. Thanks to the generosity of a friend the Brooklyn Entomological Society is enabled to revive this journal to render, we hope, as good service and fill as worthy a place as its predecessor of long ago.

The Society has long felt that a medium was needed for the appearance of those longer papers—monographs, synopses of smaller groups, biological studies, morphology, embryology, revisions, and the many excellent technical productions too long and too special, perhaps, for our regular journals yet too short for a book—emanating from many workers not connected with institutions which publish the results of the research of their staffs. The opportunity has at length presented itself; and the Society has taken the positive step.

Entomologica Americana once more takes its place among our current journals.

The publication will be issued in four numbers a year, and will average approximately 50 to 60 pages to the number, or a total of 200 to 240 pages per volume. Each number will carry *one* paper; or possibly two, but not more, in view of its purpose. The annual subscription price is set at $4.00 a volume. Single numbers will sell on an approximate basis of $1.50 for 50 pages; subscriptions will be received per volume—*not* for four consecutive numbers—payable strictly in advance. The edition for the first of the new volumes will be limited to 200 copies; and those intending to subscribe, particularly institutions and libraries, should do so promptly to ensure possession of complete sets.

Authors are invited to submit contributions, bearing in mind that such contributions must be of the required length and represent original work advancing our knowledge of the taxonomy, biology, ecology, anatomy or embryology of insects. Arrangements with regard to illustrations will be discussed for each case. Papers should be sent direct to the Editor, Entomologica Americana, 11 North Broadway, White Plains, N. Y.; subscriptions (with check) to Geo. P. Engelhardt, Treasurer, Brooklyn Entomological Society, Brooklyn Museum, Eastern Parkway, Brooklyn.

ENTOMOLOGICA AMERICANA

VOL. VII (n. s.) BROOKLYN, N. Y., SEPTEMBER, 1926 No. 2

THE FAMILY HYDROMETRIDAE IN THE WESTERN HEMISPHERE

BY J. R. DE LA TORRE-BUENO

WHITE PLAINS, N. Y.

In the naming of aquatic Hemiptera it frequently becomes necessary to test out, if practicable, all the descriptions of species in a given genus in order to be certain of what is before one. This paper had just such an humble beginning. As the work went on, however, it became evident that in order to name certain Cuban species before me so much work had to be done in this and other groups, that this paper shaped itself almost of its own impulse, so to say. The vague and intangible descriptions of the earlier workers called for a careful scrutiny of the various species catalogued. And this checking up in turn called for a complete survey of the group in the Americas and elsewhere, to weigh the validity of characters and consequently of categories.

So it has seemed better to perpetuate this labor, in order to give future workers a foundation on which to commence to build.

Meanwhile, this attempt at evaluation of taxonomic structures in Hydrometra is offered to my fellow-workers with diffidence and with consciousness of its many actual and possible insufficiencies. But since it brings together all that has been written, it will not be without usefulness for reference.

I

In the beginning, in the year 1758, Linneus in the Systema Naturae, described in his comprehensive genus *Cimex* the species *stagnorum* in these words:

> "stagnorum. 82. C. linearis nigricans compressus, pedibus anticis brevissimis.......*Habitat in* Europae *aquis pacatis.*"

His successors with more extensive and comprehensive material to work on, broke up the all-inclusive Linnean *Cimex* and set its species in other (and new) genera. Thus, in 1796, Latreille in his *Précis* (p. 86), erected his genus *Hydrometra*. Unfortunately, he could not foresee the future and its rules, so he cites no species under it, although the only species then known to fit his characterization was *C. stagnorum* L. In 1801 Lamarck named *stagnorum* in the genus and under our system of priority, it became *Hydrometra* Lamarck 1801. Here the species rested until 1835, when Burmeister (Handb., II) erected a new genus, *Limnobates*, for the Linnean species. In the meantime, in 1803, Fabricius employed the name *Hydrometra* as coextensive with his own genus *Gerris*, which has led to some confusion. In fact, since 1835 one Continental school has called the genus *Hydrometra*; while the other, the German and its followers, have named it *Limnobates*. The full generic synonymy is set forth by Reuter in Revisio Synonymica; by Oshanin in his Verzeichniss; and by Van Duzee in his Catalogue. The two latter also set forth the full family synonymy; and the last the specific synonymy of the then known North American species to its date.

II

Geographical Distribution

The species of the genus *Hydrometra* heretofore described from the Americas and their islands numbered but 12. Adding to these the 12 herein described as new to science we have a total of 24 species from the Western Hemisphere, outnumbering those described from all the other zoological regions by 12.

The American species may thus be distributed geographically; in order from North to South, in general:

North America, including Mexico

Hydrometra australis Say	Southern U. S.
H. cordubense Bueno	Mexico (Gulf Coast)

H. cyprina Bueno	Mexico (Gulf Coast)
H. martini Kirkaldy	U. S. and Eastern Canada
H. hungerfordi Bueno	Kansas
H. lillianis Bueno	California
H. myrae Bueno	Georgia
H. wileyi Hungerford	Texas

Central America

Hydrometra championiana Bueno	Guatemala, Costa Rica, Colombia
H. exilis Bueno	Honduras
H. lentipes Champion	Costa Rica
H. naiades Kirkaldy	Panamá
H. priscillae Bueno	Guatemala

The two species from the Gulf Coast of Mexico mentioned above will doubtless also be recorded eventually from Central America.

West Indies

Hydrometra caraiba Guérin	Cuba
H. championiana Bueno	Cuba
H. comata Bueno	Trinidad
H. consimilis Barber	Puerto Rico
H. gibara Bueno	Cuba

South America

Hydrometra agenor Kirkaldy	Ecuador
H. argentina Berg	Argentine
H. championiana Bueno	Colombia, Brazil
H. chilensis Reed	Chile
H. husseyi Bueno	Paraguay
H. kirkaldyana Bueno	Brazil
H. mensor B. White	Brazil
H. metator B. White	Brazil

The species of *Hydrometra* in the other faunal regions of the world are thus distributed:

Palaearctic

(7 species)

Hydrometra stagnorum Linneus	Europe
H. gracilenta Horváth	Europe

H. procera Horváth	Japan
H. lineata Eschscholtz	China, Japan
H. greeni Kirkaldy	India, Ceylon
H. albolineata Scott	Japan
H. eremopia Kiritschenko	Transcaspia

AFRICA

(2 species)

Hydrometra albolineolata Reuter	Guinea, Boma
H. ambulator Stål	Caffraria

AUSTRALIA, ETC.

(3 species)

Hydrometra aculeata Montrouzier	New Caledonia
H. papuana Kirkaldy	New Guinea
H. strigosa Skuse	Australia

On this distribution, as at present known, the family is predominantly neogeic—in fact, Neotropical;—one might almost say that the center of dispersal lies in the Caribbean Islands and littoral, about which half of the 24 known American species cluster, radiating therefrom north and south into the continental masses and west into Central America, in gradually decreasing numbers as the distance north and south from the center increases. For example, north of the Gulf of Mexico, only 6 American species are known; and South of the Amazon River only three others; while from the Caribbean countries and islands 12 species are registered. In further support of this hypothesis is cited the new genus and species *Limnobatodes paradoxus,* from Honduras, discovered by Hussey. Of course, this may indicate nothing more than that these forms have been more collected in the New World than elsewhere. But consider for instance the distribution of *Rhagovelia,* a well-known and thoroughly collected genus; or of *Microvelia,* an assemblage of minute and easily unnoted species, both of which are predominantly American. It thus seems unlikely that *Hydrometra* should have eluded capture or escaped observation, particularly since it haunts the same habitats as *Microvelia.* Until further evidence to upset this view presents itself it would seem we may well accept the foregoing as a tenable working hypothesis.

III

Biology

Habits

The habits of Hydrometra by this time have been well examined into. This genus of linear forms walks and runs about in marshes or marshy places, as its Burmeisterian name, *Limnobates,* implies. But it also stalks its prey in shallows along the rush-grown borders of ponds and other small calm bodies of water, in whose sun-warmed depths (or shallows) vast numbers of Entomostraca and other plankton furnish an abundance of food to their roving, seeking stylets. The rushes rising tall from the water afford them a foothold and a refuge, as well as a place to lay their eggs. Our knowledge, thoroughly tested and checked, is the result of the observations of Mina Palumbò, Brocher, Kirkaldy, Martin, Hungerford, and myself.

Life History

Their life-histories, both here and abroad, have been studied by the same men. The long, spindle-shaped eggs with a sculptured chorion—eggs seemingly too large for so exiguous an insect—are attached by one end to the rush stems, a short distance above the water. Our *Hydrometra martini* deposits say 175 eggs in a season, and possibly more. These eggs hatch out in anything from 4 to 20 days, but in warm summer weather, on the average in 7 days. After 5 moults, taking say 10 days, the adult insect emerges to the active affairs of life—namely, the propagation of the species. There is thus opportunity for 2 or 3 or more broods a summer.

In cold latitudes, *Hydrometra* hibernates in the adult. About White Plains, N. Y., *H. martini* may be secured as early as the middle of March, practically as soon as the ponds are ice free. At such times, the shallow water at the edges is tepid in the warming sun of early spring; and teems with plankton, principally *Daphnia, Cypris* and *Cyclops.*

Hydrometras are easily kept in captivity and breed in aquaria, thriving on a diet of flies and other small, soft-bodied insects. They are, therefore, ideal for observation.

Pterygopolymorphism

Some—a very small minority—of the adults have fully developed wings, capable of use. *Hydrometra mensor* B. White was captured at light, for instance. But the vast majority are either apterous or brachypterous, in some instances bearing only tiny vestigial wings peeping out from under the posterior edge of the much diminished pronotum; in others, narrow, strap-like microptera extending along the metathorax; or, in fine, short wings increasingly long until it becomes impossible to draw a line between the fully developed wing and the undeveloped. And this is particularly true because the fully developed *do not* reach the abdominal apex in any instance.

An examination of a series of *H. championiana* from a homogeneous locality—Los Amates and Gualán, in Guatemala—gave 9 long-winged, but the apex of the wings does not quite attain the anterior margin of the 5th abdominal segment. In the 31 micropterous (there are no fully apterous in the lot), the narrow, strap-like hemielytra reach as far as the hind acetabula.

In *H. martini* there is true micropteryy, the wings appearing just under the edge of the prothorax as two minute, scale-like tabs, scarcely to be seen except under a high power. In the winged the hemielytra reach only to the middle, or just beyond, of the 4th abdominal segment. Of some hundreds examined, barely a half-dozen were totally apterous. The long-winged are also comparatively very rare. It may then be assumed that this much reduced microptery represents the normal form in this species, the totally apterous and the long-winged being extremes attained at times. No deduction of any value may be made by counting the fully winged in any aggregate of specimens of *martini*, or of any other species, since the apterous or short-winged are rejected in numbers by collectors, while the long-winged, being great rarities, are very sedulously sought for and kept.

Poisson[1] in his recent studies examined the variation of wing-length in *H. stagnorum* (pp. 261–62) and noted the conditions under which it varied. He found that descendants of micropterous were micropterous, and of macropterous, macropterous. Where the

[1] Contributions a l'Étude des Hémiptères Aquatiques, 1924, Bull. Biol. Fr. et Belg., LVIII, fac. 1, pp. 49/305, pls. I–XIII.

micropterous parents had wings each of the same length as the other, all the progeny resembled the parents in microptery, but a few had shorter and a larger number longer wings; but where there was inequality of wing-length in the parents, there was a slight oscillation in the progeny about the wing-lengths of the parents. He did not succeed in mating macropterous with micropterous. From these tests, he concludes that microptery is hereditary and pure when the parents are of equal wing-lengths (p. 264).

IV

Alphabetical List of Neogeic Species of Hydrometra

1. *H. agenor* Kirkaldy	Ecuador
2. *H. argentina* Berg	Argentine
3. *H. australis* Say	Southern U. S.
4. *H. caraiba* Guérin	Cuba
5. *H. championiana* Bueno	Cuba, Central America, Panamá, Colombia, Brazil
6. *H. chilensis* Reed	Chile
7. *H. comata* Bueno	Trinidad, W. I.
8. *H. consimilis* Barber	Puerto Rico, Cuba
9. *H. cordubense* Bueno	Mexico (Gulf Coast)
10. *H. cyprina* Bueno	Mexico (Gulf Coast)
11. *H. exilis* Bueno	Honduras
12. *H. gibara* Bueno	Cuba
13. *H. hungerfordi* Bueno	Western U. S. (Kansas)
14. *H. husseyi* Bueno	Paraguay
15. *H. kirkaldyana* Bueno	Brazil
16. *H. lentipes* Champion	Costa Rica
17. *H. lillianis* Bueno	Western U. S. (California)
18. *H. martini* Kirkaldy	Eastern U. S., Canada
19. *H. mensor* B. White	Brazil
20. *H. metator* B. White	Brazil
21. *H. myrae* Bueno	Georgia
22. *H. naiades* Kirkaldy	Panamá
23. *H. priscillae* Bueno	Guatemala
24. *H. wileyi* Hungerford	Arizona

V

Systematic List of Neogeic Hydrometrae

A structural study of *Hydrometra* indicates that the primary divisional characters for grouping are:

1. The proportion of the anteocular to the postocular part of the head;

2. The proportion of the antennal segments *inter se*;
3. The presence or absence of pitting on the pronotum, pleura and acetabula;
4. The presence or absence of the male abdominal processes, and their form and structure.

Of these characters, the only one heretofore used by describers with a fair degree of constancy is the proportions of the parts of the head; the only American form in which this character has not been given is in *Hydrometra chilensis* Reed. The proportional ratios of the segments of the antennae to each other have also been employed to some extent, but in a rather vague manner. Horváth first employed the processes on the 6th male ventral segment, which were used subsequently by Martin, Barber and Hungerford. And finally, the thoracic pittings were first employed by Hungerford, being seemingly overlooked by all other authors to whose writings I have had access.

The proportions of the head segments may vary from equality *inter se* to an observed proportion of nearly three to one. For convenience, arbitrary limits of length of the anteocular part of less than twice, twice, 2½ times and more than 2½ times the post-ocular part. This gives 4 possible tangible variations, not likely to run one into the other in a given species, on the average.

The variation of the proportions of the antennal segments each one to the others is much wider, and they may be combined in a number of ways. In passing, it may be noted that segment III is always the longest and segment I generally the shortest; the others are more variable. Study of *Hydrometra championiana* seems to indicate a certain degree of variability within the species, not only absolutely, but also relatively.

The pittings are of five types:

a. Absent or present on the anterior lobe of the pronotum;
b. Absent or present on the posterior lobe of the pronotum;
c. Absent or present on the pleura;
d. Absent or present on all three acetabula;
e. Absent on one acetabulum, the third.

In this sorting out alone, there are nine possible distinctions between species, without taking into account whether the pits are many or few, large or small, evident or evanescent; or whether the acetabula are dull or polished. This single group of characters is sufficient to separate over 30 species. Unfortunately, in the descriptions of the species unknown to me in nature it is not mentioned; these species are *H. agenor, H. argentina, H. caraiba, H. chilensis, H. mensor* and *H. metator.*

The male abdominal processes of the 6th ventral segment are also positive characters, but they show only four changes in form, as below:

a. Processes absent;

b. Lateral tumefactions;

c. Processes linear, of varying widths and angular set on the segment;

d. Processes more or less acuminate or spinose, not linear.

In this group of characters there is the possibility of *at least* four differentiations, although at least six may be safely employed.

Without taking into consideration the antennae, which are seemingly less stable than the other characters mentioned above, the other three series of characters may be combined in 320 different ways, more than enough to distinguish ten times as many Hydrometras as are known from all over the world at this present moment.

The fundamental grouping of the species would seem to be primarily based on the male ventral processes and on the character of the acetabula and their pits. These characters, unfortunately, are not known for the species described before 1899 for the former, nor for the species described before 1923 for the latter; and in the absence of specimens, particularly of males, it has not been possible to use them throughout.

Size is a fairly constant character within species, although the females are usually much larger than the males. The mean size of the species seems to be about 10 mm., ranging from 8½ to 11½ mm. One group varies between 13½ to 16 mm., and another exceeds 17 mm., the latter comprising two species whose only structural characters given in the descriptions are the proportion of the head sections and the length. The character of the extension of the rostrum is at times difficult to delimit satisfactorily, as this structure is flexible and is frequently found curved into an arc difficult to measure, instead of lying straight, appressed to the under part of the head.

Preliminary Systematic Arrangement of the Species of Hydrometra

Anteocular part of head much less than twice the length of the postocular.
- *H. mensor* B. White.

Anteocular part slightly more or less than twice the postocular.
- No thoracic pits.
  - *H. kirkaldyana* Bueno.
- Thoracic pits.
  - Male processes acuminate, blunt or sharp.
    - *H. cyprina* Bueno.
    - *H. consimilis* Barber.
    - *H. hungerfordi* Bueno.
    - *H. lillianis* Bueno.
    - *H. wileyi* Hungerford.
  - Male processes linear.
    - *H. martini* Kirkaldy.
    - *H. myrae* Bueno.
    - *H. husseyi* Bueno.
  - Male processes not known.
    - *H. naiades* Kirkaldy.
    - *H. caraiba* Guérin.
    - *H. metator* B. White.

Anteocular part of head more than twice the postocular.
- No thoracic pits.
  - Male processes acuminate.
    - *H. comata* Bueno.
- Thoracic pits.
  - Male processes acuminate.
    - *H. australis* Say.
    - *H. gibara* Bueno.
    - *H. exilis* Bueno.
  - Male processes linear.
    - *H. championiana* Bueno.
  - Male processes absent or represented by tumefactions.
    - *H. cordubense* Bueno.
    - *H. lentipes* Champion.
    - *H. priscillae* Bueno.
  - Male processes not known.
    - *H. agenor* Kirkaldy.

Two of the described species are omitted—*H. argentina* Berg and *H. chilensis* Reed. The unfortunate absence of structures in the descriptions of these prevents placing them in their proper groups, even approximately.

Discussion of Species Represented

The arrangement of the species is in accordance with the systematic list preceding. Paucity of fixed structural details in the original (and in most cases, only) description, makes difficult this sorting out. As it is, two species are left in the air: namely, *Hydrometra argentina* Berg and *H. chilensis* Reed. No specimens from these countries are at hand; and it becomes impossible to fix the species, even approximately, because of the absence of structural characters in the original description. Buchanan White's species —*H. mensor* and *H. metator*—are in scarcely better case; fortunately, in these two, as in *H. caraiba* Guér., the head proportions and size are given, which permits their inclusion in the major divisions. *H. martini* Kirk. (=*lineata* Say) is quite recognizable from the original description; and moreover, it has been quite well characterized by subsequent writers, who are agreed on the species. This is not quite true of *H. australis* Say. The next author to describe American Hydrometras is Champion, in Biologia Centrali Americana. His work is a distinct advance on that of his predecessors, although he seems not to have recognized Buchanan White's species, nor Guérin's, for which he is scarcely to be blamed. The first really satisfactory description of a *Hydrometra* is Barber's *consimilis.* Later, Hungerford described *H. wileyi,* restudied *martini,* and examined the form he calls *australis.*

This diversity of method, and in early descriptions, inadequacy, has led to a study of the characters employed and to their evaluation as fixed specific criteria. In *Hydrometra,* as in *Microvelia,* we are at the outset confronted with the phenomenon of pterygopolymorphism, which at once does away with the form and structure of the thorax as specific characters; it even to some extent modifies the pitting on the posterior prothoracic lobe.

While many obvious characters are omitted in these new descriptions, the 10 characters employed are capable, (as shown by the algebraic formula for combinations), of at least 400 combinations, no two alike, if taken two at a time; of 3,340 combinations if taken 3 at a time. Since there are at the moment only 24 species of

Hydrometra known from the Americas (doubtless soon to be increased by the enthusiastic labors of my friends who read this), it is still possible to employ no more characters than these, and still differentiate at least 3,300 more species.

As mentioned before, a number of other characters have not been used either in these descriptions or in the key. The head, for instance, has six slender long setae in pairs, two in front, back of the antennae, two just in front of the eyes, and two in front of the anterior margin of the pronotum. These are set in pits, sometimes showing darker than the surrounding hue of the head. Their delicacy makes them plain only under high powers, on the one hand; and on the other they are at times seemingly rubbed off. Hence, they have not been employed. The proportions of the rostral joints are also unused, owing to the difficulty of seeing them, and also of measuring the curved third joint. The proportions of the legs and their joints to each other and of the joints *inter se* are quite excellent, but are scarcely needed in view of the multiplicity of other characters. The form of the thorax and the shape of its sclerites are variable, owing to polymorphism, as already pointed out; and while useful as between the fully winged forms of species, they are untenable as a universal character for all forms. The abdomen shows positive characters, although some of these are difficult to see even under high powers, as for example, the spiracles and their position in the segments, which varies with the species. The comparative length of its segments, the abdominal keel or stripe, and the structure of the connexivum are also available.

It may here be remarked that the exactness possible to the binocular microscope with an eyepiece micrometer, at magnifications from $\times 20$ up makes possible refined measurements unattainable with the hand lens, even at high powers. This tends to make descriptive entomology a matter for technical experts with suitable equipment. It may possibly be urged that too much stress is laid on numerical ratios. While this objection must be noted, it may also be pointed out that numbers and ratios are positive factors and not guesswork, for comparatives, (for example, "stouter"), simply reflect an opinion; or again, "3 punctures" is more definite than "several punctures," which may mean anything from 3 up. In general, technical descriptions are not meant for universalist entomologists who dip into selected groups here and there; and who, of course, lacking the corrective influence of extensive acquaintance with family limitations in characters, describe in haste "N. Sp." on insufficient grounds. It is perhaps as well to erect a barrier against such casuals, who rush into print with descriptions of single specimens in sweet innocence of the group to which they belong. To us who have the ungrateful task of unravelling their snarls, anything that tends to eliminate them is welcome.

Comparative measurements of structures unfortunately provide no natural law against teratology. Hemipterists have been known to erect genera on species with four antennal joints, from specimens in which the terminal segment in each antenna had been broken off. Or again, we might argue that the number of joints of the antennae was an invalid character, because at times we run across teratological individuals in which, because of accident, two joints have become fused into one.

''Know how'' is as necessary in the use and limitations of structural characters as it is in plumbing.

VI

Technique of Descriptions

All these descriptions are drawn up at a magnification of 20, under the binocular microscope. Where a higher magnification may have been used to see clearly any structure, it is so stated. All measurements and proportions are by eyepiece micrometer, at a fixed standard of 20 divisions to the millimeter. Hence, to find the dimensions of any structure, divide the unitary proportions by 20.

The length of curves, that is, of true arcs, may be ascertained by a simple device. The distance between the ends of the arc, that is, the length of the chord, is found; and to this length add 2/3 of the perpendicular from the chord to the arc at its highest point. For example, a rostrum on a curve measures from end to end of the curve 5 mm.; the perpendicular from the chord to the arc is 2 mm.; therefore, the length if the curve were straightened out would be 5 mm. + 2/3 of 2 mm. = 6.33 mm. This is sufficiently close for all practical purposes and is used in engineering practice for rough figuring.

As to the descriptions themselves, these are on a uniform plan throughout on material in hand; and all can be compared directly, structure for structure. They are not, nor do they purport to be, complete descriptions of a single specimen—the type; they are rather generalized for all the specimens studied in each species. In some sort, they are cognate to the skeletal and dentitional formulae used in differentiating mammalia, adapted to the exoskeletal structures of insects.

Perhaps this particular form of differentiating species may not be applicable to all groups in the characteristics employed in this one, but certainly where critical structural characters of a group have been developed, these may well be formulated in some such form. Such descriptions will always have the advantage of brevity and particularly of concreteness and definiteness, since all vague comparatives and judgments are discarded.

VII

Characterization of Higher Groups of Hydrometridae

The description of a new genus by Hussey (see *Bulletin Brooklyn Ent. Soc.*, XX: 115) calls for a recharacterization of the family. The number of antennal joints ceases to be a family character; the size and position of the claws likewise must be rejected for this purpose; the linear body appears to be only a generic character, as also the length of wings as compared to the abdomen and the length of the rostrum. The new definition of the family is as follows:

Family *Hydrometridae*

Billberg, 1820, Enum. Ins. Mus. Billb., p. 67.

> Head longer than thorax, with two or three pairs of setae above; eyes agglomerate, large, round, remote from the anterior margin of the prothorax; ocelli absent; front greatly produced; antenniferous tubercles lateral, antennae filiform; rostrum 3-segmented, segment II longest, basal segment concealed between the prominent bucculae; legs very slender, all fit for walking; tarsi 3-segmented; abdomen with 6 segments, not counting the genital; hemielytra semimembranous, not divided into areas; scutellum present in winged; stink orifices present but rudimentary.[2]

In the publication cited, Dr. Hussey has described his new genus *Limnobatodes,* in view of which a redefinition of the genus *Hydrometra* seems to be desirable—in fact, necessary. This, very briefly but possibly more extensively than heretofore, follows.

[2] I am indebted to Dr. R. F. Hussey for pointing this character out to me.

Genus *Hydrometra* Lamarck

1801, Syst. An. sans Vertebr., p. 295.

Antennae four-segmented, segment III longest, I shortest; body very slender, almost linear, at least ten times as long as wide; wings when present normally shorter than the abdomen; head setae in three pairs, two pairs on the anterior swollen part of the head and one pair a very short distance in front of the anterior margin of the pronotum, set in pits; rostrum not passing anterior margin of pronotum; pronotum much longer than wide; omphalium absent; tarsal claws apical, set close together.

Genus *Limnobatodes* Hussey

1925 Bull. B. E. S. XX: 115.

Antennae 5-segmented, segment V longest, II and IV shortest; body stoutish, not more than six times as long as wide; wings when present nearly reaching the apex of the abdomen; head setae in two pairs, one pair on the anterior swollen part of the head and one pair just in front of the anterior margin of the pronotum, set in non-pigmented areas; rostrum reaching middle of coxae; pronotum about as broad as long; omphalium present; tarsal claws subapical, minute, inserted dorsally.

Key to Genera of HYDROMETRIDAE

Antennae 4-segmented, segment III longest; rostrum not passing anterior margin of prosternum; claws apical; head setae 6, paired, two pairs anteriorly; omphalium absent; tylus not narrowed basally .... HYDROMETRA Lam.

Antennae 5-segmented, segment V longest; rostrum reaching intermediate coxae; claws subapical, extremely minute; head setae 4, paired, one pair anteriorly; omphalium present; tylus narrowed basally, truncate .... LIMNOBATODES Huss.

Hem Singh-Pruthi, in his just published paper,[3] states that in view of his studies of *H. stagnorum*, "The genitalia in Hydrometridae are not so different from those in Gerridae, etc., to warrant its being elevated to the rank of a distinct family; much less is it justifiable to raise it to a distinct phalanx, Hydrometriformes, as is done by Reuter and Oshanin" (p. 178). At the outset, it may be said that Oshanin merely accepted and followed Reuter. Now,

[3] The Morphology of the Male Genitalia in Rhynchota, Tr. Ent. Soc. Lond., 1925, pts. I and II, pp. 127–267, pls. VI–XXXII.

Reuter made this disposition of the family on other grounds than the genitalia pure and simple, these being in the Gerridae the presence of an omphalium, the claws aroliate if terminal, and the longer posterior legs than the anterior; and in the Hydrometridae, the absence of an omphalium, the absence of arolia in the apical claws and the slender legs. But, Hussey's finding of an omphalium in *Limnobatodes,* which has subapical claws, leaves the respective lengths of the anterior and posterior legs as the only differential criteria, which seem slight enough. However, the head structure and the agglomerate eyes would seem to be additional characters for maintaining the separate identity of the two families. It can not, nevertheless, be denied that they are closely related. In my own concept based on the structure of the egg and other structural considerations it would seem that this family, as well as the Gerridae, Reduviidae and Nabidae, are all offshoots from one primitive parent stem, whatever we may for convenience call it; and more or less related, not as links in a chain, however, but as tips of twigs, distant from the parent stem.

These relationships call for a more careful and correlated study of *all* the characters, not merely of the genitalia or the egg, or the claws, but of every structure; and of the entire embryology and development. We may, when this is done, then pronounce.

VIII

Differentiation of Species

Here, as in other groups of aquatic Hemiptera, we have to deal with extraordinarily terse primary descriptions—so terse, indeed, as to be generalized for any number of species of the same size. And here again, we have color and pattern predominating as specific criteria, with a correspondingly great absence of structural details, except here and there, until we come to Douglas and Scott in 1865. In these conditions, abundance of controlled material is necessary to reliably elucidate species. The subjoined key to the described American Hydrometrae is tentative only; and is offered for the purpose of coming to some agreement and delimiting the older species. It is accurate according to our present knowledge as derived from the species so far controlled themselves for some; and from the extremely synoptic, not to say cryptic literature for the others.

Hence, this key is far from complete or satisfactory, because of the species included in it which are unknown to me in nature and for which the original descriptions afford a minimum of structural characters. Such species are *H. mensor* B. White, *caraiba* Guérin, *metator* B. White and *agenor* Kirkaldy. Two species had to be omitted altogether because of the practically complete absence of structural characters, except the size; of these two, *argentina* Berg has the proportional length of the anteocular and postocular parts of the head given which serves to place it in a general group but no more; the sole fixed character given for *chilensis* Reed is its length.

In *caraiba* Guérin the anteocular and postocular proportions are given together with the length; the latter in itself is enough to mark the species as the largest known in the genus. Further, a direct comparison is made with *stagnorum* Linné, from which comparison the antennal proportions mentioned in the key are arrived at. *H. metator* B. White is also larger than any of the others. So these sizes have been employed as a primary division. *H. mensor* B. White stands alone in having the anteocular part of the head less than 1½ times as long as the postocular.

The primary critical characters used in this key are: (1) proportion of the anteocular part of the head to the postocular; (2) length of rostrum as compared to the head, which is expressed in terms of its extension posteriorly to or beyond the eyes; (3) proportions of the antennal segments, particularly between I and II, and II and IV; (4) thoracic and acetabular pittings, their absence or presence and character; (5) form of the clypeus; (6) proportional distance of the coxae *inter se*; (7) extension of the anterior and posterior femora as compared to the head and the apex of the abdomen respectively; (8) comparative length of the head and antennal segment II; (9) male ventral processes of the 6th segment of the abdomen; (10) terminal segment of male abdomen; (11) length.

These eleven structural characters and their variations have been employed because they appear to be stable and invariable for all forms of the species. The proportions of the segments of the head are thus measured: *anteocular* from the very tip of the clypeus to the anterior margin of the eyes; *postocular,* from the posterior margin of the eyes to the anterior margin of the pronotum, *with the head in natural position*—if the head is bent down it will be longer and if up, shorter. The length of the rostrum has been sparingly employed, since this appendage appears to be very flexible and is frequently found in quite a distinct arc of circle; its use here, however, is such that even under such a condition it may be depended upon with a fair degree of certainty. In the proportions of the antennal segments, III is omitted, for this, likewise, is likely to be curved, sometimes in more than one plane; segment IV also may be slightly curved, or even sinuate, or absent, hence is sparingly used; segments I and II are stouter and stiffer than the others and always straight. The pronotal and acetabular pittings explain themselves; and so does the form of the clypeus. The distances between the coxae are more properly the distance from the anterior part of each acetabulum to the anterior part of the one behind; if the coxae proper were used, this would not be a fixed quantity, since the position of the legs alters the position of the coxae and hence the distance between them. The extension of the apices of the anterior and posterior femora is evident. The male abdominal processes are excellent characters; these may be absent or present; if present they may be conical or linear. Lack of males of some of the species and the absence of mention of this character in descriptions has prevented the adequate use of this excellent differential structure. The terminal segments and the length require no explanation. The former have not been used as much as might be because of the difficulty of putting them into words in such a manner as to bring out differences of outline and structure unequivocably.

There are other characters and refinements which appear in the descriptions not used in this key; still other characters have been omitted altogether in both key and descriptions, because of their instability, such for instance, as the hemielytra, or the shape of the thorax, or the six head setae. The endeavor has been to make this key both practical and accurate. Beyond the first three couplets (which are based on deficient descriptions), it should be nearly free from the possibility of misinterpretation.

It may seem that too much reliance is placed on dimensions and proportions—that is, on numbers. But numbers are among the few things one mind may convey to another intact and exact, without room for play of imagination or exercise of judgment; numbers are in themselves positive; in regard of one number to another, absolute.

Thus, anyone exercising ordinary care and with the proper equipment should be able to use this key very readily and very accurately.

Key to the Known Species of Neogeic Hydrometrae

1—Anteocular part of head nearly 1½ times as long as postocular; length, 12½ mm. .... *mensor* B. White

Anteocular part of head much more than 1½ times postocular 2

2—Length of species over 17 mm.; ao much more than twice po[4] 3
Length of species less than 17 mm. 4

3—Antennal segment IV twice segment I; antennae as long as body; length, 18 mm., width, 1 mm. .... *metator* B. White
Antennal segment IV nearly three times as long as I; antennae *not* as long as body; length, 22 mm., width, 1 mm. *caraiba* Guérin

4—Ao twice or slightly more or less than twice po 5
Ao notably more than twice po 14

5—Posterior lobe of pronotum more or less pitted; acetabula more or less pitted 6
Neither pronotum nor acetabula pitted; (antennal formula I : II : IV? : III; rostrum extending beyond eyes by ½ po; length, 11 mm.) .... **kirkaldyana** n. sp.

6—Clypeus large, broad and truncate 7
Clypeus small, narrow and conical 9

7—Rostrum extending more than ½ po beyond eyes; mid coxae 1½ times as far from posterior as from anterior 8
Rostrum extending to ½ po; mid coxae twice as far from posterior as from anterior; (antennal segment II about 1½ times segment I; posterior femora in male passing apex of abdomen, in female not quite reaching 6th abdominal segment; male abdominal processes acuminate; length, male, 13½ mm., female, 15 mm.) .... *wileyi* Hungerford

8—Rostrum extending 3/5 po beyond eyes; segment II of antennae about 1 1/3 times segment I; male posterior femora just reaching tip of abdomen, female not quite reaching middle of 6th segment; male abdominal processes mammilose, blunt, widely separated; length, male, 9 mm., females, 11.35–11.8 mm. .... **lillianis** n. sp.
Rostrum extending ¾ po beyond eyes; segment II of antennae 1 2/3 times segment I; male posterior femora barely passing apex of abdomen; male abdominal processes spinose, curved backward; length, 11 mm. .... **cyprina** n. sp.

9—No pronotal punctures; (antennal formula I : II : IV : III; 4th segment of antennae about 3 times as long as I; male proc-

[4] To save space, throughout this key *ao* will stand for "anteocular part" and *po* for "postocular part."

esses spinose, glabrous, very minute and close to anterior edge of abdominal segment; length, male, 9 mm.) **hungerfordi** n. sp.

Pronotal punctures or pits *10*

10—All acetabula punctured or pitted; antennal segment II about three times as long as I; (rostrum extending 2/3 po beyond eyes; antennal segments II and IV equal; antennal formula I : II & IV : III; posterior coxae twice as far from middle as middle from anterior; length, females, 9½–11.25 mm.) *naiades* Kirkaldy

Two anterior acetabula pitted; antennal segment II twice as long as I *11*

11—Two pits only on each acetabulum, one on each side of the cleft; head about, or less than, three times as long as segment II of antennae *12*

Four pits on each acetabulum, two on each side of the cleft; head more than three times as long as segment II of antennae: (antennal formula, I : IV & II : III; segment II twice as long as I; rostrum extending more than ½ po beyond eyes; length, female, 9.5 mm.) .... *consimilis* Barber

12—Rostrum extending about 2/3 po beyond eyes; segment IV of antennae about 1½ times as long as II; length, 8.5–9.75 mm. .... *martini* Kirkaldy

Rostrum reaching or only slightly passing middle of po; segment IV of antennae subequal to or slightly longer than II *13*

13—Male abdominal processes linear; pronotal pits minute, scattered; mean antennal proportions 8 : 20 : 45 ± : 22; length, male, 8.75–9.75 mm., female, 10.55–11.25 mm. .... **myrae** n. sp.

Male abdominal processes spinose, long, slender, pronotal pits large, very shallow, irregularly scattered, more like depressions; antennal proportions 8 : 18 : 42 : 19; length, male, 10.05 mm., female, 11.7–12.35 mm. .... **husseyi** n. sp.

14—Ao not 2½ times as long as po *15*

Ao more than 2½ times as long as po *18*

15—Ao more than four times as long as antennal segment I *16*

Ao less than four times as long as antennal segment I *17*

16—Antennal segment II nearly twice (1 1/3 times) as long as I; length, 13½ mm. .... *agenor* Kirkaldy

Antennal segment II more than twice as long as I; (antennal segment III over five times as long as I; a few scattered punctures on two anterior acetabula); length, 10.6 mm. *australis* Say

17—Pronotum and acetabula without punctures or pits; rostrum extending ¾ po beyond eyes; clypeus broad, medianly excised; male abdominal processes spinose; length, 11.15 mm. **comata** n. sp.

Pronotum and acetabula deeply pitted; rostrum just passing eyes; clypeus narrow, pointed; male abdominal processes entirely absent; length, male, 10.25 mm., female, 11.35 mm. *lentipes* Champion

18—All three acetabula pitted *19*

Two anterior acetabula slightly pitted; (male processes acuminate, near anterior edge of segment; rostrum extending ½ of po beyond eyes; male anterior femora passing apex of head; antennal segment II less than twice as long as antennal segment I; length, 11 mm.) .... **gibara** n. sp.

19—Male processes linear, mere swellings, or absent *20*

Male processes acuminate or spinose .... **exilis** n. sp.

20—Male processes entirely absent, nor any abdominal tumescence; ao only slightly more than twice as long as po; (rostrum not extending beyond eyes; antennal segment IV three times as long as antennal segment I; length, male, 9.1–9.35 mm., female, 11 mm.) .... **cordubense** n. sp.

Male processes linear or tumescences; ao at least 2½ times po *21*

21—Ao 2½ times po; clypeus narrow, acuminate; male anterior femora not reaching antennal tubercles; male abdominal processes reduced to lateral tumescences; male genital segment cylindrical, apical process very short; length, male, 13.5 mm. .... **priscillae** n. sp.

Ao nearly three times as long as po; clypeus as broad as long, bluntly acuminate; anterior femora passing apex of head; male abdominal processes broadly linear, crescentic, converging anteriorly toward median line of segment and equidistant from anterior and posterior margins, black and hairy; male segment more or less sinuate laterally as seen from above, apical process sharp; length, male, 13½ mm., female, 15.25–16.5 mm. .... **championiana** n. n.
(= *caraiba* Champion, nec Guérin)

IX

Characterization of Species

Hydrometra mensor F. Buchanan White, 1879, Trans. Ent. Soc. Lond., 267, (nec Champion, 1898, Biol. C.-Am. Hem.-Het. II: 124–5; nec Kirkaldy, 1909, Can. Ent. XLI: 389).

Anteocular part of head 1½ times as long as postocular; length of insect 11½–12½ mm.

The original description reads as follows:

> "Testaceo-brunnea, oculis rufo brunneis, tibiis ad apicem tarsisque fusco-brunneis. Capite parte anteoculari parte postoculare fere 1½ longiore; pronoto ante marginem posticum tuberculis 2 subelongatis instructo; hemelytris dimidio abdominis tangentibus. Male, Long. 11½–12½ mm. Hab.—Manaos (August, 1875). Two specimens "at light," on board the steamer. The much smaller size will at once distinguish this from *H. metator.*"

This species has been misidentified both by Champion in Biologia and by Kirkaldy in Canadian Entomologist and in his Entomologist paper hereafter named. The last paper drew attention to this first mentioned fact, and for the species seen by Champion proposed the new name *naïades* (q. v.). The sole character White gives, the anteocular part of the head "nearly 1½ times as long as the postocular," cuts it off sharply from all the other American species of the genus, in which the proportion is at least two to one. The only other structural character given by White is the length of the insect, which puts it in the *martini* group.

It is regrettable that there is no authentic material in hand of this species and of *metator* B. W. and *caraïba* Guérin, since they must therefore perforce remain uncertain until such a time as more extensive collections and ampler series of material will ensure their elucidation.

Hydrometra kirkaldyana n. sp.

(= *H. mensor* Kirkaldy, 1909, Can. Ent. XLI: 389.)

> *Head,* long, 55 units; ao : po :: 36 : 16 (type female), 32 : 17 (allotype male); clypeus very narrow and pointed; upper groove between eyes shallow; rostrum passing backward beyond eyes by less than ½ of po; antennae, 9 : 20 : 52 : x, (type female), 8 : 21 : 47 : x (allotype male).
>
> *Pronotum,* long, 30 units, deep grooves running posteriorly on each side, characteristically; unpunctured.
>
> *Metanotum,* not visible; wings long, concolorous.
>
> *Coxae,* distance between I and II and II and III, 21–30 (female type), 20–30 (allotype male); coxae and acetabula glabrous, very small, acetabula unpunctured; legs slender, anterior femora not extending as far as antenniferous tu-

bercles, posterior femora reaching only to anterior margin of 5th abdominal segment.

Abdomen, 130 units long, terminal segments of type much broken, but it seems to be a female, to judge by the absence of abdominal processes; spines on male 6th abdominal segment, very small, sharp, black, close to the anterior margin of segment.

Length, 11 mm.

Type, female labelled "Amazone," from Staudinger, my coll.; allotype, male, Corumba, Brazil, Cornell Univ. Exped.; paratypes, females Lassance, Brazil; Cosquin, Argentine, Cornell Univ. Exped., in Cornell Univ. Coll.

This species is based on a specimen determined by Kirkaldy as *mensor* B. White with the three others mentioned. Clearly, it can not be the latter species, for in *kirkaldyana* the anteocular part of the head is *more* than twice as long as the postocular, while in *mensor* it is *less* than one and a half times. Such a difference in the head structure is obvious to the naked eye; and it seems impossible that Buchanan White should have made such an error. For the rest, its distinctive characters are the absence of thoracic pittings and the comparatively short posterior legs. The former places it with *comata,* but the head and antennal proportions cut it off from this species.

Hydrometra cyprina n. sp.

Head, long, 62 units; ao : po :: 35 : 20; rostrum extending ¾ of po behind the eyes; clypeus truncate anteriorly, about as broad as long, and slightly narrowed at the base; antennae, 12 : 20 : 55 : 32; upper groove of head obsolete, lower obvious, short.

Pronotum, long, 38 units; punctures present but evanescent, posterior lobe evanescently grooved longitudinally, pits more plain; on under side a row of punctures parallel to the anterior margin.

Metanotum covered by wings, which are full length.

Coxae, I to II and II to III, 24–34; pits present on all three acetabula, very evanescent and few in number on posterior, apparently three triangularly placed on each side of the coxal cleft in the two anterior coxae.

Anterior femora not passing the apex of the head; *posterior* barely passing apex of abdomen.

Abdomen, long, 120 units; male processes of the 6th abdominal segment spinose, curved backward; male terminal segment short (nearly as broad as long, exclusive of the spine), spine long and sharp.

Length, 11 mm.

Type: Male from Santa Lucia, Veracruz, Mexico, Fred'k Knab, collector, U. S. N. M. No. 28289.

While this species runs by the key to *wileyi* its much smaller size cuts it off; and its lighter color as well, the latter being a light cinnamon brown, together with the extension of the rostrum.

The type has attached to its second abdominal segment a mature water mite, a peculiar condition in which to find a hydrachnid on its host.

Hydrometra consimilis Barber, 1923, Am. Mus. Novit. no. 75, p. 9.

Head, long, 57 units (female); 46 units, (male, U. S. N. M.), ao : po :: 35 : 15 (more or less), 28 : 13 (male, U. S. N. M.), clypeus small, narrow, pointed; rostrum extending ¾ po backward; antennae, 6 : 12 : 36 : 11.

Pronotum, long, 27 units; 23 units, U. S. N. M. male: a row of large punctures parallel to the anterior margin, growing shallower from the sides dorsally and obsolescent scattered punctures on the posterior lobe more or less in long rows.

Metanotum, 16 units to divarication; wings vestigial.

Coxae, I to II and II to III, 18–30 and 14–24; pits present on anterior and middle acetabula, 2 on each side of cleft.

Anterior femora barely passing middle of anterior expansion of the head; *posterior* not reaching anterior margin of 6th abdominal segment.

Abdomen, 90 units long; male processes of 6th abdominal segment linear, parallel to anterior margin of segment.

Length, 8 to 9.5 mm.

Redescribed from 3 females from Cuba, two from Santiago de las Vegas (S. C. Bruner) and one from Camagüey (J. Acuña); and 5 females and 1 male, Anaco Dist., P. R., July 3, 1917, No. 287, Harold Morrison, Collr., U. S. N. M. Collection. Barber's type is a macropterous male, from Coama Spgs., Pto. Rico.

This is the second species to be described from the West Indies, and the first species of all to be described fully and intelligently by its describer.

In general facies it somewhat resembles *hungerfordi* (here described), but the much longer rostrum, the punctures of the collar, of the posterior lobe of the pronotum, the acetabular pits and the male ventral processes, added to the more general characters, sharply cut it off from that species. It is related to *martini* by the linear male ventral processes, but the thoracic punctures and acetabular pits, and the differently proportioned antennal segments set *consimilis* off.

Hydrometra hungerfordi n. sp.

(= *H. australis* Hungf. 1923, Can. Ent. LV: 54 et seqq., figs. 3, 4, 7, 14, 13).

Head, long, 55 units (female type), male 54, 60 units; ao : po :: 32 : 18 clypeus conical, glabrous; rostrum passing beyond middle of po by about 1 unit; antennae, type, 8:14:43:30 (varying, 8:14:37:25, or 8:15:40:x, or 8 :15 :42 :27); upper groove between eyes short, as long as eye.

Pronotum, long 27 units (23, male in Parshley coll.), female, 31; no punctures posteriorly.

Coxae I to II and II to III, 17–28 (males), 20–30 females; pits present on anterior and middle acetabula, 2 on each side of the cleft.

Anterior femora not reaching antenniferous tubercles; *posterior* in male not passing middle of genital segment; in female not passing middle of 5th abdominal segment.

Abdomen, 82 units long (male type), 88, male and 110, female; male processes of the 6th abdominal segment conical, glabrous, very minute and close together and close to the anterior margin of the segment, black.

Length, 9 mm., male, 10.8 mm., female.

Type: Male, Atchison Co., Kans., July 11, 1924; allotype, female, Leavenworth Co., Kans., July 1, 1924, R. H. Beamer; paratypes, male, Riley Co., Kans., Sept. 8, J. H. Norton, 2 males and one female, the same, Aug. 27; 9 males, Cherokee Co., Kans., Aug. 16, 1920, 3 females, ditto, Hungerford and Beamer Collectors. Type and allotype in my collection, with two paratypes; other paratypes in collection University of Kansas (Cherokee Co. specimens) and in H. M. Parshley collection.

Based on my drawing in Canadian Entomologist, Dr. H. B. Hungerford determined this species as *H. australis* Say. However, on comparison it is evident that they are not the same. While on a description the male genital segment would seem to be identical, it is more cylindrical than in *australis* (Say) Bueno, which in the latter is slightly sinuate laterally seen from above; the terminal spine also is much shorter and blunter. The head is comparatively shorter, the ao is subequal to the po, but in *australis* more than twice (2½ times) the po. The striking character is in the proportional lengths of the pronotum and metanotum; in *hungerfordi* the metanotum is about ½ (31:15) the pronotum, and in *australis* about 2/3 (30:20). This is clearly a distinct species, and I have pleasure in naming it in honor of my good friend, Dr. H. B. Hungerford, whose work in aquatic Hemiptera had added so much to our knowledge of the group in recent years.

Hydrometra lillianis n. sp.

Head, long, 51 units (male type), 60 units (female paratypes); ao : po :: 31 : 15 (type), 38 : 17 (females); upper groove between eyes strongly marked, as long as eye, lower, wide and longer extending backward within three-quarters of prosternum; clypeus truncate anteriorly, parallel sided, as long as wide, black; rostrum extending back 3/5 of po; antennae, type, 10 : 13 : 47 : 23, females, 11 : 15 : 51 : 26.

Pronotum, long, 28 units (type), 32 units (females); pits present, large, evanescent, scattered, a row parallel to anterior margin of pronotum, going below; an impressed longitudinal median line, more or less punctate, evanescent anteriorly; pleura pitted.

Metanotum, long, 15 units (type), 17 units (females); wings brachyptera, narrow, straplike, longitudinal veins pronounced, extending to posterior coxae.

Coxae, I to II and II to III, 16–25 (type), 20–30 (females); all three acetabula pitted, pits scattered, more numerous on anterior and middle than on posterior, where they are scarcely visible.

Anterior femora reaching apex of head (type), attaining antenniferous tubercles (females); posterior just reaching apex of abdomen (type); not quite reaching middle of 6th abdominal segment (females), apically expanded.

Abdomen, 85 units long (type), 127 (females); male abdominal processes widely separated, set near connexivum, mammilose, blunt, inclined outward; male segment blunt, cylindrical, terminal process scarcely evident; female segment, broad, terminal process acute but short.

Length, 9 mm. (male), 11.8–11.35 (females).

Type, male, Santa Barbara, Calif., June; paratypes, 3 females, same data; my collection.

In all probability, this is the species from the Pacific coast that masquerades as *H. lineata* Say. Certainly, I have seen no other species from California, so it is not quite possible to make a flat statement to this effect. Its dark color and velvety appearance show at once its distinctness from the glabrous apterous *martini*, were there not other extremely distinct specific characters to separate it, as for instance, numerous pits on the three acetabula, and the others here enumerated. Further, in general habitus, it is a much stouter species. It is also quite apart from the other Western and Southern species even in facies.

Hydrometra wileyi Hungerford, 1923, Can. Ent., LV: 55, figs. 1, 6, 9, 10, 11.

Head, long, 75 units (male), 78 (female); ao : po :: 45 : 22 (male), 50 : 25 (female); groove between eyes shallow, broad, on a slight elevation; clypeus broad, truncate, black, glabrous; rostrum extending back ½ of po; antennae, 16 : 25 : 70 : 32 (segment IV absent in my specimens, and refigured from the original description).

Pronotum, long, 44 units (male), 49 (female), sparse concolorous shallow punctures or pits on posterior lobe.

Metanotum, 35 units (male), 40 (female), estimated; wings long; in specimens described, narrow, straplike, just passing anterior margin of 2d abdominal segment.

Coxae, I to II and II to III, 30–55; two anterior acetabula with numerous pits.

Anterior femora, male, not quite reaching apex of head; female, noticeably passing it; *posterior* femora, male, passing extremity of abdomen, female, not quite reaching posterior margin of 5th abdominal segment.

Abdomen, 115 units long (male), 130 (female); male abdominal processes acuminate, widely separated; male segment more or less oval, pointed.

Length, male, 13½ mm., female, 15 mm.

This species has been redescribed from the paratypes, from Colorado Co., Texas, received from Dr. Hungerford by Mr. H. G. Barber, Dr. H. M. Parshley and myself. The material, therefore, is authentic. Some slight differences in dimensions may be noted from Dr. Hungerford's description, but they are not beyond the limits of variability in *Hydrometra*. It is a light colored form, of a size and general aspect of *H. championiana* (*caraiba* Champ., nec Guérin), but its well-marked male processes are sufficient to distinguish it, apart from other characters.

Hydrometra martini Kirkaldy, 1900, Entomologist, XXXIII: 175; Hungerford, 1923, Can. Ent. LV: 54–55, figs. 2, 5 and 12; Bueno, 1923, Hem. Conn. 663, p. 152. =*lineata* Say, 1832, Descr. Het. Hem., p. 35 (for full synonymy, see Van Duzee, Catalogue).

Head, long, 48 to 51 units; clypeus, narrow, conical; rostrum extending backward 2/3 po; antennae, 8 : 16 : 40 : 22, mean proportions.

Pronotum, long, 26 units, a few scattered punctures on the posterior lobe.

Metanotum, 20 units; wings absent except for little black vestigial nubbins appearing under the edge of the pronotum; some few are fully winged, as noted before.

Coxae, I to II and II to III, 17–25; two anterior pairs of acetabula with two pits each.

Posterior femora, not reaching last abdominal segment (female), not reaching middle of last abdominal segment (male).

Abdomen, 75 units to 100 units; male abdominal processes linear, transverse.

Length, 8.5 mm. to 9.85 mm.

This is the best known North American species of the genus, reported from all over the country. It ranges from Canada down the Atlantic coast to Florida and probably west beyond the Mississippi into Texas. For the present purpose it has been deemed the representative species of a group. It may seem, however, that in view of its generalized aspect and mean facies, other of the species named herein may have been determined as this by American hemipterists. Be this as it may, in view of the distribution above, it is certainly the most widespread, and while it may have been cited in error from particular localities on a basis of other species resembling it (*e.g., myrae*), it will in all likelihood be found all over, as recorded.

It is a most useful species for study because of its abundance and domesticability. Much work has been done on its life history and habits, which is given in Hungerford's Biology of the Waterbugs. But much remains to be done in its embryology, and morphology.

Hydrometra myrae n. sp.

Head, long, 51 units (male type), 53 (male paratype), 56 (female paratypes); ao : po :: 31 : 15 (type), 36 : 19 (paratype male) 34 : 18 (females); groove between eyes shorter than eye, narrow, deep; clypeus small, narrow, conical; rostrum extending back ¾ of po; antennae, 7 : 20 : 43 : 21 (type), 8 : 20 : 43 : 22 (paratypes).

Pronotum, long, 26 units (type) 30 units (female paratypes); pits minute, scattered.

Metanotum, long 18 units (paratypes male and female, apterous), not visible in the macropterous male type and female allotype. Wings in male type long, reaching to a little beyond middle of 4th segment of abdomen; in female paratypes to about middle of the same segment; in the apterous (micropterous) paratypes, vestigial.

Coxae, I to II and II to III, 20–25 (type), 20–31, female paratypes; pits present on 1st and 2d acetabula, one on each side of the cleft, at the margin of the acetabula.

Anterior femora, not reaching antennal tubercles, males; just reaching them, females; *posterior femora,* nearly reaching distal margin of 6th abdominal segment (male type), reaching to about middle of 5th segment (females).

Abdomen, 98 units (male type), 120 to 125 (females); male abdominal processes, linear, curved, black, as in *martini*; male terminal segment suddenly widened, with a long stout spine.

Length, type, 8.75 mm., apterous males, 9.75 mm., winged females, 10.55 mm., apterous, 11.2 mm., all from Billy's Island, Okeefeenokee Swamp, Ga., J. C. Bradley, Collr.

Type, allotype and morphotype, Cornell Univ. Colln., paratypes, same and coll. J. R. de la Torre-Bueno.

This species is quite close to *H. martini,* from which its more slender general aspect distinguishes it at first sight. The body segments in general are lengthened out. The fixed differential characters lie in antennal segment II, which in *myrae* is 2½ as long as I and subequal to IV; while in *martini* it is only twice as long as I and about 2/3 or 4/5 times IV; and in the more exaggerated outlines of the male terminal segment. It is also similar to *H. husseyi,* but the linear male processes at once cleanly separate it from the Paraguayan species, and the different antennal proportions as well.

/ **Hydrometra husseyi** n. sp.

Head, long, 54 units (male type), 57, 58 (female paratypes); ao : po :: 32 : 16 (type), 35 : 17 and 36 : 18 (paratypes); upper head groove short, not longer than eye, shallow, linear, in female longer than eye; clypeus small, conical for about ½ its length; rostrum extending half way the po behind the eyes; antennae, 8 : 18 : 42 : 19 (male), 9 : 19 : 40 : x, 9 : 20 : 36 (this joint appears to be broken) : x (last joint missing in the two females).

Pronotum, long, 30 units (male), 32 units (alate female), 34 (apterous female); punctures on the posterior lobe of the pronotum large, very shallow, irregularly scattered, more like depressions than pits.

Metanotum, concealed under the wings of the alate type and paratype; 18 units in micropterous morphotype (female); hemielytra reaching to middle of 6th abdominal segment (male); microptera not quite half as long as metanotum to divarication, narrow, straplike.

Coxae, I to II and II to III, 20–29 (type male), 23–32, 23–31 (females); pits present on anterior and intermediate acetabula, one on each side of the cleft, none on third acetabulum, acetabula polished.

Anterior femora, not reaching antennal tubercles; *posterior femora* reaching suture between 5th and 6th abdominal segments (male) just passing it (females).

Abdomen, 119 units (male), 145 (alate female), 127 (apterous female); male processes spinous, curved backward, sharp, set at anterior margin of segment; male terminal process long, slender, black, more than half as long as the genital segment is wide at the widest part, which segment including spine is as long as last abdominal segment proper, which in turn is excavated beneath on the posterior margin for genital segment; the male terminal process is the longest and slenderest noted; in the female also the process is long and slender, as long as the segment is wide.

Length, type, 10.15 mm.; allotype, alate, 11.7 mm.; morphotype, apterous female, 12.35 mm.

Type, male, Villa Rica, Paraguay, 11 : IX : 1923 (P. Jorgensen); allotype, same data; morphotype, micropterous female, No. 28,290 U. S. N. M., labelled "Peru" "P. R. Uhler Colln." (Note—The morphotype is a light yellowish or clay color, seemingly glabrous; probably a very old specimen, much faded.)

Type, in collection R. F. Hussey; allotype in my collection; morphotype in U. S. National Museum.

This species, based on the three specimens named, was originally identified by Dr. R. F. Hussey (in whose honor it is named), as *Hydrometra argentina* Berg, described originally from a single male specimen, but it can not be that species. Berg, in his description, says: "antennis gracilibus, longitudine articulorum ut in *H. stagnorum*." The segments in the European species are 10 : 15 : 50 :

28, while in the one here described they are as 8 : 18 : 42 : 19, a notable discrepancy not to be explained on any theory of variability of proportions.

It clearly belongs also in the *martini* group with two pits on the anterior pairs of acetabula, but differs from it in the male ventral processes and in the other characters used in the key to distinguish it.

This is another species that has been taken at light.

Hydrometra caraiba Guérin, 1856, in Sagra's Hist. Cuba, pt. 2, VII, p. 173.

Head, ao twice po.
Length, 22 mm.

These are the only two structural characters mentioned in the original description, which follows.

> "Hydrometra. Supra fusco-ferruginea, subtus albo-argentea; thorace linea longitudinali alba nigro-marginata; elytris obscure fuscis, immaculatis; pedibus obscure ferruginis basi dilutioribus. Larg. 22; anch. 1 millim.
>
> "Esta linda especie se distingue de la H. stagnorum de Europa por su tamaño algo mayor, por su cabeza aún mas alargada, teniendo los ojos al tercio de su longitud, mientras que se hallan casi al medio en la especie tipo, y por el bello color blanco plateado de su parte inferior.
>
> "Solo conocemos un individuo que forma parte de la colección de M. Signoret, que le fué remitido por M. Dohrn, como procedente de la Isla de Cuba."

Guérin's description of his species, particularly the black-margined longitudinal white line of the thorax, might possibly apply to the Central American species so named by Champion, except for the fact that there are two more which have this characteristic—namely, *exilis* and *priscillae*, herein described as new. All three species, however, have the anterior part of the head visibly much more than twice the length of the posterior, besides not attaining the enormous (for a *Hydrometra*) length of 22 mm. The other difference lies in the antennae, which are in *caraiba* as in *stagnorum*. This is not quite clear, but if it refers to the antennal *proportions*, in *stagnorum* these are: 10 : 15 : 50 : 18; in *exilis*, 13 : 23 : 90 : ×; in *priscillae*, 11 : 24 : 84 : 45; in *championiana* Bueno (*caraiba* Champion, nec Guérin) 13 : 27 : 80 : 38, varying to 14 : 31 : 95 : 45. That is to say, in *caraiba*, segment II is 1½ times I and IV not quite twice I; while in the others segment II is approximately twice I and segment IV more than three times I. It may seem to belong to the same general group, and when finally rediscovered will be found doubtless to have the three acetabula pitted and dull, as in the three species with which it has been contrasted. It may even turn out to be a gigantic specimen of one of these three, in view of the distribution and the large size of some of the specimens of *championiana.* Meantime, it seems advisable to maintain its specific identity, since there are no specimens in hand with the structural details named for *caraïba* by its author.

Hydrometra metator F. B. White, 1879, Journ. Linn. Soc. Lond., Zool., XIV, p. 486.

Head, ao twice po.
Antennae, segment IV twice I.
Length, 18 mm., width, 1 mm.

The original description reads thus: "9. *Hydrometra metator,* n. sp. Aptera, brunnea, opaca; antennarum articulo primi dimidio apicali, secundi apice et articulis 2 apicalibus (tertio ad basin excepto), rostro apice, femorum et tibiarum apicibus, necnon tarsis nigris; antennis gracillimis, corporis aequilongis. Male, long. 18, lat. 1 mm."

"*Hab.*, Brasiliam borealem (Uraçaca, Rio Jurua, Nov. 1, 1874, J. W. H. Trail)."

This species has one character beyond its length to distinguish it from all other *Hydrometrae*—its antennae are as long as the body! Moreover, its antennal segment IV is only twice antennal segment I. The first peculiarity is so unusual that it sets it apart alone. It may well be a mistake in measurement; or else an obscure statement of proportion. In any case, in the absence of the type and of any specimen which might meet the description in this and in the anteocular and postocular proportions, its identity should be preserved until these obscurities may be cleared up.

Hydrometra comata n. sp.

Head, long, 65 units; ao : po :: 40 : 18; clypeus broad, excavate anteriorly; upper groove between eyes very faint; rostrum passing eyes by ¾ po; antennae, 15 : 21 :: 66 : x.

Pronotum, long, 35 units; unpunctured.

Metanotum, long, 25 units; micropterous, wings straplike.

Coxae, distance between I and II and II and III, 20–37; neither acetabula (which are dull pilose) nor pleura punctured.

Anterior femora surpassing apex of head by about 1/5 their own length, *posterior* lost in type (but probably greatly surpassing tip of abdomen).

Abdomen, long, 100 units; male processes stout, blunt, mammilose, placed close to the anterior margin of the segment, terminal segment with an upwardly inclined long sharp black spine.

Length, 11.25 mm.

Type, male, Trinidad, West Indies, Chipman; my collection.

In addition to the structural characters mentioned, segments 2 to 6 of the abdomen are dorsally glabrous, segment 7 dull, pilose, with an anterior glabrous spot; the genital segment also is dull pilose. The under side of the body has sparse long fine erect grey hairs; dark beneath, with a darker median line.

This is one of those species which has lain undetermined in my collection. I am indebted for the type to my good friend and kind mentor, Mr. E. P. Van Duzee, who had it from Chipman. His label read: "near *mensor* B. White." Of course, it could not be this species since the anteocular part of the head is proportionally much longer than the postocular (40 : 18, that is, about 2¼ times as long, while *mensor* is barely 1½ times as long). The absence of any additional characters for *mensor* is offset entirely by the unique head proportions. The size means nothing, as it is within the limits of variability within the species.

Hydrometra comata is one of the two species without thoracic punctures, which character at once sets it apart from all the other species known to me in nature, except *H. kirkaldyana.* From this last, however, the head and antennal proportions and the extension of the rostrum abundantly separate it, as is brought out in the key to the species. In addition, the acetabula are dull pilose in this species, but glabrous in *kirkaldyana.*

Hydrometra exilis n. sp.

Head, male, long, 81 to 83 units, female, 88; ao : po : : 55 : 20, male, to 56 : 21, female, 58 : 23; clypeus as wide as long, acuminate angularly; upper groove between eyes shallow, short, not as long as eye, lower, running back from eyes nearly to pronotum, anterior groove deep, nearly as long as the expanded part of the head; rostrum passing eyes by about ½ po: antennae varying between 13 : 23 : 90 : 43 (males) and 13 : 24 : 95 : 45 (females). (These proportions vary by one or two units one way or the other, which seems to be the normal fluctuation.) Antennal tubercles very small, glabrous.

Pronotum, long, males, 40 (type), 42, 43; females, 45; punctures large and deep on posterior lobe which has a longitudinal pitted groove, propleura back of acetabula pitted; a collar goes all around the anterior part of pronotum.

Metanotum, concealed by full length wings.

Coxae, distance between I and II and II and III, males, 25–42 (type), 25–43; females, 28–45; pits present on all three acetabula, numerous and deep on both sides of the coxal cleft.

Anterior femora, male, just passing apex of head; female, passing apex of head by about 5 to 10 units; *posterior femora,* males, passing apex of abdomen by about ¼ their length; female, by nearly 1/3 their length.

Abdomen, long, 132 units (male type), 130, 138 (paratypes); 150 (allotype and female paratypes). Male abdominal processes, acute, long, mucronate, black-tipped, set a little less than half the length of the segment from its anterior margin; terminal segment nearly cylindrical, apical spine blunt, short; female apical process very small, nearly imperceptible.

Length, males, 12.65 mm. (type), 12.7, 13.2 (paratypes); 14.15 (allotype and female paratypes).

Type: Male, macropterous, from Ceiba, Honduras, F. J. Dyer, collector, U. S. N. M. No. 22654, type No. 28, 288, in U. S. N. M. collection; allotype, female, Tela, Honduras, 1. IV. '23, F. H. Hubbell, collector; paratypes, 4 males and 5 females, same data, all numbered 170. Type in U. S. N. M.; allotype and 5 paratypes in coll. University of Michigan, 4 paratypes in my collection.

We have here a species closely related (in color) to *championiana* and *caraiba,* being of the same brown with a dark-margined light pronotal stripe. It has, however, acuminate male abdominal processes, not linear, as in the former; and the male segment nearly cylindrical as seen from above, with the terminal spine short and small. It is also a much smaller insect. This color identity but structural difference is another indication of the unreliability of color as a specific criterion in the genus.

Hydrometra naiades Kirkaldy, 1902, Entomologist, XXXV: 281 = *mensor* Champion, 1898, Biol. C. Am., Hem. Het., II: 124–5.

Head, long, 50 to 60 units (females); ao : po : : 36 : 18, 38 : 20; rostrum extending about 2/3 po behind eyes; clypeus narrow, acuminate; antennae, 8 : 23 : 56 : 23; upper groove of head narrow and fine, lower groove short, shallow, barely exceeding diameter of eye.

Pronotum, long, 26 to 29 units, a few shallow obsolete punctures on the posterior lobe.

Metanotum, 19–20 units long to divarication. Wings vestigial.

Coxae, I to II and II to III, 16–32; two pits on each acetabulum, one on each side of the cleft; first and second acetabula polished.

Anterior femora scarcely reaching the antennal tubercles; *posterior* just passing the anterior margin of the 5th abdominal segment.

Abdomen, long, 95–114 units, females only; female terminal process very long and slender.

Length, 9.5–11.25 mm.

This description is drawn up from 4 females from Los Amates, Guatemala, 16. I. 5, Prof. J. S. Hine, collector. The groove under the head is quite plain between the eyes, but at times extends evanescently beyond them. It is light-colored for a *Hydrometra.*

Champion[5] in his comments on this species says: "Some North American specimens in the British Museum, received from Doubleday, are very like *H. mensor*" (this being the name under which he referred to it, later changed by Kirkaldy to *naiades*). It is obvious that he had specimens of *martini* before him, to which species *naiades* is indeed much akin. But the antennae with segment II nearly three times I (in *martini* twice I); the notably different proportional distances between the coxae; and the very long spine on the female terminal segment, are additional differences.

From *H. myrae,* the rostrum and the distances between coxae sharply cut it off. It is, however, another of the *martini* group, as is evidenced by the characteristic two punctures on the first and second acetabula.

✓ *Hydrometra australis* Say, 1832, Descr. Het. Hem., p. 35 (Fitch reprint, p. 807); Compl. Wrtgs., I: 361; Bueno, 1905, Can. Ent., XXXVII: 15, fig. 3; (nec Hungerford, 1923, Can. Ent., LV: 54/58).

[5] Biol. C. A., Het. II, p. 126.

Head, long, 65 units; ao : po : : 42 : 18; rostrum reaching nearly to base of head, 5/6 po; clypeus acute, nearly twice as long as wide, black, polished; antennae, 9 : 21 : : 51 : x; upper groove between eyes deep.

Pronotum, long, 30 units; punctures absent.

Metanotum, long, 20 units, to divarication; entirely apterous.

Coxae, I to II and II to III, 20–30; a few scattering deep, large punctures on the first and second acetabula, on each side of the coxal cleft.

Anterior femora not passing apex of head; *posterior* not exceeding abdomen.

Abdomen, long, 97 units; male abdominal processes sharp, spinose, directed back; male segment globose, apex produced in a short blunt glabrous process or spine.

Length, 10.6 mm.

Described from the same male specimen from Thomasville, Ga., from which the original drawing of the genitalia was made and figured in the Canadian Entomologist (*supra*). This specimen may therefore be deemed the autotype. Other records are from Florida (Slosson and Blatchley). The original specimen came from Louisiana.

Say's description of his "var. *australis*" may fit almost any of the slender forms from the Southern states (*e.g., myrae*). The lateral whitish points may be observed in other species as well, and are not always visible. However, in the absence of Say's type, we must take whatever most closely approximates the description; and since from locality and general characteristics the species in question has been so determined, it is best so-called. If not, Say's variety would remain among the unknown species.

The characters distinguishing this species from *H. hungerfordi* have already been commented upon. The ventral processes in the males are enough to separate it from *martini,* even without taking into consideration the differing antennal proportions, rostral length, acetabular punctures and other differential structures named in the key and the descriptions.

Hydrometra gibara n. sp.

Head, long, 68 units; ao : po : : 42 : 19; rostrum extending 2/3 of po behind eyes; antennae, 13 : 20 : 60 : 36; upper groove of head visible, lower longer and not so deep.

Pronotum, long, 35 units; row of deep punctures parallel to anterior margin, a long row of median punctures starting about 2/5 the length of pronotum from the anterior edge.

Metanotum, concealed by vestigial wings.

Coxae, I to II and II to III, 23–37; a few evanescent pits on anterior and middle acetabula.

Anterior femora passing apex of head; *posterior femora* just passing apex of abdomen.

Abdomen, long, 100 units; male abdominal processes spinous, moderately long, stout, sharp, divaricating, curved backward, near anterior margin of segment; male segment terminating in a long, slender spinous process.

Length, 11.4 mm.

Described from one male, Camagüey, Cuba, July 22, 1923, collected by J. Acuña.

This well-defined species comes in what might be called the *martini* group, with punctured pronotum, anterior and mid-acetabula glabrous, with few punctures. The length of the head, the head proportions, and the spinous ventral processes of the male sixth abdominal segment separate it sharply.

Hydrometra championiana n. n.

== *H. caraiba* Champion, 1898, Biol. C.-Am., Hem.-Het., II; 124 (nec Guérin, 1856, l. c.).

Head, long, 90 units; rostrum just reaching middle of eye; clypeus broad as long, obtusely pointed, sides parallel, polished, black; antennae, 13 : 27 : 94 : 38; head grooves present and somewhat variable.

Pronotum, long, 47 units (alate male) ; anterior collar of punctures, median longitudinal row of punctures on posterior lobe and larger pits in rows, propleura with three marginal rows of pits.

Metanotum, concealed under sooty wings which reach nearly to middle of 5th abdominal segment.

Coxae, I to II and II to III, 30–45; all three acetabula pitted, dull pilose.

Anterior femora, barely reaching or just passing apex of head; *posterior femora* passing apex of abdomen by about one-fifth of their own length.

Abdomen, 135 units long (from posterior margin of pronotum) ; male abdominal processes crescentic thickenings converging anteriorly, the ends equidistant from the respective anterior and posterior margins of the segment, broad, black, hairy; male segment underside compressed medially

to a broad keel for about ½ its length, the terminal spine short but pointed; female segment also terminated in a spine.
Length, 14.5 mm.

Redescribed from a male from Los Amates, Guatemala, 16 January, 1905, taken by Prof. J. S. Hine, from which locality there is a long series, alate and apterous males and females. Further localities are: Gualán, Guatemala 15. I. 50 (Hine); Rio Machuca, C. R. (Biolley); Rio Frio, Colombia, 23. II. 25 and 6. III. 25 (Fred M. Walker).

Strange though it may seem, workers in certain of the groups of aquatic Heteroptera employ a procrustean method in making species fit. For example, in his extremely parsimonious description of *Hydrometra caraiba* (see p. 113, *ante*), Guérin makes two positive statements, which I translate from the original Spanish: ''Long. 22, wid., 1 mm.'' is the first; the second is: ''this beautiful species is to be distinguished from *H. stagnorum* of Europe, by its somewhat larger size, by its somewhat more lengthened head which has its *eyes at about one-third of its length,* while *they are nearly at the middle in the type species.*'' In the face of these two statements (to which he refers), Champion records two specimens of a species from Panama, which, he states, ''agree sufficiently well with Guérin's description of *H. caraiba,*'' even though the larger of the two, a female, is only 16 mm. in length, as against the length of 22 mm. in the original description cited; and the anteocular part of whose head is *2½ times* the postocular, instead of only twice, as distinctly stated by Guérin. While there are fluctuations in length in *Hydrometrae* within a species, these are not so gross; and the head proportions seem a fixed and reliable character to differentiate species in the genus. It is clear that whatever Champion had, it is *not caraiba* of Guérin, but an undescribed species, which, in honor of the first to diagnose it, I here call *championiana.*

In *H. championiana* brachyptery reduces the number of punctures on the acetabula as well as their size; and also reduces the number of punctures on the ascending margin of the propleura.

This species is the representative of a group in which all 3 acetabula are pitted more or less deeply, the other being *priscillae* Bueno and *exilis* Bueno, herein described. In this group we see that ''shuffling of characters'' mentioned by Parshley in his ''Essay on Aradus.''[6] In general facies the three are very similar, as well as in coloration, but starting with the male abdominal processes we

[6] 1921, Trans. Am. Ent. Soc. XLVII: 1, 106, pls. 1–7.

note a series of differences in the structures deemed critical, as the key amply indicates.

In *H. championiana* there are certain variations from the mean as between specimens from the same locality; and much more superficially notable in specimens from distant parts.

The head varies in length from 4.5 mm. in the male plesiotype to between 4.65 and 4.35 mm.; the ao and po proportions vary from 61 : 21 in the plesiotype, to 63 : 23, 58 : 20, 60 : 22, etc.; the rostrum just reaches or just passes the eyes; and other variations might be noted, but rather unprofitably, since all seem to fluctuate about a norm, which seems well represented by the plesiotype.

A male from Carabela Grande, Cuba, in the collection of the Estación Central Agronómica, at Santiago de las Vegas, Cuba, offers certain variations, but well within the norm. The head is 96 units; ao : po :: 65 : 24; clypeus as in typical *championiana*; antennae 14 : 31 : 95 : 45; pronotum, long, 46; pits as in *championiana*, etc.: coxae, 30–50; apex of anterior femora slightly exceeding apex of head; length, 15.1 mm. Another specimen from Pto. America, Rio Putumayo, Brazil, Aug. 30, 1920, Cornell University Expedition, in the Cornell collection, at first sight, because of the greater length of head, etc., was deemed to represent a different species, yet the critical measurements preserve the proportions. The head is 105 units; ao : po :: 73 : 25; clypeus normal; coxae, 33–55 (= 3–5, as in *championiana*). Comparison with a typical specimen from Gualán, Gta., showed them to be alike. It seemed at first as though we might here have Buchanan White's *H. metator*, but it cannot be this species, since the antennae are not as long as the body (223 units as against 335). If, however, by *body* Buchanan White means the length of the insect *less the head*, then this condition is fulfilled; and *H. championiana* Bueno would be known as *H. metator* B. W.

Hydrometra cordubense n. sp.

Head, long, 58 units (type male), 60, (male paratypes), 68, (allotype and morphotype, alate female), 65, (female paratype); ao : po :: 37 : 17 (type), 37 : 18 (male paratypes), 43 : 20 female allotype and morphotype), 40 : 18 (female paratype); rostrum just passing posterior margin of eyes in all specimens; clypeus, bluntly conical, glabrous, yellow; antennae, 12 : 19 : 60 : 36 (type), 12 : 21 : 63 : 38 (allotype), 12 : 20 : 56 : 35 (morphotypes); upper and lower grooves of head short, about equal to each other and to the diameter of the eyes.

Pronotum, long, 28 units (type and male paratypes), 35 (female allotype), 37 (female morphotype); punctures on anterior collar and posterior lobe, an indented line on posterior lobe.

Metanotum, long, 13 units (type), 14, 16 (male paratypes), 15 (female allo- and paratype), not measurable in morphotype; wings vestigial in type and male paratypes and allotype, present in female morphotype and passing apex of fifth abdominal segment.

Coxae, I to II and II to III, 15–18 (in all specimens); all acetabula pitted, 3 large deep pits parallel to the lower margin of the anterior acetabulum, the middle pit being one of three in a line posterior to the cleft; intermediate, 1 deep large pit at bottom anteriorly, three in front of the cleft, two large deep ones posteriorly; third acetabulum with three pits arranged triangularly, apex at the cleft and the other two in line parallel to it, a slitlike puncture directly above cleft of anterior acetabulum.

Anterior femora just reaching antennal tubercle (type), passing apex of head (male paratypes), not exceeding apex of head but just passing antennal tubercles (females); *posterior femora* greatly exceeding end of abdomen (all specimens).

Abdomen, long, 83 units (type), 85, 80 (male paratypes); 100 (allotype), 90 (female paratype), 115 (female morphotype). Male has neither abdominal processes nor tumescences; terminal segment equal to last abdominal in length, compressed below, terminal spine short, blunt, thick. Female terminal segment spine short, blunt.

Length, 9.1 mm. (type), 9.2, 9.35 (male paratypes), 10.9 (allotype), 10.2 (female paratype), 11 mm. (female morphotype).

Type: Male, apterous, Cordoba, Veracruz, Mexico, January 16, 1901, Fred'k Knab, Collector, No. 28287 U. S. N. M.: allotype, female, Acapulco, Mexico, 29.7 Fred'k Knab, Collector; morphotype, alate female, same data; paratypes, 2 males (one apterous) and 2 females (apterous), same data, apterous male and female, 15.6, same place; and 1 alate female, 30.7 and 1 apterous female, 29.7, from Acapulco, Mexico, same collector.

The type and allotype are the only perfect specimens; the antennae are missing or imperfect in the paratypes. In the allotype female there are two large deep pits placed far apart before the anterior acetabula and parallel to the anterior row of pits. In the female morphotype the thoracic pits are deeper and linearly arranged; the scutellum is evident, with a sharp longitudinal keel; the pronotum *stout,* much stouter than in the apterous; the wings pass the apex of the 5th abdominal segment; the abdomen curves up in the female, which is also seen in other species.

Hydrometra lentipes Champion, 1898, Biol. C.-Am., Hem.-Het., II; 124/5.

Head, long, 61, 64 units (males), 70 (females); ao : po :: 37 : 17, 40 : 18 (males), 43 : 20 (females); rostrum just passing eyes; clypeus narrow, acuminate; antennae, 13 : 21 : 65 : x, 12 : 20 : 65 : x, 12 : 20 : 63 : x (males), 12 : 21 : 64 : 34 (female); upper groove of head shorter and shallower than lower groove, which becomes obsolete toward its ends.

Pronotum, long, 30 units (males), 35, (females); a row of deep subapical pits parallel to the anterior margin and close to it, nearly encircling thorax, the posterior part with scattered punctures.

Metanotum, long, 21 units (males), 20 (female); wings vestigial.

Coxae, I to II and II to III, 18–32 (males), 21–34 (females); punctured scatteringly on all three acetabula with deep punctures.

Anterior femora passing apex of head, males; not passing apex of head, females; *posterior femora* considerably passing apex of abdomen.

Abdomen, long 85, 90 units (males), 102 (female); male abdominal processes entirely absent; male segment hairy, narrowing apically, terminal process stoutish, blunt; female segment broad with a long slender spine.

Length, males, 10 to 10.25 mm.; female, 11.35 mm.

This species, originally described from Guatemala, is redescribed from 4 specimens from Costa Rica, collected by the late Professor Paul Biolley, 2 males from Rio Tiribi near San José at an elevation of 1100 metres; and one male and one female from Cangrejal de Asseri on the Pacific side, at 800 metres, the male of these two being the plesiotype and the female and the other two males the plesio-paratypes.

H. lentipes agrees with *H. priscillae* in the absence of male abdominal processes and in the pitting of the three acetabula, although neither so deeply nor so abundantly; but of course, the other characters separate it—the length, the head proportions, the antennae, the coxal distances, etc.

Hydrometra priscillae n. sp.

Head, long, 84 units (male type), 82, 85 (male paratypes), 87 (allotype, apterous female); ao : po :: 56 : 22 (male type), 55 : 22, 56 : 21 (male paratypes), 58 : 23 (allotype); rostrum not passing eyes posteriorly; clypeus bluntly angulate anteriorly, glabrous, black; antennae, 11 : 24 : 84 : 45 (type male), 11 : 25 : 75 : 44 (allotype); upper groove of head shallow, about as long as eyes, lower groove very broad, evanescent posteriorly and extending much beyond eyes.

Pronotum, long, 42 units (type), 41 (male paratype), 46 (allotype); anterior lobe not pitted, posterior with scattered but not deep pits, anterior collar of large shallow pits, a groove runs the whole length of the pronotum, pitted, one row of large deep pits follows the edge of the pleura up into the notum.

Metanotum, long, 23 units; wings, reduced to strap-like microptera.

Coxae, I to II and II to III, 27–45 (type and paratypes), 28–45 (allotype). All three acetabula deeply coarsely pitted.

Anterior femora scarcely reaching antennal tubercles; *posterior femora* going much beyond apex of abdomen.

Abdomen, long, 117 units (type), 138, 141 (paratypes), 164 (allotype); male abdominal processes reduced to lateral swellings in the 6th segment, with long, fine hairs arising therefrom; male segment cylindrical, not compressed beneath into a longitudinal keel; spine very short, acuminate.

Length, type, male, 13.25 mm.; paratypes, 14.25, 14.75 mm.; allotype, 16 mm.

Described from 6 males and one female from Los Amates, Guatemala, January 16, 1905, collected by Dr. J. S. Hine. Types in my collection.

This is a lighter colored species than *H. championiana,* with a more slender head and only one row of pleural pits.

Hydrometra agenor Kirkaldy, 1902, Entomologist, XXV: 280.

Head, rostrum reaching eyes but not beyond; antennae, 12 : 20 : 80 : 40 (estimated from description).

Anterior femora, scarcely reaching apex of head.

Long, 13.5 mm.

In this species we have more abundant structural characters and it becomes possible to fix it with a fair degree of certainty. Working back from the given dimensions on the unit system here used, we find that the ao is to the po more or less as 50 to 24. The antennal segments are stated to be about 2/3 the length of the bug, that is about 180 units, roughly proportioned as above.

These characteristics, in connection with the size, put it into the *H. championiana* class, with all three acetabula pitted, not polished. It may even develop at some future time that it is identical with one of the species in that aggregation. At the moment, absence of specimens makes it desirable to retain it as a distinct species, as indeed it has every evidence of being.

The original description is as follows:

> "Brownish castaneous, a narrow median longitudinal very pale bluish grey line on pronotum, apical margin of pronotum black. Antennae (except pallid base of first segment), apex of head, etc., black. Abdomen above shining black, connexivum flavo-stramineous, extero-lateral margin narrowly black. Abdomen beneath pale flavous, except the dark genital segments. Legs pale flavo-fuscous, tarsi and apices of femora and tibiae black. Elytra lurid, nervures black. Rostrum reaching to eyes, but not beyond; antennae equal to about two-thirds of the insect's length; anteocular part of head more than twice as long as the postocular; head somewhat dilated at apex, scarcely so at base; anteocular part of head four times as long as first segment of antennae, third more than twice as long as fourth, four times as long as second, which is two-thirds longer than the first. Apex of anterior femur scarcely reaching apex of head. Male. Long. 13½ mill. *Hap.* ECUADOR, Guayaquil (Colln. Montandon)."

Hydrometra argentina Berg, 1879, Hem. Arg., p. 182.

The original description of this species gives no characters to fit it into the general scheme of this monograph; and not alone is it unknown to me in nature, but it is doubtful that it could be recognized without a comparison with the type.

> "♂: Sublinearis, sordide testaceus, antennis, capitis parte postoculari utrimque, pectoris lateribus, rostri articulo terminali, connexivi marginibus utroque nec non hemelytrorum venis obscuribus vel fuscis, pedibus fuscecenti-testaceis, margine interiore hemelytrorum albido-maculato; capite tenui, apicem versus modice incrassato, apice ipso conico, flavescenti, medio parum elevato, obsolete fusco; antennis gracilibus, longitudine articulorum ut in *H. stagnorum*; rostro valde ultra oculos extenso, articulo prima brevissimo; pronoto fere parallelo, ante medium subtilissime constricto, postice retrorsum declivi; hemelytris angustiusculis, prope segmentum quintum extensis, venis duabus transversis fuscis

ante apicem maculisque albidis marginis interioris distinctis; alis albis, subopalinis; pedibus gracilibus, unicoloribus; femoribus posticis hemelytris paullo longioribus.—Long. $11\frac{1}{2}$; lat. pron. abdominisque $\frac{3}{4}$ mm. Patria: Buenos Aires."

Hydrometra chilensis Reed, 1901, Rev. Chil. Hist. Nat., V, page (103 of reprint).

This is another species which cannot be described in the form herein employed. The original Spanish description follows:

"*Limnobates chilensis, spc. nov.* De un bruno negruzco por encima, amarillento por debajo, en algunos ejemplares; en otros de un testaceo pálido. Antenas y patas del color del cuerpo, con las articulaciones y estremidades más oscuras. Una linea amarillenta corre por los lados del protorax y a veces por los del abdómen. En algunos ejemplares hai una linea pálida, lonjitudinal en medio del pronoto.

"Hai much variación en el desarrollo de las alas; en muchos ejemplares se encuentran rudimentos como la cuarta parte del pronoto, en otros son mas largos, y en individuos bien desarrollados son casi del largo del abdómen.

"Largo, 10 milimetros."

Baños de Cauquenes, Chile.

The English of it is:

"Of a blackish brown above, yellowish below, in some specimens; in others of a pale testaceous. Antennae and legs of the color of the body, with the joints and tips darker. A yellowish line runs along the sides of the prothorax and sometimes of the abdomen. In some examples there is a pale longitudinal line in the middle of the pronotum.

"There is much variation in the development of the wings; in many examples there are rudiments about a fourth of the pronotum, in others they are longer, and in well-developed individuals they are nearly as long as the abdomen. Length, 10 mm."

The original descriptions of these two species preceding are given for what they are worth. In time, doubtless, these species will be found, recognized and definitely placed by some competent hemipterist. At the moment, these two species are included to complete the tale.

X

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XI

Concluding Comments

In the preparation of this paper, I have been much helped by the critical comments of Dr. R. F. Hussey, who has pointed out, as elsewhere noted, obscure structures.

To Dr. L. O. Howard I am indebted for the loan of the U. S. National Museum material; Dr. J. C. Bradley has furnished a homogeneous lot of *Hydrometra martini* from the Cornell University Collection, as well as the type material for *H. myrae;* Mr. H. G. Barber has kindly loaned me his material; Mr. F. M. Gaige, of the University of Michigan, has furnished the Hubbell Honduras material; and Dr. H. M. Parshley his own collection in this group. The remainder of the specimens are from my own collection.

This extensive series of species and specimens has been of the greatest use in settling many of these species beyond doubt.

Many weak spots are discernible to me in this work. But so far as it goes and according to our present knowledge, it is my hope that it will prove useful to my fellow-workers. It will doubtless help them to set their own houses in order and to straighten out some of the difficulties indicated.

To the author, a work such as this makes keenly evident how much there is to know as to what really constitutes a species, and how frail is the basis of much work founded on the differentiation, relationship and origin of species. So many of these species seem to be regional; and, of course, arising from isolation. But how many more are there to be discovered? And how many of these here described will vanish through more exact knowledge?

Jacta est alea! Who shall recast it? And how? And to what purpose?

Finitum est opus!

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After a lapse of 36 years, this veteran journal of American entomology emerges from its hibernaculum to take its place once more as a vehicle for the progress of our branch of science. Thanks to the generosity of a friend the Brooklyn Entomological Society is enabled to revive this journal to render, we hope, as good service and fill as worthy a place as its predecessor of long ago.

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CLASSIFICATION OF THE NUT CURCULIOS [FORMERLY BALANINUS] OF BOREAL AMERICA

By F. H. Chittenden
BUREAU OF ENTOMOLOGY

The coleopterous genus *Curculio*, formerly known as *Balaninus*, comprises a well-defined group of species, the nut and acorn curculios, some of which, the true "nut weevils," as they have also been termed, are injurious to the fruit of the chestnut and chinquapin, the pecan and hickory, and the hazelnut or filbert. The remainder, as far as known, feed on the fruit of various oaks.

The genus is the type of the Curculionidae, a family of the Rhynchophora abounding in species which are seriously destructive to deciduous fruits and various other crops, including such important pests as the plum curculio, the boll weevil, various strawberry weevils, alfalfa weevil and the clover weevils, the pine weevils, rhubarb curculio, pepper weevil, tomato weevil, apple curculio, quince curculio, plum gouger, grape curculio, the chestnut curculios, and many others.

The distinguishing characters of the genus are (1) the extremely long and slender rostrum, or beak, and (2) the vertical mandibles. This latter character, taken in connection with the long slender rostrum, might entitle the genus to family rank[1] were it not that

[1] LeConte, Rhynch. Am. No. Mex., 1876, p. 322, used the term Balaninidae in connection with the genus *Balaninus*.

the former character is present in a few other genera, while in certain others the female rostrum is longer and more slender than in the short-beaked species of *Curculio*.

The genus *Curculio* was proposed by Linnaeus in his 10th edition of Systema Naturae, 1758, and Latreille, in 1810, designated *nucum* L. as the type. Nevertheless, the matter was apparently forgotten by coleopterists until Dr. W. D. Pierce called attention to it in recent years (Proc. Ent. Soc. Wash., 1925, pp. 113, 114).

The paper here presented is a brief monograph, or unpretentious study, brought together as an aid for the identification of the various species of the genus *Curculio* which inhabit America north of Mexico. The group as a whole has always been most difficult to classify, even by expert coleopterists, but it is hoped that with the aid of the illustrations, and the descriptions and tables, the paper will tend to simplify the subject. In commenting on the classification of the genus, C. W. Leng, writing in 1916, aptly observed that the species resemble one another so closely as to make specific identification very difficult, and collectors generally have experienced great trouble in classifying the specimens in their collections. The writer will admit that, even with the presentation of the subject in this paper, difficulty will still be experienced unless the worker has access to considerable material representing many species. The females present the best characters for classification; the males are exceedingly difficult to separate.

In the table separating the species into groups, the length of the female rostrum, while somewhat arbitrary in some forms, is the most reliable character that has been found. It is quite otherwise with the males. Thus in this first group the male rostrum of *proboscideus* measures three-fifths the length of the body, and in the others except *longidens* only slightly more than half is the rule. In cases where only one sex was available for description, the writer has exercised his own judgment as to the group to which each belongs, but in one species (*albidus*), where the male rostrum is nearly as long as the body, no conjecture is hazarded.

The Genus *Curculio* L.

Curculio Linnaeus, Carolus, Systema Naturae, 10th ed., 1758, pp. 377–386.

Balaninus Germar, Mag. der Ent., pp. 339, 341, 1817.

Mouthparts small, mandibles vertical, gular peduncle very long and narrow. Rostrum very long and slender. Antennae very long and slender, inserted on the rostrum usually anterior to the middle (♂) and posterior to the middle (♀); funicle 7-jointed; first joint longer, exceptionally shorter than second, outer joints usually gradually a little less elongate; club elongate oval, pointed annulated and pubescent. Eyes large, nearly flat, nearly circular in outline and finely granulated. Prothorax rather long in front of coxae, which are contiguous; broadly emarginate anteriorly, without postocular lobes; pronotum rapidly narrowed anteriorly, sides usually subparallel in basal half, base slightly bisinuate. Scutellum distinct. Elytra wide at base narrowed posteriorly, apices separately rounded; humeri not prominent; pygidium more or less exposed in male. Mesothoracic epimera attaining widely the base of prothorax, and truncating the humeral outline of elytra; metathoracic episterna narrow, dilated anteriorly. First ventral segment longer than second, and closely united with it; others subequal in length. Middle coxae moderately distant, posterior coxae widely distant, not attaining the elytral margin. Legs long, femora clavate and strongly dentate, tooth usually bearing a denticle; tibiae slender, usually sinuate; truncate at tip, not mucronate; tarsi dilated, claws divergent, bifid.[2]

The Rostrum

The genus *Curculio,* as has been stated, comprises species with exceedingly long rostra or beaks, especially highly developed in the female. Indeed, the average length is greater than in any other group of North American Rhynchophora. Naturally, valuable characters are to be found in this organ, such as its length, normal arcuation, and other structural characters. The length of the rostrum as compared with that of the entire body is an excellent character, especially valuable for division into groups. As a general rule, the female rostrum is considerably longer and more slender than that of the male, and not infrequently approaches a straight line, while that of the other sex is inclined to be rather uniformly arcuate. In certain of the smaller species there is little difference in the sexes.

In statements of dimensions here used the measurements are from selected normal specimens, and the length of the rostra is from base to apex, including the mandibles, by the chord of the arc, since it is practically impossible, except in a few species, for the average

[2] Adapted from "Rhynchophora of America," LeConte and Horn, 1876, p. 322.

student to make actual measurements of an imaginary extended arcuate rostrum. The length of the body is measured from the frons of the head to the apex of the elytra or pygidium, not from the apex of the prothorax to that of the elytra.

In statements which are made in the tables and in descriptions regarding the conformation of the base of the rostrum, such as "proceeding abruptly from the head" or "continuous with the frons," it should be understood that this description is as viewed from the side.

The mouthparts are small and the mandibles are unusually short, although in certain species twice the usual size. They are vertical in that they are incapable of motion laterally, being restricted to movement in a lateral plane, acting like scissors in which both edges are acute. Their inner edge is more convexly curved than the outer, so that in many specimens the points appear to be more or less divergent. The teeth, in fact, appear much different from those of other Curculionidae which have been studied by the writer.

The Antennae

The antennal characters afford means for the classification of only a few species, but are of much less value than the character of the rostra and the femoral teeth. The antennae of the female, because of the greater length of the funicular joints, are more pronounced, hence more easily studied.

The most striking instance of differences in the antennal structure is seen in *proboscideus* in which the second funicular joint is distinctly longer, nearly one-third, than the first joint; joints 1 and 3 being subequal. In no other species of our fauna is this character constant. In most species, as a rule, the first funicular joint is at least one-fourth longer than the second, and the second is usually distinctly longer, sometimes about one-fourth, than the third. Exceptionally, however, as in certain aberrant individuals —*e.g.*, in *rectus*—the first funicular joint is scarcely longer than the second, and in several species the second joint is scarcely longer than the third. The remaining joints 4 to 7 are usually subequal or grow very gradually smaller distally and are more or less inconstant as regards their comparative length. The antennal club is elongate fusiform, acute, annulated and finely pubescent. It presents little of apparent value in classification. The scape extends toward and nearly or quite to the eye. The eyes are quite similar in the various species. In the female, as a rule, the antennae are inserted distinctly posterior to the middle on the rostrum, in the long-beaked species in the proximal fourth or third; in the male, at, or before, or exceptionally a little posterior to the middle in most species. There are, however, exceptions; *e.g.*, in the male *pardalis* the antennae are placed well behind the middle.

The male antennae differ from those of the female also by their distinctly shorter funicular joints and by the comparatively longer scape. Otherwise, their structure is very similar.

Knowing the variability in the lengths of the funicular joints, a large series of *rectus* was examined, with the finding of two males in which the first two joints were subequal, agreeing with *cuneatus* Cas. Another series showed the second joint only a little shorter than the first, corresponding to the description of *sparsellus* Cas. Naturally, there are variations between these. Such variations occur in several species of *Curculio* but are unusual and somewhat perplexing, since there are no other obvious structural characters separating them from normal types and there is no difference in distribution.

The Legs

The legs are extremely long and slender, the femora are more or less strongly clavate and each bears a single, usually prominent, distal tooth, which generally terminates in an acute denticle. The tibiae are slender, more or less strongly bisinuate, truncate at the apex and mucronate. The tarsi are dilated, the third joint very widely bifid and provided with a dense hairy pad. The claws are divergent, strongly incurved, with an inner tooth. Somewhat extreme variation is exhibited in the length of the legs. Some are noticeably long, others comparatively short. The difference in the size of the femora and the size and shape of the femoral tooth offer excellent characters by which the species may be grouped. In species in which the rostrum is of about the same length as that of the body, there is great divergence. As examples, in *orthorhynchus* the femoral club is small and the teeth scarcely more than denticles, while in *caryae* and *nasicus* the club is much larger and the teeth strong and conspicuous. In *rectus* the club and teeth are more prominent than in *orthorhynchus* but not so strong as in the last two mentioned. In *macrodon, ruficristatus,* and *longidens* the femoral teeth attain the maximum of development, becoming strongly prolonged and with acute denticles.

The Ventral Surface

The first ventral segment is much longer than the second, and is nearly connate with it at the middle. The second segment is distinctly longer and slightly narrower than the third, from which it is widely separated. The third and fourth segments are subequal in length, while the fifth is subdeltoid, generally with a central depression or concavity of varying extent. The middle coxae are moderately distant, and the posterior coxae are widely distant, not attaining the elytral margin.

In the female the abdomen is more convex and distended than in the male; the first and a portion of the second segment are slightly convex or nearly flat near the middle. The fifth abdominal is more or less concave at the middle and is uniformly clothed. In the male the first is usually more or less concave and the fifth may be either flat or widely concave, very frequently terminating in a semi-denuded area at the extreme apex, while the pygidium usually terminates in a tuft of hairs at each side or, exceptionally, at the middle. The abdominal and pygidial characters, together with the rostrum and point of insertion of the antennae, serve as a means of distinguishing the sexes where other characters are difficult to find.

Vestiture

Before considering the subject of the vestiture of our native species of *Curculio,* it would be well to quote from Horn who wrote in 1873:[3] "The marked uniformity of vestiture of many of the species renders it extremely difficult to separate them" by that character, a statement which is only too true of the average cabinet specimen, but does not hold for reared, unrubbed, or freshly captured material. The predominant color of vestiture of our native species is ocherous, called also ochraceous, or clay-like, or more or less yellowish buff or pale yellow brown. Others of our American forms are more distinctly yellow to golden yellow, with gray of different shades as the only other ground color.[4] The vestiture of all of our species is, in the main, if not entirely composed of minute, prostrate and more or less hair-like, scales or squamules, and the arrangement of this squamulose covering of the body usually follows a nearly uniform pattern, more variable on the elytra as

[3] Horn, G. H., Proc. Amer. Phil. Soc., 1873, p. 457.

[4] Some of the European and other exotic species are decidedly rufous; and *villosus* Fab. and *crux* Fab. are black with white elytral fascia.

regards color. It is as a general rule densest and of coarsest texture at the sides and on the elytra, much longer on the prothorax, shorter on the abdominal segments, and very fine and slender on the legs. The vestiture in fresh material normally covers the head and is usually coarser and denser between the eyes, and in the males of the short-beaked series this covering sometimes extends sparsely about a third of the length from the base to the point of insertion of the antennae. On the disc of the pronotum, especially noticeable in the larger ocherous or yellow species, the long, hair-like squamules are directed toward the middle, at which point the color is paler in the form of a lineal area, extending from base to apex and appearing slightly elevated; each side of this pale line is a larger darker area, and at the sides of the disc a paler area subequal in width to the dark one. On the elytra the vestiture is, in the majority of our species, more or less spotted, these spots usually being arranged in more or less indistinct transverse fasciae, three or four in number (see fig. 1).[5]

Individual Variation

After what has been said in regard to the individual diversity of arcuation in the female antennae of *Curculio,* especially in such species as *auriger,* mention should be made in regard to variation constituting in many cases habitus or facies. This aspect is most apparent in the general form or appearance of a given zoological species and it is borne out by the experience of those who have conducted careful rearing in *Curculio,* as have Brooks and the writer, and who have exercised judgment based on experience in the selection and description of a species. There is in *Curculio* extreme variation in many species reared from the same locality and from the same species of *Quercus* or other food tree. Among such species, *rectus, pardalis* and *longidens* form striking examples, while others, such as *caryae* and *proboscideus,* are subject to similar

[5] The species of *Curculio,* it should be mentioned, like the plum curculio and many others, are of sluggish habits but have long, well-developed and serviceable wings. The character of these would warrant the conclusion that they are not only capable of long-sustained flight but that they fly longer distances than is usual in the Curculionidae. At the time of the first invasion of the boll weevil from Mexico, large numbers, especially of *victoriensis* and *parvidens,* were captured at electric lights.

diversity.[6] In the remarks on synonymy which follow in regard to different species, points like the above have been borne in mind. Merely because a specimen is stouter or more slender or has wider elytra, is a little more flat, or more nearly cylindrical than others, or has a little shorter or a little longer rostrum or antenna with different curvature, it can not be considered a species, in this genus, unless there are other constant characters of a more convincing nature, such as sexual ones.

Further, the writer believes that practically every species named in this work as such will eventually be proved, by rearing and biologic study, along the line so ably started by Mr. Fred E. Brooks,[7] and in less detail by Doctor Hamilton, Mrs. Blake and the writer, to be a zoological species.

Literature

For the proper understanding of a genus, one must necessarily study sooner or later, as in everything of like nature, by beginning at the ground and working upwards, a method which necessitates an interpretation of the descriptions of the earlier authors. In the old Melsheimer Catalogue,[8] published in 1806, one species is listed, *Curculio nucum* L., a European form not known to occur in this country. Say[9] recognized five species as follows: *Balaninus proboscideus* Fab., our largest known species, and *nasicus* Say, accepted by coleopterists as a fasciate form having the female rostrum as long as the body. Judging by the description alone and what we know of many of Say's descriptions, this might apply equally to *strictus* Casey, since it reads: "Rostrum *not* so long as the body or hardly longer"; also *rectus* Say, formerly known as *quercus* Horn, and *nasutus* Say, the latter designated by Horn and others as a synonym of *nasicus*, but perhaps the male of *proboscideus*. Since this name is sunk in synonymy and the types are not known,

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[6] Such variation is so striking in this genus as to have resulted in the creation of a superfluity of synonyms. Synonyms of this nature might be traditional, "book," collection or commercial names, the last class including certain dogs and other domestic animals.

[7] Bul. 128, W. Va. Agr. Exp. Sta., March, 1910.

[8] Melsheimer, F. V., Catal. Ins. Penna., Hanover, 1806.

[9] Say, Thomas, Descr. North Amer. Curcul., etc., July, 1831, p. 279.

further discussion is superfluous. The fifth is *B. constrictus* (= *Desmoris constrictus* Say).

In Harris's first catalogue of Coleoptera, published in 1838,[10] *rectus* is mentioned as being found in the vicinity of hazel bushes, leading Harris to believe that it inhabited the nut of that shrub, from which fact it would seem evident that he had in mind the species subsequently described by Blanchard as *obtusus*. In his later treatise[11] he mentions a single species, *nasicus* Say, and describes it as having the snout longer than the whole body, and this identification is probably correct. The species, however, which he found paired upon the hazelnut tree in July is again, barring an improbable accidental occurrence, *obtusus*. *B. nasicus* Say (of authors) again is a composite, especially as the statement has been made that it infests not only acorns but hazelnuts as well.

In Dr. Horn's table, issued in 1873, only six species are treated, two being described as new. Of these *quercus*, according to the nearly simultaneous conclusion of Casey and the writer (unpublished), is *rectus* Say, while Horn's "*rectus* Say" was mentioned at the same time as not that species but *auriger* Cas. *B.* "*uniformis*," inasmuch as it contains brief descriptions of three varieties and is stated to occur from Canada to Texas and Kansas as well as in California and Oregon, is a composite, as proved by the description and specimens identified by various authorities, and contained probably all forms which Horn had the opportunity of studying that were not included in the consideration of the other species in his paper. The type is from California.

Location of types: *B. obtusus* Blanch., type in the Museum of Comparative Zoology at Cambridge, Mass., seen by the writer; *nasicus* Say, *rectus* Say, and *nasutus* Say, types believed to have been destroyed by fire; *uniformis*, type at the Museum of Comparative Zoology, specimens seen by the writer, compared by both Fall and Blanchard; *caryae* Horn, type in the Philadelphia Academy of Sciences, well known and easily identified; *confusor*, types in Carnegie Museum at Pittsburgh, Pa., seen by the writer.

Distribution

The species of *Curculio* occurring within the confines of our American faunal regions north of Mexico are so far as known native

[10] Harris, T. W., *in* Hitchcock's Economical Geology of Mass., p. 83.

[11] Insects Injurious to Vegetation, 1862 ed., p. 74.

to this country. They are well distributed throughout the United States and the arable portions of Canada, and are apparently rare in Mexico and not so abundant on the Pacific Coast. Four species only have thus far been noted as occurring in California, but in Texas, Arizona and New Mexico there are many species, considering the scarcity of material from Mexico. In Texas alone a dozen or more species occur and a like number in Arizona and New Mexico combined, and a similar number in the faunal region of the District of Columbia.

In the preparation of this paper the writer had access to the United States National Museum collection, including that of Col. Thos. L. Casey, who described several species of *Curculio*, and of an accessory collection of the Bureau of Entomology, which latter has been greatly augmented by accumulations received from agents and correspondents of the Bureau, including many specimens reared from acorns, obtained for the purpose. The writer is especially indebted for material to Fred E. Brooks, Bureau of Entomology, to L. L. Buchanan, A. B. Champlain, W. T. Davis, H. C. Fall, C. A. Frost, L. G. Gentner, Dr. C. P. Gillette, Dr. H. P. Löding, C. H. Popenoe, Dr. E. C. Van Dyke, Prof. H. B. Hungerford, Prof. H. F. Wickham, Major Wirt Robinson, Prof. Franklin D. Sherman, and the late H. W. Wenzel, as well as others who will be mentioned in the discussion of species. Through the kindness of Dr. W. J. Holland, the writer consulted the collection at the Carnegie Institution, Pittsburgh, Pa.; through Dr. J. McDunnough, he has studied the collection of the National Museum of Canada, and through Dr. Nathan Banks material from the Museum of Comparative Zoology. The writer also wishes to acknowledge the assistance of Mrs. D. H. Blake in the rearing and preparation of specimens for study.

Table of Groups

A. Rostrum ♀ nearly as long (five-sixths or more) or longer than body.
  Femora strongly clavate and dentate, teeth with obtuse reentrant angles.
    Rostrum ♂ ♀ continuous with frons ....1. *proboscideus* group
    Rostrum ♂ ♀ proceeding abruptly from head; of ♂ usually more than half as long as head........2. *nasicus* group
  Femora feebly dentate and clavate, rostrum ♀ nearly straight, hair-

like; rostrum ♂ scarcely one-half as long as body .... 3. *orthorhynchus* group

B. Rostrum ♀ more than half to four-fifths as long as body; of ♂ one-half to two-thirds.

Rostrum ♀ three-fourths to four-fifths as long as body .... 4. *pardalis* group

Rostrum ♀ one-half to three-fifths as long as body .... 5. *q. griseae* group

Rostrum ♂ nearly as long as that of ♀, of latter less than to fully one-half as long as body.

Rostrum parallel or subparallel with frons .... 6. *obtusus* group

Rostrum proceeding abruptly from head .... 7. *monticola* group

1. Table of the *proboscideus* group

Species with rostrum ♀ about as long as, or longer than, the body; of ♂ more than one-half as long as body; ♂ ♀ continuous with frons, strongly enlarged at base.

First funicular joint of antennae shorter than second.

Femoral club and teeth large; Eastern U. S. .... 1. *proboscideus* Fab.

First funicular joint of antennae longer than second.

Femoral club and teeth smaller; Eastern U. S., Ariz., (?) .... 2. *auriger* Cas.

2. Table of the *nasicus* group

Rostrum ♂ ♀ proceeding abruptly from head.

a. Femoral club and teeth large, latter right-angular, not strongly produced. Rostrum ♀ longer than body.

Rostrum ♀ distinctly arcuate. Pygidium ♂ not cup-like.

Rostrum ♀ strongly, subequally arcuate. Vestiture scaly, with 2 distinct transverse pale fasciae on elytra. Antennae ♂ inserted far in front of middle; Eastern U. S., Tex. .... 3. *nasicus* Say

Rostrum ♀ strongly arcuate only toward apex. Vestiture hair-like; elytra without fasciae. Antennae ♂ inserted at middle; Eastern U. S., Tex. .... 4. *caryae* Horn

Rostrum ♀ nearly straight, abruptly recurved at apical 4th; very slender.

Pygidium ♂ and ♀ cup-like. Elytra not or very feebly fasciate; Eastern U. S., Tex. .... 5. *rectus* Say

b. Femoral club and teeth very large, latter strongly produced with prominent denticles.

Vestiture of elytra short, alternately banded with light and dark brown.

Form robust subcylindrical. Posterior femoral teeth about as long as anterior; Tex. .... 6. **macrodon** n. sp.

Form deltoid, not cylindrical. Posterior femoral teeth distinctly shorter than anterior; Mass.—Fla., Tex. .... 7. **longidens** n. sp.

Vestiture of elytra long, red, irregular, ♂ with strong tuft at apex; antennae ♂ inserted slightly behind middle; form elongate; Tex. .... 8. **ruficristatus** n. sp.

3. Table of the *orthorhynchus* group

Rostrum ♀ slightly shorter than the body; femoral club and tooth small; reentrant angles obtuse.

Rostrum ♀ slender, hair-like, nearly straight; last one-seventh suddenly recurved; of ♂ less than one-half as long as body. Length 6.0–7.5 mm.; N. H.—Ala., Wis. .... 9. *orthorhynchus* Chttn.

Rostrum ♀ thicker, gradually strongly arcuate.

Vestiture mainly ocherous, composed of long squamules.

Elytral vestiture faintly dotted with slightly darker areas.

Femora feebly dentate with denticles obsolete. Rostrum ♂ two-thirds as long as body. Length 6.0–7.0 mm.; Ariz. .... 10. **longinasus** n. sp.

Elytral vestiture with several strongly alternate pale and dark fasciae.

Femora rather strongly dentate; denticles nearly obsolete. Rostrum ♂ nearly three-fifths as long as body; length 6 mm.; Wis. .... 11. **multifasciatus** n. sp.

Elytral vestiture strongly intermixed with dark brown areas, subfasciately arranged.

Femora quite strongly dentate with denticles distinct and produced. Rostrum ♂ less than one-half as long as body. Length 4.5–5.5 mm.; So. Cal. .... 12. **pardus** n. sp.

Vestiture mainly gray. Rostrum ♂ four-eighths to five-eighths as long as body.

Slender, convex; vestiture dense dull gray, strongly intermixed with brownish gray. Elytral intervals flat. Antennae ♂ inserted just behind middle. Length 5.8–6.0 mm.; Ariz. .... 13. **gracilis** n. sp.

Robust, depressed; vestiture sparse, dark gray. Elytral intervals convex. Antennae ♂ inserted at middle. Length 6.3–6.6 mm.; Western Tex. .... 14. **wenzeli** n. sp.

4. Table of the *pardalis* group

Rostrum ♀ three-fourths to four-fifths as long as the body. Femora strongly clavate and dentate;

teeth deltoid with outer edge forming a right angle; denticles prominent.

Rostrum ♂ ♀ distinctly enlarged at base, strongly at apex, stout.

Vestiture bright ocherous or yellow brown; elytra strongly mottled with small darker brown spots. Rostrum ♂ nearly two-thirds as long as body; antennae ♂ inserted well behind middle of rostrum; Eastern U. S., Tex. .... 15. *pardalis* Chttn.

Rostrum ♂ ♀ somewhat enlarged at base, not at apex.

Vestiture gray or pale ocherous; elytra lightly spotted with pale brown. Rostrum ♂ one-half as long as body; antennae ♂ inserted at middle of rostrum; Tex., Kans., Ala., S. C. .... 16. *victoriensis* Chttn.

Rostrum ♀ scarcely enlarged at base, not at apex, more slender.

Vestiture pale gray; elytra with small brown or fuscous spots. Rostrum ♂ one-half as long as body, proceeding abruptly from head; antennae inserted in front of middle. Body slender. Length 5.0–6.5 mm.; N. Mex. .... 17. **emarginatus** n. sp.

Vestiture pale ocherous to reddish; elytra irregularly spotted and fasciate. Rostrum ♂ more than one-half as long as body, subparallel with frons; antennae generally inserted about at middle. Body robust. Length 6.0–8.0 mm.; N. J.—N. C.—N. Mex., Utah, Tex. .... 18. *strictus* Cas.

5. Table of the *q. griseae* group

Rostrum ♀ more than one-half to three-fifths as long as the body.

Femoral club, teeth and denticles somewhat strongly developed.

Antennae ♀ inserted behind basal fourth.
Vestiture yellow-brown on dorsum, variegated with red-brown on elytra; lower surface silvery gray. Robust; Ariz. .... 19. *q. griseae* Chttn.
Vestiture mostly ocherous yellow.
Anterior femoral tooth large, posterior one close to apex.
Abdomen ♂ with double concavity; Eastern U. S., S. Dak. .... 20. *confusor* Ham.
Antennae ♀ inserted two-fifths from base.
Anterior femoral tooth small, posterior large, distant from apex. Abdomen ♂ without double concavity; Cal.—Ore., Ut., B. C. .... 21. *uniformis* Lec.
Femoral club, teeth and denticles more feebly developed.
Antennae ♀ inserted nearly one-fifth from base of rostrum; of ♂ well behind middle. Rostrum ♀ thick, three-fifths as long as body, strongly arcuate; of ♂ one-half as long as body. Femora moderately clavate; Gulf States, N. C. .... 22. *parvidens* Chttn.
Antennae ♀ inserted not less than one-fourth from base, of ♂ about at middle. Rostrum ♀ slender, nearly straight from base, distinctly arcuate at apex; of ♂ more than one-half as long as body. Legs slender; Eastern U. S., Tex. .... 23. *baculi* Chttn.
Antennae ♀ inserted near basal third.
Vestiture sparse, whitish gray, covering larger brown squamules, pale silvery gray be-

low, not spotted on elytra. Body slender; Cal. .... 24. **cervulinus** n. sp.

Vestiture dense, bright ocherous, lightly spotted on elytra, much paler below. Rostrum ♂ three-fifths as long as body, strongly dilated at apex; antennae ♂ placed well behind middle. Form robust; Ariz. ... 25. *undulatus* Cas.

Vestiture nearly uniform light brown.

Rostrum comparatively slender, moderately arcuate; of ♂ more than one-half as long as body; antennae ♂ inserted about at middle; Tex. .... 26. **microdon** n. sp.

Rostrum thick, somewhat strongly arcuate; antennae ♂ inserted far behind middle; N. Mex. .... 26[a]. *microdon* **rectitibialis** n. var.

6. Table of the *obtusus* group

Rostrum ♀ about one-half as long as, or shorter than body, thick; parallel or nearly parallel (view from side) with frons. Vestiture mainly ocherous or yellow.

Dorsum strongly convex.

Rostrum ♀ one-half as long as body; 5th ventral ♀ feebly concave.

Rostrum moderately stout, same length in ♀ and ♂.

Antennae ♂ inserted at middle of rostrum. Elytra and abdomen very strongly convex; elytra wide with prominent humeri; Eastern U. S. —Can., Tex. .... 27. *obtusus* Blanch.

Antennae ♂ inserted nearly three-fifths from base. Elytra and abdomen not so strongly convex; elytra narrower, humeri not prominent; Ia., Wis., Col., Can. ... 28. **numenius** n. sp.

Dorsum moderately convex.

Rostrum very thick, not more than half as long as body.

Rostrum ♂ and ♀ of subequal length.

Antennal scape as long as first 4 funicular joints.

Rostrum ♀ nearly straight in basal three-fourths, rather abruptly arcuate at apex, distinctly carinate; N. Mex., Can. .... 29. **funicularis** n. sp.

Rostrum ♂ shorter than in ♀, two-fifths to one-half as long as body.

Rostrum ♀ feebly subuniformly arcuate, feebly dilated at apex.

Antennal scape ♀ shorter than first 4 funicular joints.

Head and eyes large, prothorax as long as wide, posterior legs extending beyond elytra; N. Y.—N. C.—Wis., Tex. .... 30. *iowensis* Cas.

Head and eyes smaller, prothorax not as long as wide, posterior legs not extending beyond elytra; Ariz. .... 31. **ibis** n. sp.

Dorsum considerably depressed.

Rostrum moderately thick, more than one-half as long as body; humeri not prominent; Can. .... 32. **exilis** n. sp.

7. Table of the *monticola* group

Rostrum ♀ one-half to fully as long as body, proceeding more or less abruptly from the head (lateral view).

Form oblong oval, about twice as long as wide.

Vestiture yellow or ocherous; rostrum thick, feebly arcuate in ♂.

Prothorax strongly convex.

Rostrum ♀ slightly more than one-half as long as body; of ♂ slightly less.

Elytra and abdomen depressed. Femora abruptly clavate, teeth blunt, denticles minute; Western Tex., N. Mex. .... 33. *monticola* Cas.

Rostrum ♀ and ♂ one-half as long as body, very thick, feebly uniformly arcuate; 5th ventral ♀ lightly impressed at middle; vestiture ocherous gray; Ariz. .... 34. **crassirostris** n. sp.

Rostrum ♀ less than one-half as long as body; thick; 5th ventral ♀ longitudinally deeply concave at middle.

Vestiture dense golden yellow or paler; Cal. .... 35. **aurivestis** n. sp.

Prothorax and elytra depressed. Rostrum (♀) comparatively slender; antennae inserted far behind middle.

Vestiture sparse, fulvous; elytra with red-brown fasciae; Cal. .... 36. **brevinasus** n. sp.

Vestiture gray; rostrum slender, more strongly arcuate in ♂.

Rostrum ♀ nearly straight. 5th ventral broadly indented at middle third.

Elytra wide, rounded at apex; striae fine and shallow; intervals wide, nearly flat, feebly elevated. Vestiture dark gray, mostly dense and composed of short scales; N. Mex. .... 37. *nanulus* Cas.

Elytra narrow, acuminate to apex; striae wide and deep; intervals narrow, convex, strongly elevated. Vestiture pale gray, mostly sparse, composed of comparatively hair-like scales; Western Tex. .... 38. **striatus** n. sp.

Form very robust, less than twice as long as wide.

Subrhomboidal; prothorax short, distinctly tubulate at apex; elytral striae deep, strongly punctate; femora with minute denticles but without teeth; Fla. ...... 39. *humeralis* Cas.

1. *Curculio proboscideus* Fab. (Fig. 2)

Curculio proboscideus Fab., Syst. Ent., 1775, p. 142.

♀ *Balaninus caryatrypes* Boh., *in* Schönh. Gen. Curc., vol. VII, p. 276, 1845; Horn, Proc. Am. Phil. Soc., 1873, p. 458.

♂ *Balaninus hariolus* Cas., Can. Ent., XLII, 1910, p. 114.

♀ *Balaninus cylindricollis* Cas., l. c., p. 115.

Elongate elliptical in outline, body and rostrum piceous, legs and antennae dark brown. Vestiture dense, varying from golden yellow or ocherous to gray with or without dark brown spots or fasciae on elytra; squamules very fine and short with the exception of those on the prothorax which are hair-like.

Rostrum ♀ nearly one-fourth longer than entire body,[12] at base subparallel with the frons, much thickened, narrowing toward apex; from point of insertion of antennae subuniform in width, nearly straight in the basal half, increasingly arcuate in the apical third, not enlarged at apex. Antennae inserted in front of basal fourth, second funicular

[12] Measured by the chord of the arc from the frons to the apex of the pygidium.

joint longer than first. Mandibles small. Prothorax considerably longer than wide, tubular at apex. Elytra elongate subovate, acuminate at apex, moderately wider than the prothorax. Femora long, strongly clavate and dentate, reentrant angles of teeth strongly obtuse; denticles large and prominent, subacutely produced. Last ventral segment broadly and deeply concave at middle.

Rostrum ♂ about three-fifths as long as the body, strongly arcuate. Last ventral segment concave at the middle. Pygidium with a dense brush of golden hairs.

Length ♀ 8.0–13.0 mm.; width 3.3–4.0 mm.; length of rostrum ♀ 12.0–16.0 mm. Length ♂ 6.5–11.0 mm.; width 2.5–4.0 mm.; length of rostrum ♂ 5.0–7.0 mm.

Type Boreal America. The known distribution extends from Massachusetts to North Carolina and Tennessee and westward to Kansas.

Distinct from all other species by the antennal structure. It is the largest *Curculio* in our fauna, the rostrum attaining a length in the male of 7 millimeters and in the female 16 millimeters. The expression by various writers that the female rostrum is twice as long as the body evidently is based on the measurement of the body minus the thorax. A large series shows extreme variation in size, color and curvature of the rostrum. Among color variations are nearly uniform golden brown, ocher, gray, and bright brown mottling on the elytra. Some individuals are much more robust than others and depauperated specimens so closely resemble *auriger* that it is necessary to examine the antennae to determine the species.

Type of *caryatrypes* ♀ North America; ♂ unknown; of *hariolus* (♂) unknown, stated to be probably Indiana; described merely as smaller, more slender and more acuminate with shorter legs and beak. Type of *cylindricollis* ♀, Tennessee; differs from other ♀ *proboscideus* simply in being much smaller, more slender, with vestiture uniform tawny yellow, the shorter, nearly straight rostrum and the apically constricted prothorax. Further remarks on synonymy would be practically superfluous, since so much is in doubt (see Gyllenhal, *in* Schönh., Gen. et Spec. Curc. 1836, p. 375).

Breeds in the fruit of chestnut and chinquapin, to which it is quite destructive.

2. *Curculio auriger* Cas. (Fig. 3)

Balaninus auriger Casey, Can. Ent., vol. XLII, 1910, p. 117.

Balaninus rectus Say, of Horn (nec Say)
Horn, Proc. Am. Phil. Soc., 1873, p. 459. Casey in part.
♂ *Balaninus auriger mollis* Cas., l. c., p. 118.
♀ *Balaninus strigosus* Cas., l. c., p. 118.
♂ *Balaninus algonquinus* Cas., l. c., p. 118.
♀ *Balaninus acuminatus* Cas., l. c., p. 119.
Balaninus setosicornis Cas., l. c., p. 119.
Balaninus macilentus Cas., l. c., p. 120.
♂ *Balaninus perexilis* Cas., l. c., p. 120.

Slender, convex; piceous-black, antennae and legs rufopiceous to pale red. Vestiture dense, variegated golden yellow; scales fine and short, hair-like on the prothorax with a wide dark brown area each side of the middle of the prothorax and with smaller, irregular, dark brown, subtransverse fasciae on the elytra.

Rostrum ♀ usually distinctly longer than the body, slender, subparallel with the frons, moderately enlarged at the base, scarcely at the apex; strongly and nearly uniformly but somewhat variably arcuate. Antennae inserted behind the basal third; scape longer than the succeeding three funicular joints together, 1 one-third longer than 2, 2 slightly longer than 3. Prothorax a little longer than wide. Femora moderately clavate and somewhat feebly dentate, with denticles large and strongly produced; reentrant angles obtusely rounded. Fifth ventral segment very widely and deeply concave.

Rostrum ♂ about half as long as the body, thicker than in ♀, strongly arcuate, much enlarged at base. Femoral tooth less strongly developed than in ♀. Antennae inserted about at, or just in front of, the middle. Last three ventral segments gradually ascending, the fifth narrow.

Length ♀ 4.5–8.0 mm.; width 1.8–3.0 mm.; length of rostrum ♀ 4.5–9.0 mm. Length ♂ 4.5–6.2 mm.; width 1.8–2.5 mm.; length of rostrum ♂ 2.2–3.5 mm.

Distributed from Canada to North Carolina and westward to Ohio and Tennessee. "Ariz." type locality doubtful.

Readily separable from *proboscideus* by the characters furnished in the table and from all others by the female characters.

Of the synonyms indicated, it should be stated that *auriger* "Arizona" antedates the others and must, therefore, be accepted.

auriger mollis subsp. (♂), is without type locality, stated to be "probably from Arizona."

strigosus ♀, Arizona, compared with *auriger,* "legs shorter, especially the female peduncle."

algonquinus ♂ unique, from Indiana. Fifth ventral (♂) feebly impressed and scantily clad, gradually feebly deflexed apically, apex feebly sinuate, cleft between segments 2 and 3 very large. Said to be "distinguished from any other of the eastern forms of this group by its shorter and relatively stouter form." It might further be stated of this aberration that it is nearly immaculate and subuniformly dark golden yellow with reddish rostrum.

acuminatus ♀ unique, without definite locality, "probably Arizona or Colorado." Stated to be "readily distinguishable from *auriger* by its much longer beak, more elongate prothorax" and "fifth ventral more obtuse and more concave."

setosicornis ♂, ♀ "West Virginia." Type locality not indicated but probably from Blacksburgh, (Fred E. Brooks).

macilentus ♂, ♀ West Virginia. "Same as the preceding." The writer received a set ♂ and ♀ of these specimens at the same time from the same source.

B. perexilis ♂, New Jersey, is simply a depauperated male.

B. quercus must necessarily be briefly mentioned, since the name was not dropped by Casey, either in his work (l. c.) or in his collection. In the former the differences between *quercus* and others are pointed out. Finally to clarify the atmosphere, if possible, it should be repeated that in the opinion of the writer, Leng and others, Horn's *quercus* of collections is, by the original description, positively *rectus* Say.

The species breeds in the fruit of the chestnut and chinquapin and, with the preceding, is very destructive. The writer has seen specimens labeled "bred from acorns" from Arizona, but is skeptical both as to food plant and locality.

3. *Curculio nasicus* Say (Figs. 10, 11)

Balaninus nasicus Say, Curcul. N. A., 1831, p. 16, Lec. ed., v. I, p. 279; Gyllenhal, *in* Schönh., Gen. Curc., v. III, p. 377, 1836; Horn, Proc. Am. Phil. Soc., 1873, p. 460, 461.
Curculio nucum (Melsh. Cat. ♂ [teste Say]).
? *Balaninus nasutus* Say, l. c.
? *Balaninus rostratus* Gyllenhal, l. c., p. 374.
? *Balaninus sparsus* Gyllenhal, l. c., p. 379.
♂ *Balaninus auctus* Casey, Can. Ent., 1910, p. 124.

Elongate oval, piceous throughout, or rostrum, legs and antennae rufous. Vestiture very dense, composed of short fine squamules becoming sparse and hair-like on disk of prothorax and legs; gray-ocher to reddish ocher, much darker on dorsum with a distinct pale fascia one-third from apex and a less distinct fascia at basal third, usually interrupted at middle.

Rostrum ♀ slightly longer than, or as long as, body, slender, strongly nearly uniformly arcuate, proceeding abruptly from head, not thickened at either extremity, punctulate basally. Antennae inserted behind basal third; scape as long as first 4 funicular joints, first funicular one-third longer than 2, second one-third longer than 3. Mandibles very small. Prothorax about as wide as long, moderately arcuate at sides. Elytra subtriangular, humeral angles prominent, scarcely arcuate at sides, rapidly acuminate to apex. Legs long, femora very strongly clavate; teeth very large, reentrant angles nearly right angles, distal edge more than half as long as width of club, sinuous, produced a little apically with small denticle. Tibiae strongly sinuous, especially posterior pair. Fifth ventral female moderately concave at middle.

Rostrum ♂ a little more than half as long as body, more strongly arcuate in distal half, proceeding less abruptly from head, somewhat feebly enlarged basally, gradually decreasing in diameter to apex which is slightly enlarged. Antennae inserted well in front of middle, scape as long as first 5½ funicular joints. Fifth ventral with large feebly concave semi-denuded area at apex; pygidium with long orange hairs.

Length ♀ 6.0–8.5 mm.; width 2.7–4.0 mm.; length of rostrum ♀ 7.0–8.8 mm. Length of rostrum ♂ 2.5–4.5 mm.

In its restricted sense, omitting *strictus* with which it has been generally confounded, this species has a wide distribution. Specimens have been seen by the writer from exact localities in Vermont, Massachusetts, Rhode Island, New York, New Jersey, Pennsylvania, District of Columbia, Maryland, Virginia, West Virginia, North Carolina, Illinois, Michigan, Iowa, and Wisconsin; East Ontario; Aylmer, Quebec; and Ottawa, Canada. It occurs more commonly northward and is somewhat rarely found in the more southern localities.

Recorded by F. E. Brooks and Doctor John Hamilton as breeding in acorns of *Quercus alba, prinus, rubra* and *coccinea*; also collected in numbers on *Q. ilicifolia.*

The synonymy of *nasicus* is for the most part doubtful. *Curculio nucum,* a common European form, listed as occurring in Pennsylvania, is naturally a mistake. In *B. nasutus* (type ♂ ?

Penna.) no specific differences are given to separate it from *B. rostratus* ♂, ♀; said by its describer to be synonymous with *nasutus* Say. *B. auctus* ♂, however, is nearly typical of *nasicus* as here considered.

4. *Curculio caryae* Horn (Fig. 9)

Balaninus caryae Horn, Proc. Am. Phil. Soc., 1873, p. 460.

Moderately robust ovate, convex; rufo-piceous. Vestiture very dense dull brown to ocherous, composed of short, fine scales, coarser on elytra, hair-like on prothorax and legs, the latter nearly completely covered.

Rostrum ♀ a little longer than body, proceeding abruptly from head, somewhat thick, especially at base and less so at apex, straight in basal half to three-fourths, thence strongly recurved to apex. Antennae inserted behind basal third. Scape a little longer than first four funicular joints together; first funicular one-fourth wider than 2, 2 nearly one-fourth wider than 3. Prothorax about as wide as long. Femora strongly clavate; teeth large with reentrant angle forming a right angle, sinuous on distal face; denticles prominent, acutely produced. Fifth ventral narrowly deeply concave.

Rostrum ♂ five-eighths as long as body, a little more enlarged at the extremities than in ♀; basal two-thirds nearly straight, apical third suddenly or moderately recurved. Prothorax as wide as, or wider than long.

Length ♀ 8.0–11.0 mm.; width 4.0–5.0 mm.; length of rostrum ♀ 8.5–13.2 mm. Length ♂ 7.0–9.5 mm.; width 3.2–4.0 mm.; length of rostrum ♂ 4.3–5.1 mm.

Ipswich, Mass. (D. H. Blake); New York, Brooklyn, N. Y (type); St. Vincent, Colemanville, Singlestown, Pa. (V. S. Fisher); New Richmond, Nicholsville, Cincinnati, Ohio; Indiana; Hancock, Md. (F. R. Cole); Holly Springs, Starkville, Miss.; Canadian, Okla.; Nashville, Tenn.; Little Rock, Ark. (J. K. Thibault); Georgia; Texas.

This species, in point of size and length of rostrum, is second only to *proboscideus*. It is quite distinctive, separable by the characters defined in the table.

It infests hickory and pecan and is injurious to both, especially to the latter, whence its names of pecan curculio and *Curculio caryae*.

5. *Curculio rectus* Say (Fig. 12)

Balaninus rectus Say, Curcul., 1831, p. 16, Compl. Writings, v. I, p. 279; Casey, Can. Ent., v. XLII, 1910, pp. 116, 117; Leng, Rhynch. N. E. Am., 1916, p. 266.
Balaninus rectirostris Gyll., *in* Schoenh., Gen. Curc., v. III, 1836, p. 376.
? *Balaninus sayi* Gyll., l. c., p. 375.
Balaninus quercus Horn, Contr. Curculionidae, U. S. 1873, pp. 458, 459.
Balaninus cuneatus Cas., l. c., pp. 115, 116.
Balaninus quercus sparsellus Cas. subsp., l. c., p. 116.

Slender, elliptical oval, nearly two and one-half times as long as wide, red brown, legs light brown. Vestiture composed of fine, short, dense squamules, nearly uniform yellow brown except on elytra, which is strongly and finely spotted with darker brown.

Rostrum ♀ distinctly longer than the body, very slender, of uniform diameter, proceeding abruptly from the head, nearly straight or feebly arcuate, somewhat suddenly recurved in apical fourth or fifth. Antennae inserted just in front of basal fifth; scape shorter than first three funicular joints; first funicular about one-third longer than 2, 2 about one-third longer than 3. Legs long; femora somewhat feebly clavate; teeth rather small, reentrant angles obtuse, denticles prominent. Fifth ventral segment feebly concave at middle. Pygidium terminating in a small cup-like concavity.

Rostrum ♂ about one-half as long as body, strongly, nearly uniformly arcuate; mandibles large. Antennae inserted about at basal third. First ventral broadly concave, fifth with partially denuded area in middle third. Pygidium terminating in a larger cup-like process, glabrous within, surrounded by long hairs.

Length ♀ 6.5–9.7 mm.; width 2.6–4.0 mm.; length rostrum ♀ 7–11 mm.; length rostrum ♂ 4–5 mm.

Occurs commonly from Massachusetts to Wisconsin and Colorado southward to Florida and Texas. Type locality, Pennsylvania; description indicates that it was drawn from the female.

The very slender and hair-like rostrum, distinctly longer than the body in the female, slender delicate antennae, and more especially the cup-like or excavated pygidial concavity present in both sexes and especially prominent in the male, distinguish this species from all others. This character of the female pygidium has hitherto been overlooked. It is between one-fourth and one-third the size of the male process.

This species has been reared from a large proportion of the oaks growing within its range, including *Quercus rubra, coccinea, ilicifolia, velutina, nana, imbricaria, nigra, phellos, michauxii, marilandica, laurifolia, myrtifolia, brevifolia,* and *palustris.* For some reason it has not yet been found on *alba* and *prinus,* species of oaks little affected by the genus, but has been collected on *macrocarpa.* The synonym *cuneatus* ♂, Huntington, W. Va., differs from type only in a slight aberration in which the first two funicular joints are of equal length. Of *sparsellus* n. subsp., type ♂, N. J., the describer did not specify actual subspecific characters.

6. **Curculio macrodon** n. sp. (Fig. 6)

Elongate suboval, twice as long as wide, subcylindrical, deep brown, prothorax piceous, rostrum, antennae and legs rufous brown. Vestiture dense, ocherous brown, strongly banded with darker brown on elytra, squamules short and subparallel, much shorter and paler on ventral surface, hair-like on prothorax and legs.

Rostrum ♀ eight-ninths as long as the body, proceeding abruptly from the head, nearly uniform, slender, moderately and nearly uniformly arcuate, scarcely enlarged at apex, punctulate in basal half. Antennae inserted behind basal fourth, scape longer than first two funicular joints, first funicular nearly one-fourth longer than second, second fully one-fourth longer than third. Prothorax slightly transverse, sides subparallel in basal half, slightly tubulate apically. Elytra one-third wider than prothorax, one-fourth longer than wide, humeral angles not prominent, striae regular, rather deep and wide. Legs long; all femora very strongly clavate, posterior pair reaching slightly beyond apex of elytra; tooth of each very large and prominent, extending forward and downward beyond club ending in an acute point, distal edge strongly sinuous; denticle not distinct from tooth. Tibiae long, slender, sinuous. First and second abdominal segments broadly and feebly concave at middle, fifth moderately concave at middle.

Length ♀ 7.5 mm.; width 3.7 mm.; length of rostrum ♀ 6.5 mm. "Texas."

Type, ♀, Cat. No. 28,994, U. S. National Museum. Type unique.

7. **Curculio longidens** n. sp. (Figs. 7, 8)

Elongate subtriangularly ovate, twice as long as wide, dark rufous throughout, antennae lighter; vestiture sparse ocherous yellow and light brown; squamules very fine and short, much longer on prothorax and legs; elytra with three broad, light brown fasciae, sub-basal, medial and apical, the last broadest.

Rostrum ♀ nine-tenths as long as the body, proceeding abruptly from the head, moderately slender, of uniform width, nearly straight in basal half, moderately arcuate in apical half; base faintly punctulate; mandibles small. Antennae inserted about one-fourth from base; scape about as long as first three funicular joints, first nearly as long as second and third together, second little longer than third. Prothorax little wider than long. Elytra one-fourth wider than prothorax, strongly convex, humeri prominent, rounded, striae somewhat deeply impressed. Anterior legs much longer than posterior, the latter not extending beyond the apex of the elytra; femora somewhat feebly clavate; teeth large, of anterior pair strongly developed, much longer than posterior, extending anteriorly and downward in a prominent acute point; teeth of middle femora short with apices scarcely produced; of posterior pair much shorter than anterior, but much longer than middle pair and with apices strongly acutely produced. Fifth ventral segment ♀ concave.

Rostrum ♂ four-sevenths as long as body, proceeding abruptly from head, more slender than in ♀, strongly arcuate, very slightly enlarged at base from which point it very gradually lessens in diameter beyond the middle; apical half a little more slender, apex distinctly enlarged. Antennae inserted directly behind middle. Fifth ventral segment nearly flat with tufts of pale yellow hairs at sides.

Length ♀ 5.0–6.5 mm.; width 2.5–3.5 mm.; length of rostrum ♀ 4.5–6.0 mm. Length ♂ 5.3–6.5 mm.; width 2.8–3.2 mm.; length of rostrum ♂ 3.5–4.0 mm.

Cumberland, Md. (F. E. Brooks—type and allotype); Birmingham, Ala. (J. E. Graf); Raymond, Miss.; Pine Apple, Oakchia, Eakley, Okla., September 29 (R. V. Montague); Raleigh, August 31, 1916 (R. W. Leiby); Grotto, Acme, Mangum, N. C.; Georgetown, S. C. (W. A. Thomas); Framingham, Mass. (C. A. Frost); Lowell, Mass. (Blanchard); Buffalo, N. Y.; Bedford, Pa.; Odenton, Md., Aug. 8, 1921 (W. H. White); Gainesville, Fla.; DeKalb, Tex.

Reared from *Quercus rubra, falcata, laurifolia, phellos* and *alba.* Beaten from *Q. marilandica* by Mr. White.

Type, ♀, Cat. No. 28,995, U. S. National Museum.

This species is isolated but exhibits some relationship to the larger *macrodon.* The femora are less strongly clavate; the teeth of the anterior pair more strongly and acutely produced, of the middle pair much shorter, posterior pair distinctly shorter. The vestiture is much finer, especially on the elytra. The anterior femoral tooth is sometimes less prominent than in typical individuals. The rostrum of the female varies in degree of arcuation to about the same extent as in *rectus,* exceptional individuals having the rostrum nearly as straight as in *orthorhynchus.*

8. **Curculio ruficristatus** n. sp.

Elongate ovate, much less than twice as wide as long, general color dark brown. Vestiture golden brown, banded with red, squamules shorter, pale brown on ventral surface. Prothorax short, distinctly transverse, strongly tubular at apex, sides strongly arcuate on apical half, nearly parallel in basal half. Elytra moderately convex, much wider than thorax at base, basal angles subacute, strongly narrowed to apex, apices divergent, striae rather wide but very irregular in width, with long, irregular tufts of coarse red hair. Legs long; femora strongly toothed, middle pair with shorter denticle than the anterior, posterior pair apparently as long as anterior but with shorter denticle.

Rostrum ♂ slightly more than half as long as the body, proceeding abruptly from the head, slightly wider at base and at apex, otherwise nearly of same diameter, moderately arcuate; mandibles large. Antennae inserted slightly behind the middle. First abdominal segment strongly and widely concave, fifth segment subdivided toward apex, the latter composed of a wide tuft of long yellow hairs.

Length ♂ 6.7 mm., width 2.9 mm.; length of ♂ rostrum 4.8 mm.

Chisos Mts., Tex., July 16 (H. A. Wenzel).

Type, ♂, 29,010, U. S. National Museum. A single specimen.

Different from the preceding or following species by the characters furnished in the table, also by others which may be summarized: Vestiture banded with red, irregular on elytra. Pronotum short and transverse, tubular at apex. First ventral concave, last with strong red tube-like tuft.

9. *Curculio orthorhynchus* Chttn. (Fig. 13)

Balaninus orthorhynchus Chittenden, Proc. Ent. Soc. Wash., v. X, p. 26, 1908.

Slender, elliptical ovate, rufo-piceous; antennae and base of rostrum distinctly rufous. Vestiture dense, composed of pale yellowish squamules, finer on dorsal, much shorter and wider on lower surface. Elytra wide at base, strongly acuminate to apex; striae of moderate width, with few scales; vestiture variable, nearly uniformly yellow or with pale brown spots of variable size.

Rostrum ♀ of about the same length as the body, very slender, uniform in diameter, nearly straight, arcuate at extreme apex (six-sevenths from base). Antennae ♀ inserted at about basal fifth, scape about same length as the first two funicular joints, first funicular fully one-fourth longer than second, second a fourth longer than third. Fifth ventral segment subtriangular, strongly concave in medial third, slightly tufted at extreme apex. Legs very long and slender. Femora feebly and suddenly clavate toward apex, posterior teeth small, acutely produced distally into denticles, reentrant angles obtuse, somewhat arcuate.

Rostrum ♂ less than half as long as body; moderately arcuate; antennae inserted near (from slightly before to slightly behind) the middle. Pygidium not tube-like. Fifth ventral segment with a small, partially denuded medial area in apical half.

Length 6.2–7.5 mm.; width 2.8–3.2 mm.; rostrum ♀ 6.5–7.0 mm., rostrum ♂ 3.0 mm.

Types described from French Creek, W. Va. Observed in Pennsylvania (Ziegler and Melsheimer) and Ohio (M. C. Z.); Cumberland, Md. (F. E. Brooks); Birmingham (J. E. Graf), Auburn, Thomasville, Ala.; Redmonds, Highlands, N. C.; Pine Brook, N. J.; Delavan, Wis. (S. B. Fracker); St. Louis, Mo. (T. L. Casey); Dallas, Tex. (Boll).

Breeds in acorns of *Quercus rubra, coccinea, ilicifolia* (*nana*) and *phellos.*

The rostrum of the female is more nearly straight than in any other long-beaked species of the genus, which character alone will distinguish it, the male rostrum is proportionately shorter and the antennae are placed much nearer the middle. It has somewhat the appearance of a small *rectus,* but is shorter, has distinctly smaller femoral teeth and lacks the open tube-like pygidium in the male.

10. **Curculio longinasus** n. sp. (Fig. 14)

Elongate ovate, a little less than twice as long as wide; strongly convex; dark rufous, rostrum and antennae light yellow-brown. Vestiture dense, dull ocherous, composed of very long squamules, becoming hairy on legs, somewhat faintly mottled with brown on elytra.

Rostrum ♀ nine-tenths as long as body, proceeding abruptly from head, moderately slender, nearly straight in basal half, strongly and uniformly arcuate in apical half, slightly enlarged at extreme base, very slightly at apex. Antennae inserted in front of basal fourth, scape as long as first three funicular joints, first funicular one-third longer than 2; 2 one-third longer than 3. Prothorax slightly transverse, sides parallel beyond middle, rapidly narrowed toward apex. Elytra strongly convex, humeral angles not prominent, striae shallow, intervals apically prominent; each elytron separately rounded at apex. Legs long, femora extending beyond elytra, feebly clavate; tooth small, reentrant angles widely obtuse, somewhat rounded, denticles very small, subobsolete. Fifth ventral slightly concave.

Rostrum ♂ about two-thirds as long as body, a little more strongly and more uniformly arcuate than in ♀, distinctly but moderately enlarged at either extremity, mandibles rather large. Antennae inserted distinctly behind middle; pygidium with a somewhat tube-like tuft of long golden yellow hairs.

Length ♀ 6.2 mm.; width 2.8 mm.; length of rostrum 5.8 mm. Length ♂ 7.0 mm.; width 3.2 mm.; length of rostrum 4.0 mm.

Paradise, Ariz., 1920 (H. H. Kimball).

Type, ♀, Cat. No. 28,996, U. S. National Museum.

A moderately distinctive species, not closely related to either those which precede or which follow it in the table.

10*a*. **Curculio longinasus mandibularis** n. var. (Fig. 15)

Of similar appearance to typical *longinasus*, differing in the following characters: Vestiture composed mainly of rather short, fine squamules. Rostrum ♂ only slightly more than half as long as the body, somewhat robust, moderately arcuate, strongly enlarged at base and apex; mandibles large. Antennae attached just behind middle; scape as long as first four funicular joints together, first joint more than one-third longer than 2; 2 scarcely longer than 3. Elytra conjointly acuminate at apex.

Length ♂ 6.8 mm.; width 3.1 mm.; length of rostrum ♂ 3.7 mm.

Paradise, Ariz., July 24, 1919 (H. H. Kimball).

Type, ♂, Cat. No. 28,997, U. S. National Museum. Unique.

This variant is quite unusual in having the male rostrum so much shorter than and otherwise different from that in the typical form. It recalls the longer female rostrum of some *uniformis* from Oregon compared with typical *uniformis.*

11. **Curculio multifasciatus** n. sp. (Fig. 16)

Slender, more than twice as long as wide; dark rufous, rostrum, antennae and legs bright rufous. Vestiture dense, yellow ocherous, squamules small, closely set, except on prothorax and legs; elytra ornamented with five narrow deep brown fasciae, which with the paler squamules form a nearly bilaterally symmetrical pattern of nine fasciae; apex also deep brown.

Rostrum ♂ a little less than three-fifths as long as body, moderately slender, proceeding abruptly from the head, strongly nearly uniformly arcuate; feebly enlarged at base, little more strongly at apex; mandibles small. Antennae inserted distinctly behind the middle; scape about as long as first 4 funicular joints, first funicular one-fourth longer than 2; 2 one-fourth longer than 3. Prothorax narrow, slightly transverse, widest at base, at sides somewhat sinuate basally, gradually narrowing apically, squarely truncate at the base. Elytra about one-third wider than prothorax, one-third longer than wide, strongly convex; striae narrow; intervals wide, nearly flat. Femora somewhat weakly clavate; teeth moderately large, reentrant angles slightly obtuse, outer edges nearly straight, denticles very minute, subobsolete. First and second ventral segments depressed, fifth feebly depressed with minute apical subglabrous area; pygidial tuft of hairs long, reddish yellow.

Length ♂ 6.2 mm.; width 2.8 mm.; length of rostrum 3.8 mm.

Wingra Lake, near Madison, Wis., September 14, 1913 (A. C. Burrill).

Type, ♂, Cat. No. 28,998, U. S. National Museum. Unique.

Since the female is unknown, it is difficult to correlate this species with exactness. The distinctive characters of the male consist of the feebly developed femoral club and denticles, and the peculiar pattern of the elytral vestiture, a form of coloration as striking as it is unusual in the genus.

12. **Curculio pardus** n. sp. (Fig. 17)

Ovate, about four-ninths as wide as long, piceous, rostrum and antennae yellow-brown. Vestiture dense, composed of long, coarse, dull yellow squamules on prothorax, shorter on elytra, strongly interspersed with conspicuous deep brown spots, more or less contiguous or forming somewhat regularly tessellate fasciae; sides, legs and ventral surface pale yellowish gray.

Rostrum ♀ five-sixths as long as body, proceeding abruptly from head, very slender, of uniform width throughout, moderately arcuate, more strongly in apical fourth. Mandibles very small. Antennae inserted at basal five-eighteenths; scape longer than first two funicular joints, first fully one-fourth longer than second, second one-fourth longer than third. Prothorax transverse, squarely truncate at base. Elytra one-fourth wider at base than prothorax, humeri prominent; striae rather wide, ornamented with yellow scales somewhat distantly placed in a single row; sutural intervals scarcely elevated. Scutellum elongate, convex, acuminate at apex. Legs long, slender; femora strongly clavate, posterior extending well beyond apex of elytra, all pairs with strong teeth, produced into prominent denticles, directed distally with reentrant angles feebly arcuate, strongly obtuse. Fifth ventral feebly narrowly concave at middle.

Rostrum ♂ four-sevenths as long as body, moderately uniformly arcuate, scarcely enlarged at extremities. Mandibles large. Antennae inserted far behind middle. Last ventral feebly compressed at middle.

Length ♀ 5.4 mm.; width 2.5 mm.; length of rostrum ♀ 4.6 mm. Length ♂ 4.7 mm.; width 2.4 mm.; length of rostrum ♂ 2.7 mm.

Alhambra, Riverside, Cal. (R. E. Campbell).

Type, ♂, Cat. No. 28,999, U. S. National Museum. Type and allotype.

Reared from acorns of *Quercus agrifolia* two years after collection.

This species is quite distinct from others in our fauna, being noticeable in this group because of its short, robust body, especially wide across the elytral humeri, in contrast to its long and slender rostrum in the female. The tessellate elytral fasciae with the rows of yellow scales in the striae impart an unusually attractive appearance to the species. In the male specimen the dark spots form three less regular bands.

13. **Curculio gracilis** n. sp.

Elongate ovate, a little more than twice as long as wide, moderately convex, dark rufous; rostrum, antennae and legs bright rufous. Vestiture dense on dorsum, sparse on lower surface, nearly uniform dull brownish gray, composed chiefly of moderately fine, short squamules on dorsum, slender and hair-like on legs, elytra densely dotted with fine pale brown spots; ventral surface and sides slightly paler than dorsum.

Rostrum ♀ fully five-sixths as long as body, moderately slender, nearly uniformly rather feebly arcuate, scarcely enlarged at base and not at all at apex, punctate at base. Mandibles small. Antennae inserted at a point a little less than one-third from the base; scape about as long as first three funicular joints together, 1 nearly one-third longer than 2; 2 nearly one-third longer than 3. Prothorax slightly transverse. Elytra about one-fifth wider than prothorax and three-fourths as wide as long, acuminate to apex; striae fine, moderately deep and wide; intervals flat. Legs quite long and slender. Femora feebly clavate and dentate; reentrant angles of teeth rounded, distal edge strongly obtuse; denticles acute, somewhat strongly produced. Tibiae scarcely sinuate. Fifth ventral segment wide, broadly, moderately deeply concave at middle.

Rostrum ♂ four-eighths to five-eighths as long as body, stouter, curvature a little stronger but similar to ♀, slightly enlarged basally and apically. Antennae inserted just behind middle. First ventral broadly distinctly concave.

Length ♀ 6.0 mm.; width 2.9 mm.; length of rostrum ♀ 5.0 mm. Length of ♂ 5.8 mm.; width 2.7 mm.; length of rostrum ♂ 3.6 mm.

Yavapai Co., Ariz. (O. Buchholz); Globe, Ariz. (D. K. Duncan); Silver City, N. Mex. (J. B. Wallis).

Type, ♀, Cat. No. 29,000, U. S. National Museum. Types, allotypes and paratypes.

Quite distinct from any species previously considered and not closely affiliated to the two species which follow.

14. **Curculio wenzeli** n. sp. (Fig. 18)

Somewhat robust oval, subdepressed, about twice as long as wide; dark piceous, prothorax opaque black, rostrum and antennae deep rufous. Vestiture somewhat sparse, nearly uniform dark gray, more dense and faintly variegated with pale brownish spots on elytra; scales minute and short, longer and hair-like on legs. Eyes large, narrowly separated; space between about one-third the width of one eye. Elytra narrow, acuminate at apex; striae moderately wide; intervals rather strongly convex.

Rostrum ♀ a little less than five-sixths as long as body, moderately slender, rather feebly, nearly uniformly arcuate, punctulate near base, scarcely enlarged either at base or apex. Antennae inserted in front of basal fourth; scape not as long as first three funicular joints, 1 nearly as long as 2 and 3 together, 2 and 3 subequal. Prothorax slightly transverse. Fifth ventral segment very slightly concave at extreme apex. Legs long, slender, femora feebly clavate, teeth very small, reentrant angle curved, distal edge strongly obtuse, denticles minute, acute but not strongly produced.

Rostrum ♂ half as long as body, curvature similar to ♀, feebly enlarged at base, but distinctly at apex. Antennae inserted at the middle. First and second abdominal segments broadly and feebly concave at middle.

Length ♀ 6.3 mm.; width 2.8 mm.; length of rostrum ♀ 4.8 mm. Length ♂ 6.6 mm.; length of rostrum ♂ 3.3 mm.

Chisos Mts., Tex., July 16–26 (H. A. Wenzel).

Type, ♂, Cat. No. 29,001, U. S. National Museum. Type and allotype.

Differs from *gracilis* especially by the smaller size, the more robust depressed form of the body, the sparse dark gray vestiture and the convex elytral intervals. The male antennae are inserted at the middle, instead of behind the middle, as in the latter. Dedicated to the late H. A. Wenzel.

15. *Curculio pardalis* Chttn. (Fig. 5)

Balaninus pardalis Chittenden, Proc. Ent. Soc. Wash., v. X, pp. 24, 25, 1908.

Balaninus virginicus Cas., Can. Ent., 1910, p. 123 (in part).

♂ *Balaninus appalachius* Cas., l. c., p. 125.

Robust elliptical, piceous or subrufous; antennae, rostrum, and legs rufo-testaceous. Vestiture very dense, composed of long, bright ochraceous or yellow brown squamules on dorsum and legs, and of shorter scales on ventral surface; elytra strongly mottled with small darker brown spots.

Rostrum ♀ three-fourths to four-fifths as long as body, stout, moderately arcuate, more strongly in apical half, distinctly enlarged at base and at apex; a faint carina and punctation barely indicated at extreme base; mandibles large and conspicuous. Antennae inserted in basal third, scape as long as next three joints; funicular joint 1 fully one-third as long as 2, 2 scarcely longer than 3. Prothorax one-fourth wider than long, strongly arcuate near middle, rapidly narrowing toward apex. Elytra three-fourths as wide as long, comparatively wide toward apex, striae very fine. Femora not extending beyond elytra, strongly clavate, teeth moderately large and prominent, reentrant angle nearly right, proximal edge gently sinuous, denticles moderately large, acute. Fifth ventral segment moderately concave in median third.

Rostrum ♂ less than two-thirds as long as body, extending abruptly from the head, a little more strongly arcuate than in ♀, enlarged at each extremity; mandibles very large; antennae inserted well behind the middle. Fifth ventral segment flat at middle, strongly bilobed at apex; pygidium produced into a closed somewhat tube-like brush of long hairs.

Length ♀ 6.0–7.5 mm.; width 2.8–4.0 mm.; length of rostrum ♀ 4.0–5.0 mm.; rostrum ♂ 3.5–4.0 mm.

The known distribution extends from Rhode Island southward to Florida and Alabama and westward to Iowa, Arkansas, Kansas and Texas. The species is abundant in the Atlantic region and evidently rare west of the Mississippi River. The type locality is Washington, D. C.

It breeds in the acorns of *Quercus bicolor, velutina, pedunculata, alba* and *prinus.*

This species is subject to considerable variation as regards color and proportions. Some specimens, including, *e.g.*, marked female collected by F. E. Brooks, at French Creek, W. Va., have the rostrum insensibly enlarged, as remarked by Casey of *virginicus*, and there is a series, obviously depauperated, smaller and paler than the average, in which the female rostra are from five-sixths to ten-elevenths as long as the body, and the legs are very slender.

16. *Curculio victoriensis* Chttn. (Fig. 20)

Balaninus victoriensis Chittenden, Bul. 44, Div. Ent., U. S. Dept. Agric., p. 31, 1904; Proc. Ent. Soc. Wash., v. X, pp. 23, 24, 1908.

Form elliptical, about twice as long as wide; black, rostrum black, or partly piceous, antennae rufous. Vestiture dense, composed of gray or pale ocherous squamules, fine and short, shorter on lower surface. Elytra lightly spotted with slightly elevated, pale brown, pubescent squamules.

Rostrum ♀ four-fifths as long as body, moderately, nearly uniformly arcuate, very slightly enlarged at extreme base and at apex, basal fourth somewhat strongly punctate. Antennae inserted in basal fourth; scape as long as next 2½ joints, first funicular joint nearly one-third longer than 2, 2 scarcely longer than 3. Prothorax about as wide, or slightly wider than long. Femora strongly clavate, teeth very large, denticles large and prominent; reentrant angles nearly right, a little obtuse. Fifth ventral segment moderately concave in median third.

Rostrum ♂ not exceeding one-half the length of the body, slightly more arcuate, scarcely enlarged at either extremity. Antennae inserted at or slightly behind middle. First and second ventral segments feebly concave, fifth strongly narrowed; a median concave area in apical half with long hairs at sides, denuded and feebly recurved to transverse line at apex; pygidial tuft short.

Length ♀ 5.0–7.0 mm.; width 2.4–3.6 mm.; length of rostrum ♀ 3.8–5.5 mm.; rostrum ♂ 2.8–3.5 mm.

Victoria (type locality) and elsewhere, Texas; Wellington, Kans. (C. L. Scott); Baton Rouge, La., September 27, 1916 (T. H. Jones); Evangeline, La. (E. S. Tucker); Stonewall, Okla.

This species is so closely related to *pardalis* that the ocherous forms are difficult to separate, but the point of insertion of the male antennae, at or slightly behind the middle, is a ready means of recognition. In *pardalis* they are distinctly behind the middle; the rostrum is stouter and more enlarged at base and apex, and the color is usually brighter. In *victoriensis* the femora and the denticles, especially the anterior pair, are more prominent.

Breeds in *Quercus alba, virens, velutina, stellata, virginiana, marilandica, breviloba* and *macrocarpa*. Reared from acorns the year following their collection, also in September and October from material collected two years previously, showing that the species also winters over a second year as a larva. According to observations by J. D. Mitchell, in Texas, adults issue from April 2 to July 1 and again in September and December, which would tend to show that the beetles are more or less active in that state, except in the months of January to March.

16*a*. *Curculio victoriensis* **fulvus** n. var.

Of the same form and general appearance as typical *victoriensis,* a little larger and with vestiture nearly uniformly pale yellow-brown or drab; elytra very lightly, scarcely apparently dotted with darker squamules. Rostrum ♀ five-sixths as long as body. Fifth ventral segment strongly concave at median third; of male nearly flat with fine denuded transverse line at apex.

Length ♀ 7.0 mm.; width 3.5 mm.; length of rostrum 6.0 mm. Length ♂ 5.7–7.0 mm.; width 2.8–3.5 mm.; length of rostrum 3.2–3.6 mm.

Type, ♀, Cat. No. 29,003, U. S. National Museum.

Georgetown, S. C. (W. A. Thomas); Mobile, Ala. (H. P. Löding).

Reared from acorns of *Quercus virginiana,* September 19, 1922.

Aberration *b.*—Robust, four-sevenths as wide as long; dark brown, rostrum and antennae lighter brown. Vestiture yellow brown, elytra with few dark spots. Rostrum ♂ four-sevenths as long as body. Prothorax feebly tubulate at apex, widest at middle. Elytra two-thirds as long as the body. Femoral teeth with reentrant angles forming nearly right angles.

Boerne, Tex. Reared from *Quercus velutina,* September 10, 1906.

Undoubtedly an aberration, in the writer's opinion, although a perfect specimen. At first sight it appears to be a short individual of *baculi curtus* but is easily distinguished by the rostral and femoral characters. The head is slightly retracted into the pronotum. The general appearance is that of an entirely distinct species. The length of the elytra of normal *victoriensis* is five-eighths as long as the body.

17. **Curculio emarginatus** n. sp.

Slender subovate, about two and one-half times as long as wide; fuscous, rostrum rufous, black at base and at apex; vestiture dense, composed of nearly uniform pale gray squamules, mostly fine and short, longer on the prothorax; elytra with numerous small, pale brown or fuscous spots.

Rostrum ♀ about three-fourths as long as the body, slender, nearly uniformly moderately arcuate, scarcely enlarged at base, slightly so at extreme apex; base feebly punctulate. Antennae inserted behind basal third; scape about as long as first three funicular joints, 1 less than one-fourth longer than 2, 2 one-fourth longer than 3. Prothorax feebly transverse, sides subparallel in basal half. Elytra about one-third wider than the prothorax; humeri rounded; striae fine, somewhat shallow; intervals wide and feebly convex. Femora somewhat strongly clavate and dentate; reentrant angles of teeth feebly obtuse, denticles strongly produced. Fifth ventral segment somewhat strongly roundly concave in median third.

Rostrum ♂ half as long as the body, proceeding abruptly from the head. Antennae inserted just in front of the middle of the rostrum. First and second ventral segments nearly flat; fifth not narrowed, uniformly convex, widely and feebly emarginate at apex.

Length ♀ 6.0–6.5 mm.; width 2.5 mm.; length of rostrum ♀ 4.5 mm. Length ♂ 6.0 mm.; width 2.7 mm.; length of rostrum ♂ 3.0 mm.

Las Vegas, N. Mex., August 10–15 (Barber & Schwarz). On oak.

Type, ♀, Cat. No. 29,004, U. S. National Museum.

Closely resembles *victoriensis,* differing especially by its smaller size, more slender form, shorter rostrum, and by the more feebly clavate and dentate femora. In some females the rostrum is more strongly arcuate, the length of that organ, measuring by the chord of the arc, being not more than two-thirds as long as the body.

18. *Curculio strictus* Cas. (Fig. 21)

♀ *Balaninus strictus* Casey, Col. Not., vii, 1897, pp. 660, 661.
♀ *Balaninus longipes* Casey, l. c., p. 661.
Balaninus virginicus Casey, Can. Ent., 1910, p. 123 (includes *pardalis* in text and specimens).
♂ *Balaninus ordinatus* Casey, l. c., pp. 124, 125.
♂ *Balaninus utensis* Casey, l. c., p. 126.
♀ *Balaninus tubulatus* Casey, l. c., pp. 126, 127.

Ovate, about twice as long as wide, rufo-piceous; rostrum, antennae and legs usually lighter. Vestiture very dense throughout, composed of short, fine squamules, of variable color, pale ocherous, yellowish, reddish, or exceptionally golden yellow, with many feebly to strongly defined irregular fasciae and spots on the elytra, usually paler on lower surface.

Rostrum ♀ about three-fourths as long as body, moderately slender, nearly uniformly strongly arcuate, not enlarged at either extremity, punctate at base. Antennae inserted at or behind basal third; scape shorter than first three funicular joints, 1 nearly one-third longer than 2; 2 nearly one-third longer than 3. Mandibles small. Prothorax narrow, as wide as, or a little wider than, long; strongly arcuate at sides. Elytra short with prominent humeral angles, feebly acuminate to apex. Legs somewhat shorter, otherwise much as in *nasicus*. Fifth ventral segment moderately concave at middle.

Rostrum ♂ a little more than half as long as the body, subparallel with frons, scarcely enlarged at apex, otherwise nearly as in *nasicus*; antennae inserted about, at or sometimes slightly in front of or even behind the middle. Fifth ventral segment concave at middle. Pygidium with short tuft of yellow hairs.

Length ♀ 5.2–8.0 mm.; width 2.3–4.0 mm.; length of rostrum ♀ 4.5–7.0 mm. Length ♂ 5.4–6.5 mm.; width 2.5–3.3 mm.; length of rostrum ♂ 3.0–3.6 mm.

New Jersey (allotype); Colmanville, Jeanette, Pa.; French Creek, Aurora, Morgantown, W. Va.; Arlington, Afton, Va.; North Carolina; Tennessee; Illinois; Putnam Co., Ind.; Iowa City, Ia.; Kenoshaw, Nebr.; Topeka, Kans.; Colorado Springs, Manitou, Ouray, Col.; Millcreek, American Fork, Provo, Stockton, Utah; Las Vegas, N. Mex. (type ♀); Williams, Ariz.; Perkins, Okla.; Rosser, Tex.

This species closely resembles *nasicus* with which it agrees in many particulars. It may be distinguished by the more arcuate elytra, the usual absence of the two regularly defined pale, transverse elytral fasciae present in the latter, its uniformly shorter, slightly more robust rostrum in the female, by the male antennae being attached nearer the middle of the rostrum, and by the shorter scape. The degree of arcuation in the rostrum of the female is variable, causing, when measured by the chord of the arc, corresponding variability in the length as compared with that of the body. There is less inconstancy in the shorter male rostrum. The colors of the vestiture vary greatly, from gray to ocher yellow, brown and exceptionally red. The elytra are normally mottled with dark or red brown, either finely or coarsely spotted, in subtessellate form, and not infrequently with little evidence of maculation. The abdominal surface is paler in dark specimens. Careful examination of large series from the Atlantic States and from New Mexico, and of some from Utah, fails to reveal any constant structural character separating the eastern from the western forms. The western examples, however, usually have brighter colored rostra and that of the female is very feebly carinate, except at the extreme base. In the specimens from the Atlantic region this carina is a little more pronounced and the punctation of the basal portion of the rostrum is also a little stronger.

In most collections examined this species has been placed generally with *nasicus,* and in some cases with *confusor.*

Reared from acorns of *Quercus prinus, pedunculata* and *alba.*

Owing to the somewhat unusual variability of this species as regards color and proportions, as evidenced by the list of synonyms, some remarks may be of interest. *Balaninus longipes,* described from Manitou, Colo., differs from the type of *strictus* only in color and size. The type is a large robust female of an exceptionally bright golden yellow color. The male is not in the Casey collection but one from Colorado Springs, Colo., in the National Collection is nearly as bright yellow. *B. virginicus* is normal. To the writer's surprise, *pardalis* was also included in this series which very naturally accounts for Casey's surmise that the writer might possibly have included this form with *pardalis. B. ordinatus,* founded on a male from Tennessee, is a robust specimen. *B. utensis* does not differ from other *strictus* in any discernible manner. *B. tubulatus* is founded on a badly mounted, somewhat distorted female from Stockton, Utah. The specimen is flattened and unduly extended.

19. *Curculio q.-griseae* Chttn. (Fig. 19)

Balaninus q.-griseae Chittenden, Proc. Ent. Soc. Wash., v, X, 1908, pp. 22, 23.

Balaninus proprius Casey, Can. Ent., 1910, p. 121.

Moderately robust ovate, piceous; rostrum, antennae, and legs rufous. Vestiture composed of hair-like squamules, yellowish brown on dorsum, silvery gray on ventral surface; elytra with large, variable subtransverse pale fasciae. Head with a distinct interocular line with prominent tufts of squamules each side.

Rostrum ♀ three-fifths as long as body, slender, of uniform width, arcuate, rather more so toward apex. Antennae inserted behind basal fourth, scape short, about as long as first two funicular joints, first funicular long, second and third subequal. Elytra moderately narrowed toward apex; striae deep and wide; intervals somewhat strongly convex. Femora strongly clavate, of posterior legs not extending to elytra, teeth large with long conspicuous denticles, especially on anterior pair. Fifth ventral strongly impressed at middle third.

Rostrum ♂ slightly less than half as long as body, curvature somewhat stronger than in ♀; stout, much enlarged at base but proceeding abruptly from head, squamules covering nearly half from base to antennal insertion. Antennae inserted at or just behind middle. Last ventral and pygidium with yellow hairs forming a tuft beyond the elytra.

Length 6–7 mm.; width 2.8–3.2 mm.; length of rostrum ♀ 3.6–4.0 mm.; rostrum ♂ 2.9–3.2 mm.

Inhabits Arizona (type, Ft. Grant). Reared from acorns of *Quercus grisea* and collected on *Q. gambelii.*

A moderately isolated form. The coloration is variable, some individuals being nearly reddish brown with distinctly paler bands, some nearly uniform brown or gray, others gray with yellowish prothorax and a few yellow transverse bands. The silvery gray lower surface by contrast with the darker dorsum is a distinguishing feature. This species does not occur in Indiana as surmised by Casey. His type does not differ from that of the writer.

20. *Curculio confusor* Ham. (Figs. 22, 24)

Balaninus confusor Hamilton, Can. Ent. XXV, 1893, pp. 309, 310.

Elongate suboval, vestiture very dense, ocherous yellow, irregularly spotted and banded on elytra, scarcely lighter on ventral surface; vestiture fine, hair-like, scaly on venter and sides.

Rostrum ♀ three-fifths as long as the body, stout, much enlarged at base, more moderately at apex. Antennae inserted less than one-third from base, scape nearly as long as first 4 funicular joints. Legs short, femora strongly clavate and strongly convex, posterior pair scarcely extending beyond elytra, tooth comparatively short, reentrant angle obtusely rounded, distal edge less than half as wide as femur at that point, anterior femora less strongly toothed. Fifth ventral very deeply and widely concave, concavity circular.

Rostrum ♂ two-fifths as long as body, very stout, parallel with frons and very strongly enlarged at base. Antennae inserted well in front of middle. Abdomen with a double concavity, first and second segments feebly concave at middle, third, fourth and fifth very deeply and broadly concave.

Length ♀ 6.5–7.0 mm.; width 3.5 mm.; length of rostrum ♀ 4.0 mm. Length ♂ 5.0–6.5 mm.; length of rostrum ♂ 2.5 mm.

The distribution is wide, including New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, West Virginia, Ohio, Michigan, Wisconsin, Tennessee, Missouri, and South Dakota. Recorded as occurring in Massachusetts, Indiana, Illinois and North Carolina. Type locality probably Allegheny, Pa., but not indicated. Dr. John Hamilton, describer of the species, appears to have taken it in numbers in Pennsylvania, and there is a good series from there in the collection of the Museum of Comparative Zoology collected by Melsheimer & Ziegler, but elsewhere it is somewhat rarely found.

Breeds in acorns of *Quercus nana* and *Q. prinus.*

A distinctly isolated species. The short strongly convex femoral club with the posterior tooth near the apex of the femur, and the deeply concave abdomen of the male distinguish this species from any other described form.

21. *Curculio uniformis* Lec.

Balaninus uniformis Leconte, Pacif. R. R. Rept., 1857, p. 57.

Balaninus occidentis Casey, Ann. N. Y. Ac. Sci., v. IX, 1897, pp. 858, 859.

Balaninus brevirostris Casey, l. c., p. 662.

Balaninus caseyi Chittenden, Proc. Ent. Soc. Wash., 1908, p. 26.

Elongate suboval, less than twice as wide as long, strongly convex, vestiture dense, ocherous yellow, variegated with irregular yellow-brown spots, forming irregular fasciae on the elytra, considerably paler on ventral surface.

Rostrum ♀ five-eighths to six-eighths as long as body, slender, moderately arcuate in anterior half. Antennae inserted on rostrum about two-fifths from base to apex; scape as long as first 3½ funicular joints. Mandibles small. Legs long; anterior femora much shorter than rostrum, posterior pair extending well beyond apex of elytra, somewhat clavate, especially anterior pair, and correspondingly small teeth, with obtuse reentrant angles and prominent denticles. Fifth ventral segment deeply concave in middle third.

Rostrum ♂ a little less than half as long as body, considerably enlarged at base, inclined to become parallel with the frons; point of antennal insertion fully three-fifths from base to apex. First abdominal segment feebly broadly concave at middle, fourth and fifth a little less concave, fifth sparsely squamulose. Pygidium with dense mass of red hairs.

Length ♀ 4.8–6.4 mm.; width 2.2–3.2 mm.; length of rostrum ♀ 2.8–4.8 mm. Length of rostrum ♂ 2.6–3.1 mm.

Inhabits California (type), Utah (Am. Fork Canyon), and Oregon.

A very distinct species. Specimens collected on canyon live oak (*Quercus chrysolepis* and *californica*) by Albert Koebele. H. C. Fall states that the species affects several species of oak. Some female specimens from Oregon have much longer beaks than California examples.

22. *Curculio parvidens* Chttn. (Fig. 25)

Balaninus parvidens Chittenden, Proc. Ent. Soc. Wash., v. X, p. 24, 1908.

Elongate oval, dark piceous, antennae and sometimes rostrum rufous. Vestiture dense, pale yellowish gray, composed of fine squamules, nearly hairy on dorsal surface, much shorter and wider below; elytra variegated with a few small, pale brown spots.

Rostrum ♀ three-fifths as long as body, of moderate diameter, strongly and subequally arcuate, scarcely enlarged at base and faintly at apex. Antennae moderately slender, inserted nearly one-fifth from base; scape shorter than first two funicular joints. Fifth ventral segment subtriangular, moderately tufted at extreme apex. Elytral humeri prominent, striae narrow, with few scales. Femora somewhat strongly clavate, with posterior teeth very small and reentrant angles obtuse and feebly rounded.

Rostrum ♂ half as long as body, stouter and slightly more arcuate than in ♀, more distinctly enlarged at apex. Antennae inserted well behind middle. Fifth ventral segment with feebly concave, sometimes nearly bare, median area with small tuft of long yellow hairs each side and a longer pygidial tuft.

Length ♀ 6.0–7.0 mm.; width 2.8–3.2 mm.; length of rostrum ♀ 3.3 mm. Length ♂ 5.4–6.0 mm.; width 2.4–3.1 mm.; length of rostrum ♂ 2.6–3.0 mm.

Recorded from Texas (Victoria, Tex., type), Mississippi and Alabama. Seen from Rock Point, Smithfield, Jonesboro, N. C.

Reared from the acorns of *Quercus nigra, stellata* (*minor*) and *virginiana.*

Very distinct in this group of small species by the point of insertion of the female antennae which is about two-ninths from the base to the apex, nearer the base than in any other species.

23. *Curculio baculi* Chttn. (Fig. 23)

Balaninus baculi Chittenden, Proc. Ent. Soc. Wash., vol. X, pp. 20, 21, 1908.

Moderately elongate-ovate; vestiture scant; of lower surface and legs, composed of short pale gray scales; of elytra, similar, with many small, moderately dull brown, inconspicuous scaly areas.

Rostrum ♀ a little less than three-fifths as long as the body, slender, of nearly uniform width, slightly widened at extreme base and apex, impunctate, nearly straight to anterior fourth or third, where it is more or less abruptly recurved. Antennae inserted just behind proximal third. Scape scarcely longer than first two funicular joints, 1 a little shorter than 2 and 3 together, one-fourth to one-third longer than 2; 3 scarcely shorter than 2. Fifth ventral segment deeply and widely concave at middle, with sides more than usually arcuate and rounded. Femora comparatively slender, teeth small, acute, with reentrant angle weak and rounded.

Rostrum ♂ a little shorter than in ♀, distinctly more than one-half as long as body, moderately and nearly uniformly arcuate, more thickened at extreme base and distinctly punctate. Fifth ventral segment with a very small apical bare area, showing margin, with tuft of hairs each side. Pygidium with long tuft of yellowish hairs.

Length 5.0–7.5 mm.; width 2.8–3.2 mm.; length of rostrum ♀ 3.5–4.0 mm.; rostrum ♂ 2.8–3.5 mm.

Recorded from New York (Ithaca, type locality), westward to Michigan and southward to Mississippi, Alabama and Oklahoma. More recently the species has been reared from acorns from Wisconsin and Florida and specimens have been seen from Brewster County, Chisos Mountains, and elsewhere in Texas, and from Ottawa, Ont., and Aylmer, Quebec, Canada.

It breeds in *Quercus, alba, rubra, coccinea, velutina, prinus, bicolor, ilicifolia* and *phellos.* Specimens reared from the small acorns of willow oak are correspondingly and unusually small, measuring less than 4.0 mm. in length or half the size of the largest specimens which attain a length of fully 8.0 mm. Specimens were reared in October, 1921, from acorns from Macclenny, Fla., from which larvae had emerged two years previously, the insect having passed two years as larva.

Specimens from other localities than the type exhibit much variation as regards the rostral structure, which is seldom so abruptly recurved at the apex.

The type of this species, described from Ithaca, N. Y., and formerly well known in collections as *uniformis,* possesses quite a distinctive habitus, not at all closely resembling *nanulus,* although structurally these two species are related. The differences may be tabulated as follows:

C. baculi Chttn.	*C. nanulus* Cas.
Elongate-ovate, wide at humeri. Scaly covering of body mostly short.	Narrowly elongate-oval. Scaly covering mostly narrow, long and hair-like.
Head wide. Prothorax slightly transverse, feebly tubulate at apex.	Head narrow. Prothorax about as long as wide, not tubulate at apex.
Rostrum ♀ nearly three-fifths as long as body, dark brown, arcuate, at least apically.	Rostrum ♀ about one-half as long as body, bright red, nearly straight.
Antennae ♀ inserted behind basal third, first funicular joint one-fourth to one-third longer than 2.	Antennae ♀ inserted at basal third, first funicular joint scarcely one-fourth longer than 2.
Rostrum ♂ more than one-half as long as body.	Rostrum ♂ less than one-half as long as body.
Length 5.0–7.5 mm.	Length 5.5–6.0 mm.
Mass.—Ala.	New Mexico.

23*a*. *Curculio baculi curtus* Chttn. (Fig. 23*c*)

Balaninus baculi curtus Chittenden, Proc. Ent. Soc. Wash., v. X, p. 21, 1908.

Differs from typical *baculi* in its smaller size, wider elytra, and paler colored scales. The rostrum is proportionately and very distinctly shorter, more slender and not so abruptly recurved at the apex, frequently being nearly straight.

The typical form has been observed only from Texas (Boerne, type locality) and Florida, where it replaces typical *baculi.* Study of a much larger series than was available at the time that the original description was made hardly shows *curtus* to be a geographical race, but a variant, since specimens with straight beaks sometimes occur in most intermediate localities from Texas northward to Massachusetts.

Reared chiefly from acorns of *Quercus velutina* and *rubra*.

24. **Curculio cervulinus** n. sp. (Fig. 26)

> Slender oval, more than twice as long as wide, red brown; rostrum, antennae and legs rufous. Vestiture dense gray brown, composed mostly of small slender squamules on dorsal surface, mixed with very fine squamules densely covering the prothorax and elytra, the latter sparsely spotted with brown; lower surface and sides densely, uniformly coated with short, fine, silver gray scales.
>
> Rostrum ♀ two-thirds as long as body, as long as elytra, of moderate width, moderately and nearly uniformly arcuate, scarcely enlarged at base, distinctly at apex. Mandibles large. Antennae inserted a little farther than one-fourth the distance to apex; scape as long as 2½ funicular joints, first about one-fourth longer than 2; 2 less than one-fourth longer than 3. Prothorax about as wide as long. Elytra three-fourths as wide as long; striae fine, shallow; intervals flat. Legs moderately long, slender; femora feebly enlarged, teeth moderately small, reentrant angles rounded, distal edge moderately obtuse, denticles acute and produced; teeth of middle pair only slightly smaller. Tibiae strongly sinuate. Fifth ventral segment with a small deep rounded concavity at middle, midway between base and apex.
>
> Rostrum ♂ half as long as body, stouter, enlarged basally, curvature similar to female. Antennae inserted distinctly behind middle.
>
> Length ♀ 6.0 mm.; width 2.8 mm.; length of rostrum ♀ 4.0 mm. Length ♂ 5.8 mm.; width 2.8 mm.; rostrum ♂ 2.6 mm.

Pachico Pass, Santa Clara Co., Calif. (E. A. Goldman). Reared from acorns of *Quercus douglasii,* August 20, 1909.

Type, ♂, Cat. No. 29,006, U. S. National Museum. Type and allotype.

The distinctly attractive fawn-colored vestiture of the dorsum alone readily serves to distinguish this species from others occurring in the same region. Otherwise it resembles the Arizona *gracilis,* differing chiefly by the shorter rostrum in both sexes, the small rounded fifth ventral concavity in the female, and the distinctly sinuate tibiae.

25. *Curculio undulatus* Cas. (Fig. 27)

Balaninus undulatus Casey, Col. Not. VII, pp. 659, 660.

Robust oval, about twice as long as wide, brown. Vestiture bright ocherous, very dense throughout even on legs, composed of very fine, slender, closely placed squamules, much paler on ventral surface, lightly spotted with brown on elytra.

Rostrum ♀ less than two-thirds as long as body, proceeding abruptly from head, moderately slender, very feebly punctulate near base; of nearly uniform diameter, moderately subuniformly arcuate. Antennae inserted in front of basal third; scape as long as first 2½ funicular joints, first funicular about one-fourth longer than second, second very little longer than third. Prothorax transverse, widest at base, which is strongly sinuous. Elytra one-third wider than prothorax, one-fourth longer than wide, strongly convex; striae dotted with one row each of distantly placed squamules. Legs rather short; posterior femora extending slightly beyond elytra, feebly clavate, tooth very small, reentrant angle with distal edge obtuse, denticle prominent; tibiae rather robust, feebly sinuous, densely clothed with very long hairs. Fifth ventral segment somewhat weakly concave at middle with long parallel hairs in concavity.

Rostrum ♂ three-fifths as long as body, somewhat stout, scarcely more arcuate than in ♀, a little enlarged at base and strongly at apex. Antennae inserted just behind middle, mandibles rather large. Fifth ventral impressed at middle, pygidium with usual fringe of golden yellow hairs.

Length ♀ 5.0–6.0 mm.; width 2.6–2.8 mm.; length of rostrum ♀ 3.8–4.0. mm. Length ♂ 5.4 mm., of rostrum 3.3 mm.

''Arizona'' (type); Santa Catalina Mts., reared from acorns of *Quercus alba,* October 10, 1916, collected by Mr. Chrisman.

The type is a male and the female has not hitherto been described. As remarked by Casey, this species is quite isolated and is not closely related to any other.

26. **Curculio microdon** n. sp.

Elongate ovate, a little less than half as wide as long; rufo-piceous, rostrum bright rufous, antennae and legs pale rufous. Vestiture moderately dense, uniform pale yellow brown, composed mostly, except on prothorax, of fine squamules, scarcely imbricated.

Rostrum ♂ more than half as long as body, proceeding rather abruptly from the head, slender, of nearly uniform width, moderately nearly uniformly arcuate. Antennae inserted at middle, first funicular joint more than one-third longer than 2; 2 about one-fifth longer than 3. Mandibles moderately small. Prothorax slightly transverse, well narrowed apically, sinuate at base. Elytra more than four-fifths as wide as long, strongly tapering to acuminate apex; striae moderately wide; intervals feebly convex. Femora feebly clavate; anterior without tooth but with distinct denticle; middle and posterior more distinctly but feebly toothed, teeth with reentrant angles strongly obtuse, distinctly denticulate as in anterior pair. Tibiae moderately sinuous. Fifth ventral segment slightly depressed at extreme apex. Pygidium with somewhat tube-like tuft of yellow hairs at apex.

Elongate oval, more than twice as long as wide, rufopiceous, rostrum and antennae yellow brown. Vestiture light brown, composed mostly of short fine squamules; prothorax and elytra partly covered with much longer gray squamules. Ventral surface somewhat densely and uniformly coated with long, fine, gray squamules.

Rostrum ♀ less than two-thirds as long as body, a little longer than elytra, thicker than *microdon,* of nearly uniform width, not enlarged at base or apex, moderately, nearly uniformly arcuate. Antennae inserted about one-third from base; scape distinctly shorter than first three funicular joints together; first one-fourth longer than second, second one-fourth longer than third. Prothorax transverse, nearly uniformly arcuate at the sides. Elytra two-thirds as wide as long, feebly convex. Legs moderately long and slender. Femora feebly enlarged; teeth of anterior and posterior pairs somewhat strong, obtusely angled, extreme apex acute, feebly denticulate; teeth of middle pair much smaller, rounded, tending to become obsolete. Tibiae scarcely sinuous on inner surface. Fifth ventral segment strongly widely concave at middle. Elytra with tuft of hair at apex.

Length ♂ 5.5–6.8 mm.; width 2.3–3.2 mm.; length of rostrum ♂ 3.4–4.0 mm.

Dallas, Tex., reared from acorns of *Quercus rubra* (C. R. Jones); Chiricahua Mts., June 1, 1908 (E. P. Van Dyke); Ft. Wingate, N. Mex. (W. T. Davis).

Type, ♂, Cat. No. 29,013, U. S. National Museum. Type and paratypes.

27. *Curculio obtusus* Blanch. (Fig. 4)

Balaninus obtusus Blanchard, Bul. Bklyn. Ent. Soc., 1884, p. 107.

Short, ovate, scarcely twice as long as wide; rufo-piceous, rostrum, antennae and legs dark rufous. Vestiture dense, squamules very short on prothorax, varying from gray to yellow ocherous and red, uniform or strongly and irregularly banded with deep brown to black on elytra; ventral surface silvery gray, squamules very small and short.

Rostrum ♀ half as long as body, moderately slender, moderately, nearly uniformly arcuate, scarcely enlarged at base, distinct at apex, mandibles rather small. Antennae inserted distinctly behind middle, scape a little longer than first three funicular joints, first and second funicular joints subequal, second about one-fourth longer than third. Prothorax small, very narrow, nearly as long as wide, widest at base. Elytra fully one-third wider and three times as long as prothorax, strongly convex. Legs short, posterior femora not extending to apex of elytra, femora feebly clavate, tooth of anterior pair small, reentrant angle strongly obtuse, denticle prominent; of posterior pair a little larger, distal edge slightly more than half as long as width of femur, somewhat strongly obtuse, terminating in a less prominent denticle. Tibiae moderately thick, slightly sinuous. Fifth ventral slightly depressed.

Rostrum ♂ a little less than half as long as body, slightly more arcuate than in ♀, thicker, somewhat more enlarged both at base and at apex. Mandibles large. Antennae inserted at or slightly in front of middle. First ventral broadly concave, fifth with long tuft of hairs.

Length ♀ 6.0–7.5 mm.; width 3.0–4.0 mm.; length of rostrum ♀ 3.0–3.7 mm. Length ♂ rostrum 2.5–3.0 mm.

Maine, New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, Ohio, Illinois, Indiana, Michigan, Wisconsin, Iowa, West Virginia, Maryland, Ontario, Manitoba, Can., "Texas." The distribution extends into Mexico and, according to Champion, to Guatemala. No type locality specified.

Breeds in hazelnut (*Corylus americana*).

An isolated species, as shown both by the structure and food habit. In addition to the characters indicated in the table, the small prothorax, much wider and larger elytra with prominent humeri, and abdomen readily separate this from all related species. The subequal first two funicular joints are also a distinctive character.

28. **Curculio numenius** n. sp. (Fig. 28)

Somewhat slender, distinctly less than twice the width; rufo-piceous; rostrum, antennae and legs bright rufous. Vestiture very dense, composed of very fine, pale ocherous squamules, much longer on prothorax, closely placed on elytra, which is banded with pale brown, scarcely paler on ventral surface, densely covering abdominal segments.

Rostrum ♀ one-half as long as body, comparatively slender, inclined to be subparallel with frons at base, nearly straight in basal half, somewhat strongly arcuate apically, apex scarcely enlarged; mandibles small. Antennae inserted well behind the middle, nearly two-fifths from base to apex; scape longer than first three funicular joints together, first funicular fully one-third longer than second, second about one-fourth longer than third. Prothorax strongly convex, narrow, about as long as wide, sides subparallel in basal half, gradually narrowed to apex. Elytra about one-fourth wider than prothorax, about one-third longer than wide, moderately convex; humeri not prominent, feebly arcuate; striae rather narrow, intervals convex. Legs short, posterior femora extending to apex of elytra; femora somewhat strongly clavate, teeth moderately large, reentrant angles strongly obtuse, of anterior pair with prominent denticles, of middle and posterior pair with denticles feebly developed. Tibiae moderately thick, slightly sinuous. First and second ventral segments nearly flat, fifth deeply ovally depressed at middle.

Rostrum ♂ one-half as long as body, subparallel with frons, much enlarged at base, narrowing gradually to point of insertion of antennae, thence uniformly slender to apex, which is slightly enlarged; nearly straight in proximal two-fifths, moderately subequally arcuate in distal three-fifths; somewhat feebly carinate and coarsely punctate in basal third; mandibles rather large. Antennae inserted well in front (less than three-fifths) of rostrum.

Length ♀, ♂ 6.4–7.2 mm.; width 3.1–3.3 mm.; length of rostrum 3.2–3.4 mm.

Lake Okoboji, Iowa, June 20–July 15, 1917 (L. L. Buchanan, type, allotype and paratype localities); Lake Miller, Ind.; Marquette, Mich. (T. L. Casey); Volga, S. Dak.; Palmer Lake, Colo., June 30, 1905 (C. P. Gillette); eastern Ontario; Wawansea (Mrs. E. Ellis), Aweme, Manitoba, Canada (N. Criddle).

Type, ♀, Cat. No. 29,014, U. S. National Museum. Paratypes also in the Canadian National collection.

The rostral characters closely resemble those of *obtusus* and form a link between that species and *funicularis* and its allies. In the location of the scape the resemblance is more strongly like the latter.

29. **Curculio funicularis** n. sp. (Fig. 29)

Elongate ovate, twice as long as wide, moderately convex dorsally; piceous, rostrum, antennae, elytra and legs dark rufous brown. Vestiture dense, composed of very short pale ocherous squamules, somewhat faintly banded with gray and dotted with pale brown on elytra, scarcely lighter on ventral surface.

Rostrum ♀ about half as long as body, base parallel with the frons, moderately thick, but gradually narrowing to near apex, nearly straight in basal three-fourths, arcuate at apex. Antennae inserted slightly behind middle, scape as long as first four funicular joints; latter very short, first fully one-third longer than second, second about one-fourth longer than third, third short, scarcely longer than fourth. Prothorax nearly as wide as long, of usual form, somewhat feebly lobed at middle. Scutellum whitish, subovate. Elytra one-fourth wider than prothorax, humeral angles strongly rounded, apex comparatively wide. Legs rather short, extending somewhat beyond elytra; femora moderately clavate; teeth rather large, reentrant angle somewhat obtuse, slightly rounded; denticles large, acute on anterior femoral tooth, subacute on middle and posterior pair. Tibiae rather robust, somewhat feebly sinuate. Fifth ventral segment with light median depression, somewhat shallow, nearly covered with hair-like squamules.

Rostrum ♂ nearly as long as in ♀, continuous with frons, a little more arcuate near apex, which is strongly enlarged. Antennae inserted nearly three-fifths from base. Ventral segments subuniformly flat, with subglabrous depression at apex of fifth. Pygidium with flattened brush of pale hairs.

Length ♀ 6.3–7.0 mm.; width 2.8–3.3 mm.; length of rostrum ♀ 2.8–3.2 mm. Length ♂ 5.8–6.0 mm.; width 2.9–3.1 mm.; length of rostrum ♂ 2.8–3.0 mm.

Las Vegas, New Mex., August 12 (Barber and Schwarz, type and allotype); Toronto, Canada, September 8, 1910 (Evans).

Type, ♂, Cat. No. 29,008, U. S. National Museum. Paratype in the Canadian National collection.

This species may be recognized by the characters tabulated.

30. *Curculio iowensis* Cas. (Figs. 30, 31)

Balaninus iowensis Casey, Can. Ent., 1910, pp. 122, 123.

Oblong oval. Body a little more than twice as long as wide, piceous; rostrum, antennae and legs rufous. Vestiture moderately dense, pale yellow ocherous; elytra with a normally broad medial pale brown fascia and a similar shorter interrupted subapical fascia; ventral surface little paler. Squamules short, somewhat coarse.

Rostrum ♀ about half as long as body, subparallel with frons, thick, nearly uniformly feebly arcuate, much enlarged at base, narrowing to the point of antennal insertion, moderately dilated at apex, surface coarsely punctate and coated with squamules at base; strongly carinate in basal third; mandibles moderately large. Antennae inserted just behind the middle; scape nearly as long as first 4 funicular joints, first funicular fully one-third longer than second, second similarly longer than third, the latter very short. Prothorax as long as wide, widest near middle. Scutellum concolorous with adjacent parts. Elytra two-thirds as wide as long, about one-fifth wider than prothorax, humeri rounded, not prominent; intervals nearly flat. Femora a little shorter than rostrum, stout, somewhat strongly clavate, teeth of moderate size, distal edge less than half as long as width of femur, reentrant angles obtuse rounded; denticles large, acute, very prominent on anterior pair. Fifth ventral segment moderately and narrowly concave at middle.

Rostrum ♂ only two-fifths as long as body, more thickened at base and more arcuate at apex than in ♀, covered with squamules from vertex to point of attachment of antennae. Antennae inserted nearly two-thirds from base to apex. Fifth ventral slightly depressed, not concave, with shortened hairs and minute glabrous area at extreme apex; pygidial hairs yellow, short and flat.

Length ♀ 6.3–7.8 mm.; width 2.8–3.8 mm.; length of rostrum ♀ 2.9–3.2 mm. Length ♂ 6.5–7.3 mm.; width 2.6–3.5 mm.; length of rostrum ♂ 2.5–3.2 mm.

Keokuk, Ia. ♂ (type); Ithaca, N. Y., June 25, New York, N. Y. (Chittenden); Central Park, L. I. (W. T. Davis); Watch Hill, R. I. (W. Robinson); Washington, D. C. (Chittenden); Beltsville, Md. (L. L. Buchanan); Veith, Va. (W. L. McAtee), Richmond, Va. (W. T. Davis); Charter Oak, Pa., June 22, 1920 (J. N. Knull); Harrisburg, Pa., June 15, 1913 (A. B. Champlain); Allegheny, Jeanette, Pa.; Madison, Wis.; Topeka, Kans. (C. H. Popenoe); Morgantown, W. Va. (A. D. Hopkins); French Creek, W. Va. (F. E. Brooks); Linville Falls (4,000 ft.), Henderson, N. C., June, 1907 (F. Sherman).

Collected by the writer on oak, by Mr. Davis on *Quercus minor* and by Mr. Brooks on *Q. alba*.

The first funicular joint is sometimes nearly as long as the second and third together and may be a little less than a third longer than the second, and the second is not more than one-fourth longer than the third. The color of the vestiture is subject to the usual variation from pale ocherous to reddish. It is usually darker than *numenius* and more distinctly fasciate and the beak is shorter and thicker. In many specimens the point of antennal insertion is nearer the base in both sexes.

31. **Curculio ibis** n. sp.

Elongate ovate, twice as long as wide, noticeably narrowed at each end, dark brown; rostrum, antennae and legs bright rufous. Vestiture coarse and dense, pale ocherous yellow, elytra with a rather wide transverse fascia behind the middle. Head small, narrow, eyes noticeably small and somewhat closely placed together.

Rostrum ♀ about one-half as long as the body, subparallel with frons, slightly more slender than *iowensis*. Antennal scape only as long as first three funicular joints, first joint nearly as long as second and third together. Prothorax feebly transverse, sides subparallel in the basal half, anterior half strongly narrowed. Elytra much wider at humeri than the prothorax. Legs short, femora of posterior pair not extending beyond the apex of the elytra.

Rostrum ♂ of about the same length and of similar character to ♀; antennae inserted nearly three-fifths from the base.

Length ♀ 6.2–6.6 mm.; width 3.1–3.4 mm.; rostrum ♀ 2.8–3.1 mm. Length ♂ 5.6–7.0 mm.; width 2.8–3.1 mm.; rostrum ♂ 2.6–3.2 mm.

Williams, Ariz. (Barber and Schwarz), on *Quercus gambelii.*

Type, ♀, Cat. No. 29,0~~10~~07, U. S. National Museum.

The small eyes alone will serve as a ready means of recognition of this species. It is closely related to *iowensis,* from which it is further distinguished by its coarser vestiture, smaller head, wider and different shaped pronotum, shorter scape and shorter legs.

32. **Curculio exilis** n. sp.

Slender, elongate oval, more than twice as long as wide; dark brown, rostrum, antennae and legs deep rufous. Vestiture dense, composed of extremely fine, hair-like squamules, sparse and longer on legs; elytra with pale subapical fasciae. Eyes small and widely separated.

Rostrum ♀ a little more than half as long as the body, comparatively slender, subparallel with frons, feebly enlarged at base, rather strongly at apex, nearly straight in proximal two-thirds, feebly arcuate in the distal third; mandibles small. Antennae inserted far behind the middle (more than two-fifths from base); scape about as long as first 3 funicular joints, 1 about one-fourth longer than 2, 2 one-fourth longer than 3. Prothorax about as wide as long, of normal shape. Scutellum wide, slightly paler than elytra. Elytra one-third wider than prothorax, humeri feebly indicated; striae very fine; intervals flat. Legs short and slender, posterior femora not attaining the end of the elytra; femora somewhat feebly clavate, teeth of moderate size, reentrant angles nearly right-angled, distal edge strongly rounded, denticles large, acute. Tibiae slender, rather strongly sinuous. Fifth ventral segment with moderately deep concave oval area at middle.

Length ♀ 5.0 mm.; width 2.2 mm.; length of rostrum ♀ 2.8 mm.

Ottawa, Ontario, Can., on oak, August 17.

Type, ♀, unique, in Canadian National collection.

Distinct from any species hitherto described. The shape of the body is like those forms with moderately long beaks, *e.g., uniformis.* The male has not been seen.

33. *Curculio monticola* Cas. (Fig. 32)

Balanius monticola Casey, Col. Not. VII, p. 663.
Balaninus timidus Casey, Can. Ent. 1910, pp. 121, 122.

Elongate subovate, twice as long as wide, piceous throughout; prothorax strongly convex, elytra and abdomen comparatively depressed. Vestiture dense, composed of coarse ochraceous squamules, scarcely paler on ventral surface, strongly spotted and somewhat distinctly banded on elytra with pale brown, becoming hairy, almost bristly on legs.

Rostrum ♀ slightly more than one-half as long as body, proceeding abruptly from the head, somewhat feebly, nearly uniformly arcuate, strongly punctate in basal half and carinate in front of the eyes, somewhat strongly enlarged at base and at apex. Mandibles of moderate size. Antennae inserted well behind middle, at which point the rostrum is distinctly expanded at the sides; scape nearly as long as first 4 funicular joints, the latter short and thick, 1 one-fourth longer than 2, 2 fully one-fourth longer than 3. Prothorax nearly as long as wide, sides subparallel in basal two-thirds, feebly tubulate apically; vestiture nearly uniform on disc. Scutellum whitish. Elytra fully one-fourth wider than prothorax; striae rather wide and deep, intervals convex, elevated. Legs short, thick, anterior pair much longer than posterior; femora scarcely extending to apex of elytra, somewhat strongly and abruptly clavate; teeth rather small, reentrant angles widely obtuse, distal edge rounded, with feeble, not prominent denticles; tibiae nearly straight, of moderate size. Fifth ventral segment feebly concave at middle.

Rostrum ♂ slightly less than one-half as long as body, subparallel with frons, moderately and uniformly arcuate, strongly punctate in basal half, much enlarged at base, very strongly at apex. Mandibles rather large. Antennae inserted well in front of middle. First and fifth ventral segments moderately impressed; pygidium with large somewhat tubular brush of long hair.

Length ♀ 4.8–6.4 mm.; width 2.4–3.2 mm.; length of rostrum ♀ 2.6–3.3 mm. Length ♂ 3.1–5.0 mm.; width 2.4–3.2 mm.; length of rostrum ♂ 2.4–3.1 mm.

Colorado Springs, Colo. (type a single female); Las Vegas, N. M., August 3–16 (Barber and Schwarz); Alpine, Tex., Chisos Mts., Tex., July 16, 17 (H. A. Wenzel).

Balaninus timidus is founded on a rather small but not depauperated, male example, from Alpine, Tex., the type of which has been studied.

Quite distinct from other species in our fauna, recognizable by the strongly convex prothorax, with comparatively flat elytra and abdomen, rostrum longer than in other short-beaked species, abruptly clavate femora, and blunt teeth with feebly developed denticles.

In one male the rostrum is a little shorter than normal, the elytra more nearly flat; striae not so wide or deep, surface with darker elevated brown maculae, forming a pale fascia well behind the middle, and the femora with denticles so minute as to appear absent as viewed from the inner surface.

34. **Curculio crassirostris** n. sp.

Moderately robust, ovate; piceous, rostrum, antennae, elytra and legs deep rufous. Vestiture of dorsum somewhat sparse, composed of pale yellow finely hairy squamules; on lower surface of short, slender, gray squamules; elytra with yellow-brown subtransverse fasciae.

Rostrum ♀ about half as long as body, feebly, nearly uniformly arcuate, proceeding somewhat abruptly from head, very thick, of uniform diameter, except slightly thicker at extreme base and at extreme apex. Antennae inserted a little behind middle of rostrum; scape very long, about equal to first 4 funicular joints together, 1 nearly one-third longer than 2, 2 scarcely longer than 3. Prothorax nearly as long as wide. Elytra fully one-fourth wider than prothorax; striae wide and deep; intervals strongly convex. Femora short, posterior not extending to apex of elytra, moderately clavate, teeth with reentrant angles, especially of anterior and middle femora, widely obtuse without distinct denticles. Fifth ventral lightly impressed at middle.

Rostrum ♂ half as long as body. Antennae inserted about at middle of rostrum, otherwise nearly as in the female. Ventral segments convex without visible impression on fifth.

Length 6.3 mm.; width 2.9 mm.; length of rostrum ♂ 3.3 mm. Length ♂ 6.3 mm.; width 2.9 mm.; length of rostrum ♂ 3.3 mm.

Paradise, Ariz., 1920 (H. H. Kimball); Silver City, N. Mex., June (J. B. Wallis).

Type, ♀, Cat. No. 29,016, U. S. National Museum. Type and allotype.

Nearly related to *iowensis,* differing by the male and female being nearly alike in the rostrum and point of attachment of the antennae, the former being stouter and nearly equal in diameter and less parallel with the frons. The difference in the denticles in the sexes is probably individual.

35. **Curculio aurivestis** n. sp. (Fig. 33)

Slender oval, about two and one-fourth times as long as wide; dorsum very strongly convex. Vestiture dense, bright golden yellow, strongly irregularly banded with brown on prothorax; ventral surface pale ocherous.

Rostrum ♀ less than half as long as body, proceeding abruptly from frons, short and stout, of nearly uniform diameter, slightly enlarged at extreme base, a little more strongly at apex, feebly arcuate, arcuation gradually stronger toward apex; squamules at base extending very little beyond eyes; punctate nearly to apex. Antennae inserted more than three-sevenths of distance from base, scape shorter than first four funicular joints, first funicular fully one-fourth longer than second, second correspondingly longer than third. Prothorax about as wide as long, widest near middle, feebly sinuate toward base, basal angles acutely produced. Elytra one-fourth wider than prothorax, humeral angles not prominent. Legs rather long; femora moderately, somewhat feebly clavate, anterior pair extending beyond rostrum, posterior not beyond elytra, teeth small placed distantly from distal end with reentrant angle and apex obtuse, distal edge strongly curved, denticles distinct but neither acute nor prominent. Fifth ventral segment widely and very deeply concave at middle, especially toward apex, concavity sparsely squamulose.

Length ♀ 6.8 mm.; width 3.0 mm.; length of rostrum ♀ 3.1 mm.

Mt. Wilson, Calif., July 23, 1905 (H. C. Fall).

Type, ♀, Cat. No. 29,017, U. S. National Museum. One female.

This species is quite isolated, its distinctive characters consisting of the very short, decidedly thick, feebly arcuate female rostrum. The strongly concave fifth ventral is a character more often seen in the long-beaked groups, although present also in *baculi* and some others of the short-beaked forms.

36. **Curculio brevinasus** n. sp.

Elliptical oval, about twice as long as wide; somewhat strongly depressed; piceous, rostrum, antennae and legs rufous. Vestiture sparse, composed of long fulvous yellow scales on dorsum, much shorter, pale gray on ventral surface; elytra with many red-brown spots, forming irregular fasciae. Eyes large and narrowly separated.

Rostrum ♀ a little more than one-half as long as body, comparatively slender and nearly uniform in diameter, proceeding somewhat abruptly from base, feebly arcuate, nearly straight in proximal half, gradually more arcuate to apex; not enlarged, punctate but not carinate at base, distinctly but not strongly dilated at apex. Antennae inserted far behind, but less than two-fifths from, middle; scape as long as first 3½ funicular joints, the latter short and thick, 1 one-fourth longer than 2, 2 less than one-fourth longer than 3. Mandibles minute. Prothorax about as wide as long. Scutellum elongate, paler than elytra. Elytra somewhat prominent at humeri; striae well impressed; intervals flat, 2 or 3 times as wide as striae. Legs of moderate length. Femora somewhat feebly clavate, teeth rather small, denticles moderately long and acute. Tibiae moderately sinuous. Fifth ventral segment deeply widely concave in medial third.

Length ♀ 5.3 mm.; width 2.5 mm.; length of rostrum ♀ 2.8 mm.

Catalina Island, Cal., on oak (D. W. Coquillett).

Type, ♀, Cat. No. 29,018, U. S. National Museum. Unique female.

A distinctive form, somewhat resembling *uniformis*. It is more slender, the vestiture is more scanty, the rostrum in the female is shorter and thicker, and is enlarged at the apex, while the antennae are inserted nearer the middle. More closely related to *exilis*, differing especially in the darker color of the vestiture, larger and narrowly separated eyes and in the female rostrum proceeding abruptly from the head.

37. *Curculio nanulus* Cas.

♂ *Balaninus nanulus* Casey, Col. Not. VII, 1897, p. 658.
♀ *Balaninus sulcatulus* Casey, l. c., pp. 661, 662.

Narrowly elongate oval, dark piceous, legs rufescent, rostrum and antennae bright rufous. Vestiture gray or white, with variably subtransverse darker patches on elytra, where the scales become slightly less slender and very dense; scales of prothorax linear and sparse, becoming wider and denser toward the sides, broad and dense on the lower surface.

Rostrum ♀ about one-half as long as body, proceeding abruptly from the head, moderately stout, nearly straight, feebly arcuate distally, nearly as long as elytra. Antennae inserted at basal third; scape short, not as long as first three joints of funicle, first funicular scarcely one-fourth longer than 2, 2 fully one-third longer than 3, 3 and 4 subequal. Prothorax slightly transverse, strongly arcuate at sides. Scutellum large, shield-shaped, whitish. Elytra elongate, nearly one-third longer than wide, nearly one-third wider than prothorax, evenly elongate ogival in form, somewhat obtuse apically; humeri not prominent, narrowly rounded; striae rather fine and shallow, about one-fourth as wide as intervals, the latter flat. Femora moderately clavate, feebly dentate; denticles acute, produced. Fifth ventral broadly indented in middle third.

Rostrum ♂ less than half as long as body, slightly shorter than in ♀, more distinctly subuniformly arcuate. Antennae inserted about at middle.

Length ♀ and ♂ 5.5–6.0 mm.; width 2.3–3.0 mm.; length of rostrum ♀ and ♂ 2.8–3.0 mm.

Las Vegas, N. Mex. (type, ♂, Barber and Schwarz); Koehler, N. Mex. (H. F. Wickham); Paradise, Ariz. (H. H. Kimball).

This small species is allied structurally to *baculi* by the point of insertion of the antennae. The legs are a little shorter and the femoral club and teeth more highly developed. In the female of *baculi* the rostrum is longer, also distinctly longer than that of the male, and the intervals are wider as compared with the striae. The principal differences are cited under the discussion of *baculi*. The writer has examined a fairly large series from other regions than the type locality and can find no differences, which applies also to *sulcatulus* ♀ from the same locality.

38. **Curculio striatus** n. sp.

Elongate subelliptical, moderately convex on dorsum; dark brown, head and legs reddish brown, rostrum and antennae bright rufous. Vestiture somewhat sparse, composed mainly of fine, long, overlapping, dull gray hairs, especially long on prothorax and legs, becoming dense squamiform on the elytra and venter. Elytra mottled with fine brown spots.

Rostrum ♀ four-ninths as long as body, proceeding abruptly from the head, thick, subuniform in diameter, nearly straight in proximal two-thirds, gently recurved in last third. Antennae inserted just behind proximal third. Scape a little longer than first two funicular joints, 1 considerably shorter than 2 and 3 together, 2 nearly one-fourth longer than 3. Prothorax about as wide as long, moderately tubulate at apex; sides subparallel in basal half; base subtruncate. Elytra about one-fourth longer than wide; humeri rounded, not prominent; sides moderately arcuate, somewhat strongly convergent to apex; striae wide and deep, especially apically; intervals correspondingly narrow, convex. Scutellum very small, pale gray. Ventral segments 1 and 2 feebly separated at middle, 3 and 4 subequal in length, 5 somewhat deeply, narrowly indented at middle. Legs short, slender; femora feebly clavate, teeth very small with reentrant angle obtuse, acutely denticulate. Tibiae slender and sinuous.

Rostrum ♂ distinctly less than one-half as long as body, moderately nearly uniformly arcuate. Antennae inserted at middle. First ventral segment broadly moderately concave, fifth with semidenuded area at apex. Pygidium with long yellow hairs.

Length ♀ 6.0–6.4 mm.; width 2.8–2.9 mm.; length of rostrum ♀ 2.8 mm. Length ♂ 5.2 mm.; width 2.2 mm.; length of rostrum ♂ 2.3 mm.

Chisos Mts., Tex. (H. A. Wenzel).

Type, ♀, Cat. No. 29,019, U. S. National Museum.

Resembles *baculi* and *nanulus,* differing especially in the shorter and stouter rostrum in both sexes, the much deeper and wider elytral striae and the longer and finer scales and hairs composing the vestiture.

39. *Curculio humeralis* Cas.

Balaninus humeralis Casey, Can. Ent., 1910, p. 657.

Short fusiform; less than twice as long as wide, dark piceo-rufous, prothorax piceous; vestiture dense, short, nearly uniform, pale ocherous. Head scarcely more than two-fifths as wide as the prothorax.

Rostrum ♂ less than half as long as the body, moderately slender, evenly and distinctly arcuate, punctate and feebly carinate above toward base; antennae inserted just behind middle; first four funicular joints decreasing rather rapidly in length. Prothorax relatively rather short, fully one-half wider than long, sides subparallel, very feebly arcuate toward apex, rapidly rounded and sinuate to the distinctly tubulate apex; base broadly lobed at middle; surface moderately convex, densely and somewhat coarsely punctate. Elytra short, scarcely longer than wide, twice as long as prothorax and fully two-fifths wider, sides rapidly convergent and very feebly arcuate from the prominent humeri, apex parabolic; striae moderately coarse, deep, strongly, somewhat distantly punctate, intervals wide, feebly convex, strongly and closely punctato-rugose. Femora strongly clavate, without teeth, but each with a minute and acute denticle, and with the reentrant angle strongly obtuse, the outer surface or edge long and straight. First and second ventral segments together forming a feeble concavity, fifth slightly concave at apex and tufted each side.

Length 6.5 mm.; width 3.5 mm.

Florida.

A distinct and isolated species described from the male. The facies is quite different from that of any other species, owing to the stout fusiform body, distinctly tubulate apex of the prothorax and other characters specified in the table. Unique, probably from the extreme southern part of Florida and likely to occur on neighboring islands.

ADDENDA

Because of the reasons stated in the introductory remarks in regard to the general character of the species *albidus* to the effect that the male rostrum is much longer than usual and the female is unknown, it has been thought desirable to consider the species separately because it is practically impossible to give it a zoological status. The finding of the female will doubtless serve to solve this problem.

40. **Curculio albidus** n. sp.

Elongate oval, twice as long as wide, somewhat depressed; rufo-piceous, rostrum, antennae and legs rufous. Vestiture nearly uniform whitish gray, dense and very coarse except on legs and head, composed of coarse and slender squamules with darker spots faintly indicated on elytra.

Rostrum ♂ five-sixths as long as body, thick, scarcely enlarged at base, somewhat strongly at apex, nearly uniformly and moderately arcuate. Antennae inserted just behind middle; first funicular joint fully one-third longer than second, 2 and 3 subequal. Mandibles of medium size. Prothorax about as wide as long, wide at apex. Elytra one-third wider than prothorax, about two-thirds as wide as long; striae wide, deep; intervals nearly flat and narrow, only as wide to twice as wide as striae. Legs long; femora feebly clavate; teeth small, reentrant angles widely obtuse, denticles very minute but acute. First ventral segment broadly, somewhat feebly concave, fifth convex. Pygidium with somewhat tube-like brush of hairs.

Length ♂ 4.5 mm.; width 2.2 mm.; length of rostrum ♂ 3.8 mm.

Oracle, Ariz., July 10 (Hubbard and Schwarz).

Type, ♂, Cat. No. 29,002, U. S. National Museum.

Since the female is unknown, the length of the rostrum is problematical, hence it is impossible to correlate the species with any other beyond peradventure. It bears some resemblance to *gracilis* and *wenzeli* but is smaller than either, the male rostrum is much longer, the point of attachment of the antennae is farther from the middle and the second and third funicular joints are subequal.

Since the above was sent to the printer, the writer has been able to study through the loan of H. C. Fall two sexes of species not previously described. These descriptions are added.

36. **Curculio aurivestis** Chttn.

Rostrum ♂ less than one-half as long as the body, with tendency to proceed subparallely from the frons; squamules at base extending well beyond the eyes. Antennae inserted far in front of the middle; scape longer than first 4 funicular joints. Fifth ventral segment very feebly concave at middle, with squamules much shorter. Pygidium moderately hairy forming a brush. The remaining characters correspond very closely to those furnished on a preceding page of the female.

Length ♂ 6.0 mm.; width 2.8 mm.; length of rostrum ♂ 2.2 mm.

Santa Clara County, Calif. (Coquillett). Forest Grove, Oregon (M. M. Recher).

Allotype, ♂, Cat. No. 29,017, U. S. National Museum.

The type is a single female. Another female (paratype) in the Fall collection has a slightly longer rostrum and distinctly longer legs but the former is robust as in *aurivestis* and agrees in other respects.

37. **Curculio brevinasus** Chttn.

Rostrum ♂ distinctly less than one-half as long as the body, more enlarged at apex than in ♀, proceeding much less abruptly from, nearly continuous with, frons, and of similar curvature. Antennae inserted well in front of, but less than two-thirds from, the middle; scape longer than first 4 funicular joints, 1 fully one-fourth longer than 2; 2 scarcely longer than 3. Fifth ventral segment feebly concave at middle of basal portion. Pygidium hairy.

Length ♂ 5.0 mm.; width 2.5 mm.; length of rostrum ♂ 2.2 mm.

Catalina Id., Cal., August 22, 1892 (H. C. Fall).

Allotype ♂ in Mr. Fall's collection.

The type is a female and the male was previously undescribed.

Because of considerable resemblance between this species and *exilis,* the following table is added to expedite their recognition:

brevinasus	*exilis*
Rostrum ♀ less than ½ as long as body, proceeding somewhat abruptly from head.	Rostrum ♀ more than ½ as long as body, subparallel with frons.
Eyes large, narrowly separated.	Eyes small, widely separated.
Dorsal vestiture coarse and sparse, especially on prothorax; elytra dark, not spotted; humeri prominent; striae coarse and wide.	Dorsal vestiture fine, dense; elytra gray with pale wide transverse fasciae; humeri not prominent; striae fine and narrow.
Catalina Island, Calif.	Ottawa, Ontario, Canada.

PLATE XII

Plate XII, Fig. 1.—*Curculio iowensis,* much enlarged.

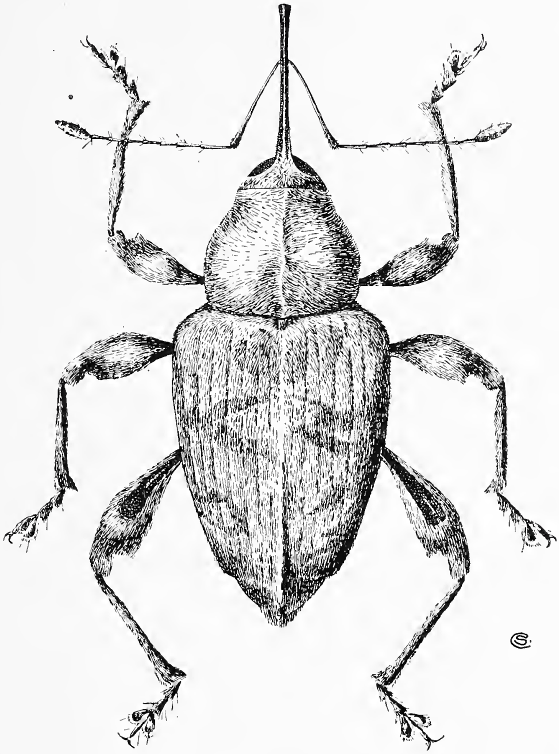

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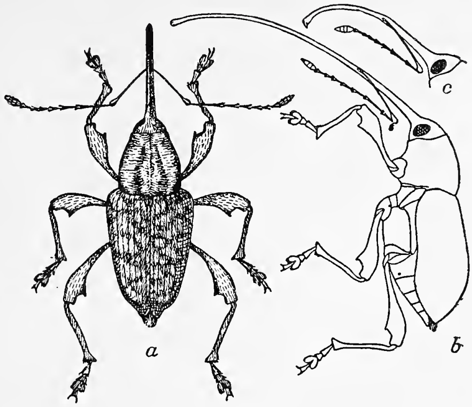
PLATE XIII

Plate XIII, Fig. 2.—*Curculio proboscideus: a,* female, dorsal view; *b,* female, lateral outline; *c,* male. 3. *auriger: a, b,* ♀ *c,* ♂. 4. *obtusus*: *a, b,* ♀ ; *c,* ♂. 5. *pardalis* ♂—all several times natural size.



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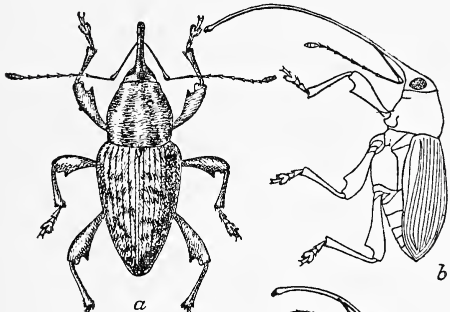

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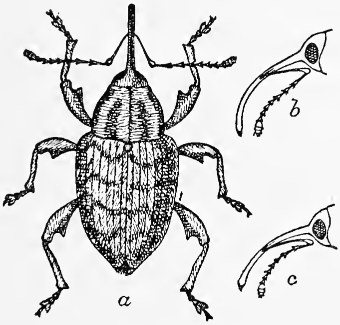

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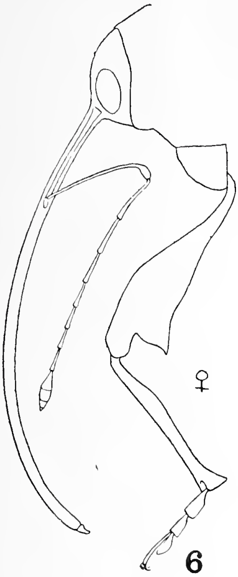
PLATE XIV

Plate XIV, Fig. 6.—*Curculio macrodon* ♀ ; 7. *longidens* ♂ ; 8. *longidens* ♀ ; 9. *caryae* ; *a*, ♀ , dorsal view ; *b*, ♀ , lateral view ; *c*, ♂ .



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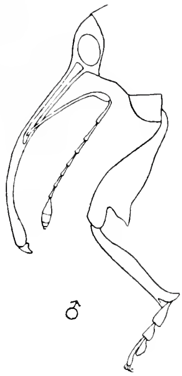

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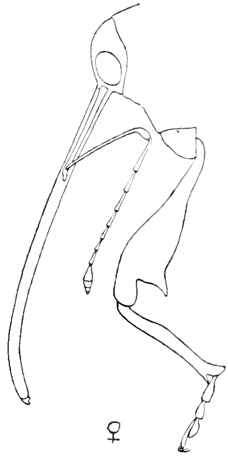

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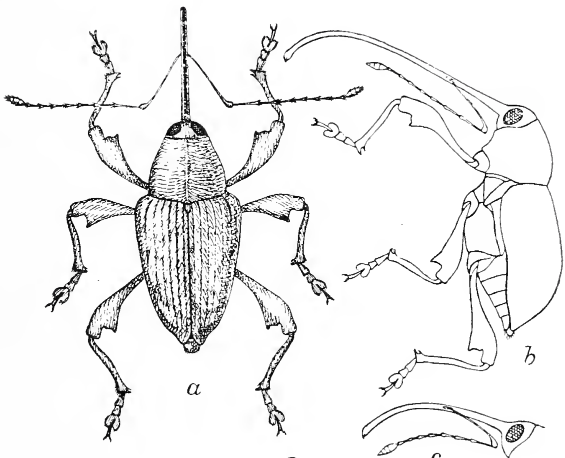

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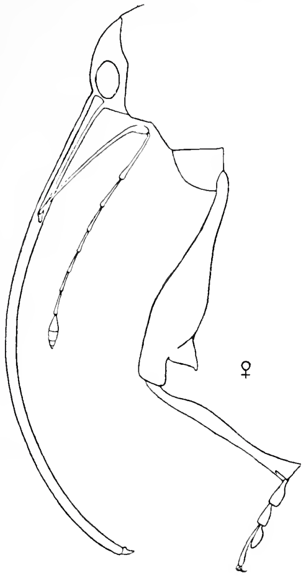
PLATE XV

Plate XV, Fig. 10.—*Curculio nasicus* ♀ ; 11. *nasicus* ♂ ; 12. *rectus* ♀ ; 13. *orthorhynchus* ♀ .



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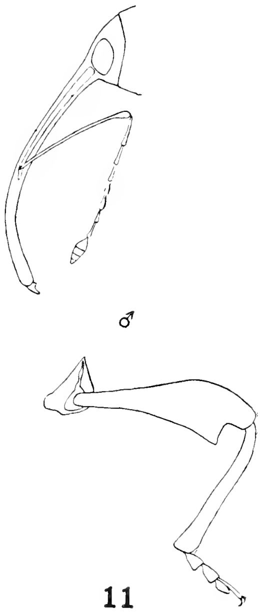

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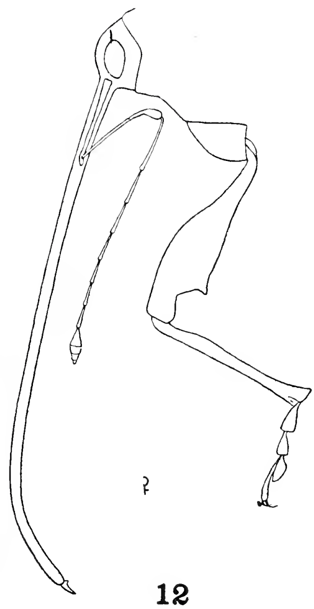

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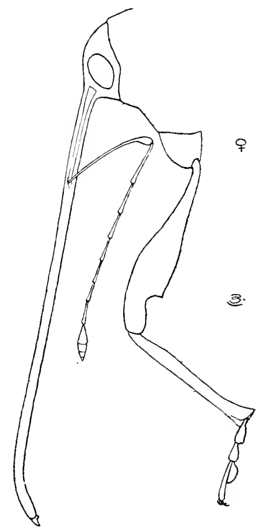

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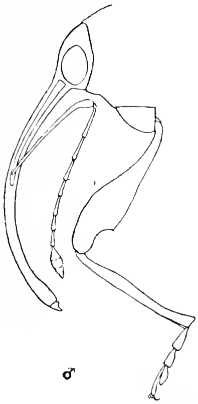
PLATE XVI

Plate XVI, Fig. 14.—*Curculio longinasus* ♂; 15. *longinasus mandibularis* ♂; 16. *multifasciatus* ♂; 17. *pardus* ♀; 18. *wenzeli* ♀; 19. *q. griseae* ♀.



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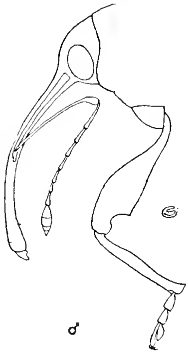

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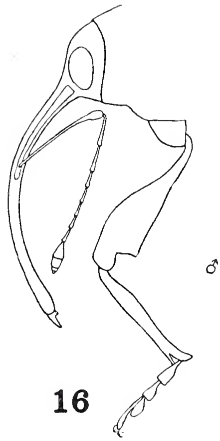

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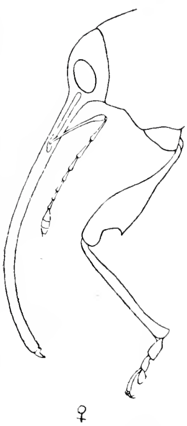

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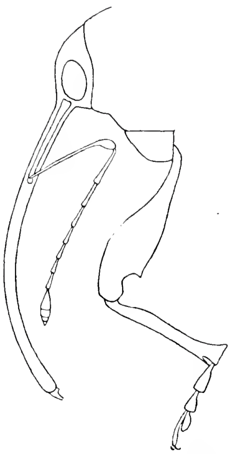

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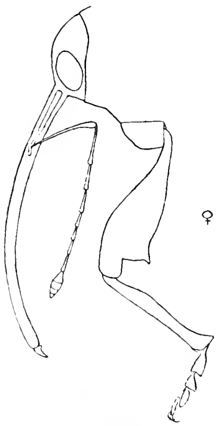

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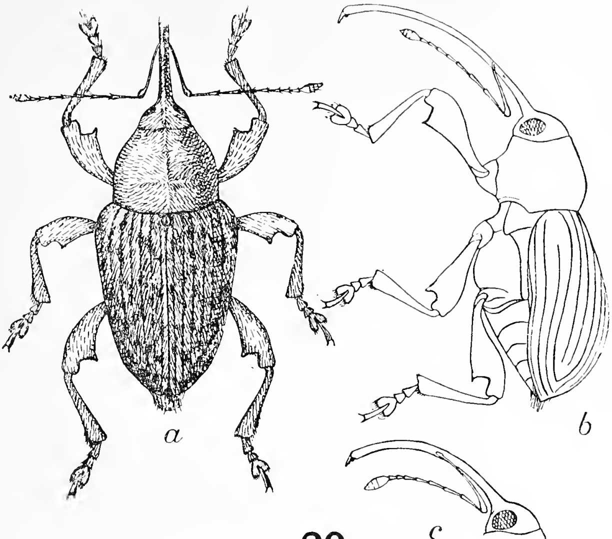
PLATE XVII

Plate XVII, Fig. 20.—*Curculio victoriensis: a,* ♀ dorsal view; *b,* ♀ lateral view; *c,* ♂ head; 21. *strictus* ♀; 22. *confusor* ♀, posterior femur.



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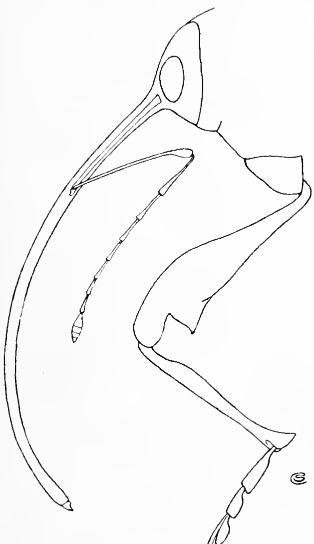

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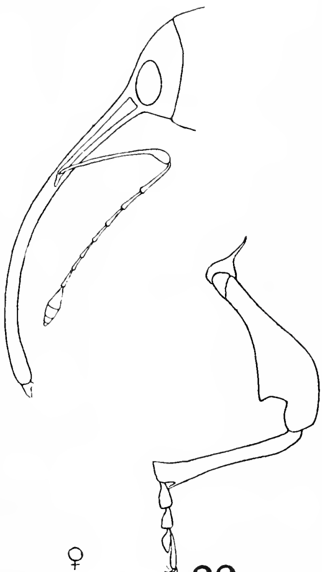

♀

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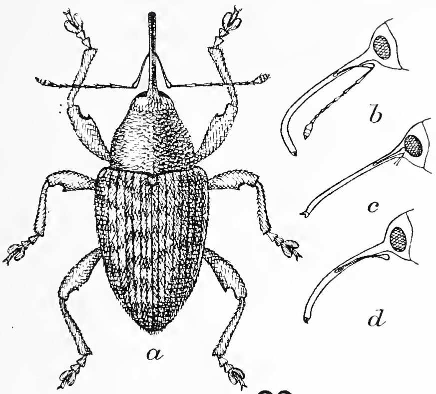
PLATE XVIII

Plate XVIII, Fig. 23.—*Curculio baculi: a,* ♀ ; *b,* ♀ typical rostrum; *c,* var. *curtus* rostrum; *d,* ♂ rostrum; 24. *confusor,* ventral segments ♂ ; 25. *parvidens* ♀ ; 26. *cervulinus* ♂ ; 27. *undulatus* ♂ .



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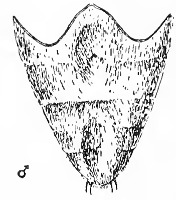

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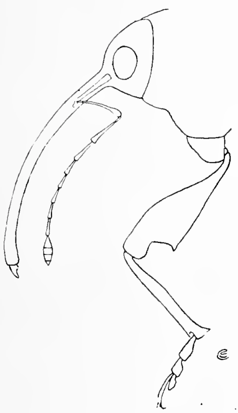

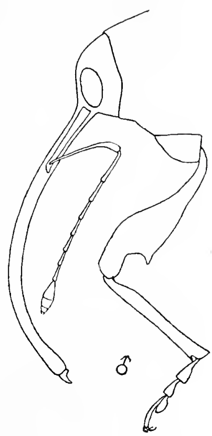

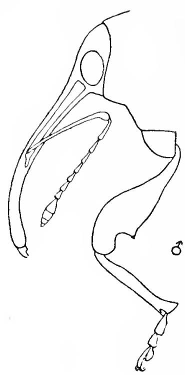

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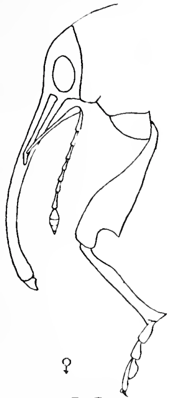
PLATE XIX

Plate XIX, Fig. 28.—*numenius* ♀; 29. *funicularis* ♂; 30. *iowensis* ♂; 31. *iowensis* ♀; 32. *monticola* ♀; 33. *aurivestis* ♀.



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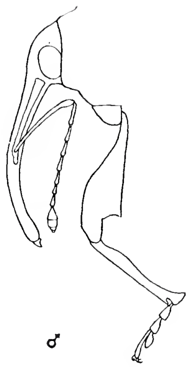

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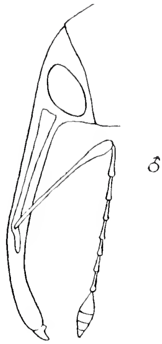

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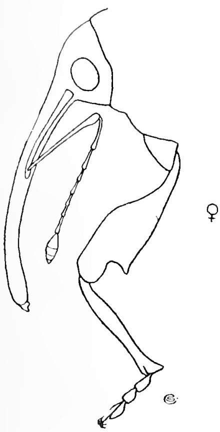

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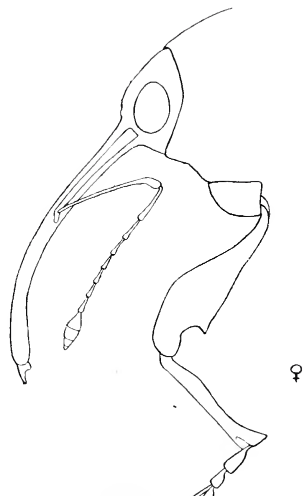

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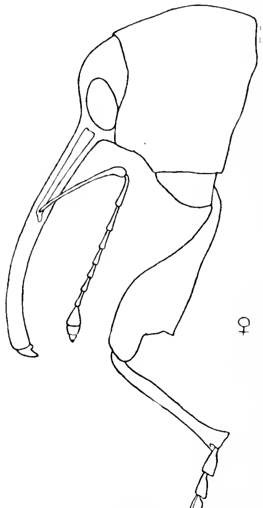

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VOL. VII (New Series) MARCH, 1927 No. 4

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ENTOMOLOGICA AMERICANA

Vol. VII (n. s.) Brooklyn, N. Y., March, 1927 No. 4

A CONTRIBUTION TOWARD THE KNOWLEDGE OF NEW YORK THYSANOPTERA, WITH DESCRIPTIONS OF NEW GENERA AND SPECIES

II

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The first paper of this series on the Thysanoptera of New York was published in 1925, in the Bulletin of the Brooklyn Entomological Society, Vol. 20, pp. 124–130. The present article, the second of the series, has for its purpose the bringing forward of several new species and the recording of some observations on the synonymy and distribution of New York forms, as a necessary step preliminary to the publication of the state list of insects.

Six species originally described from Europe are for the first time recorded from America in this paper, but only after the most painstaking comparison, by means of companion microscopes, with thoroughly authentic material secured for the purpose from the leading specialists in Europe—Priesner, Bagnall, Karny, O. M. Reuter, Schille, Buffa, Uzel, John, and others.

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* Contribution from the Entomological Laboratories of Cornell University.

Some of the species discussed have been mentioned repeatedly in the literature, and I have found it necessary in several cases to confine the citations to a few of the more important papers only.

The types of the new species are in the author's collection.

Æolothrips nasturtii Jones

1912. *Æolothrips nasturtii* Jones, Tech. Ser. No. 23, Pt. I, Bur. Ent., U. S. Dept. Agr., p. 2, Pl. I, figs. 1–4. [1 ♀, San Jose, California, on *Nasturtium officinale.*]

1913. *F.* [*ranklinothrips*] *nasturtii* Bagnall, Trans. 2d Ent. Congr., p. 397.

1915. *Æolothrips nasturtii* Hood, Ent. News, Vol. XXVI, p. 162.

Improbable though it may seem, no differences are to be found between the holotype of this species, described from California, and two specimens taken by the writer at Ithaca, New York, May 13, 1926. It was not uncommon among the grass growing about the trees in an orchard close to the Cornell campus, and many more specimens could easily have been taken—and would have been—had I not mistaken it for *Æolothrips fasciatus* at the time.

The absence of cross veins in the wings has been stressed as the chief means for recognizing this species, and, to be sure, these veins are not readily seen; but they are undoubtedly present, and in the usual positions. For the recognition of the species, far better characters are to be found in the long head, slender wings, and the proportionate lengths of the antennal segments. In antennal structure the species suggests *Æ. bicolor* Hinds, in that the last four segments are not subequal. The following table shows the constancy of this character in three females, the measurements being in microns and pertaining to segments 3 to 9:

	3	4	5	6	7	8	9
San Jose, California (holotype)	130	104	68	36	20	16	12
Ithaca, New York	137	108	69	40	22	14	12
" " "	......	100	68	36	20	16	12

The following material is before me:

COLORADO: Boulder, June 14, 1924, flowers of *Iris missouriensis*, L. O. Jackson; 1 ♀.

Denver, June 21, 1918, in sweepings, L. O. Jackson; 4 ♀.

Golden (South Table Mt.), June 20, 1918, L. O. Jackson; 9 ♀.

ILLINOIS: Muncie, July 18, 1908, and May 16, 1909, in sweepings, C. A. Hart; 3 ♀.

NEW YORK: Ithaca, May 13, 1926, in sweepings from grass, J. D. Hood; 2 ♀.

Sericothrips cingulatus Hinds

1902. *Sericothrips cingulatus* Hinds, Proc. U. S. Nat. Mus., Vol. XXVI, p. 141, Pl. III, figs. 27–29. [♀, ♂, Amherst, Mass., on various grasses.]
1911. *Sericothrips cingulatus* Moulton, Tech. Ser. No. 21, Bur. Ent., U. S. Dept. Agr., pp. 14, 24. [Nebraska City, Neb., on grass.]
1913. *Sericothrips cingulatus* Morgan, Proc. U. S. Nat. Mus., Vol. 46, p. 45. [Clarksville, Tenn., on broom sedge and plantain.]
1917. *Sericothrips cingulatus* Hood, Ins. Insc. Menstr., Vol. V, p. 58. [Maryland and Illinois, on grass.]

Professor Glenn W. Herrick has submitted to me for determination specimens of this species which were taken by Mr. H. J. Pack, in May, from the stomach of a very young trout reared in the Fish Hatchery at Cornell University, Ithaca, New York. Though a common grass species of wide distribution, this is its first known occurrence in New York.

Sericothrips annulipes sp. nov. (Pl. XX, Fig. 4.)

Female (*macropterous*).—Length about 1.0 mm. Color straw-yellow, with numerous brown markings, pterothorax and last two or three abdominal segments more intensely yellow, prothorax more nearly colorless; head darkened with brown except for a yellow ring around eyes; ocellar pigment red; prothoracic brown blotch broken up into two longitudinal series of three or four small spots; pterothorax brown in anterior half, metascutum darker than mesoscutum, the latter pale posteriorly; abdomen with a narrow, transverse, dark brown line at base of tergites 2–7, behind which is a more or less obscure brown band, broadest at sides; tergites 7 and 8 almost entirely brown, paler and yellowish along posterior margin only; antennæ with segments 1–4 nearly colorless, excepting extreme tip of 3 and apical third of 4, which are gray-brown; 5–8 dark gray-brown with basal half of 5 paler; legs concolorous with body, all femora apically and all tibiæ at middle with a distinct brown annulus; fore wings with scale dark brown or gray and with a median dash of brown at extreme base, the remainder of basal fifth, the third fifth, and the apical fifth, white or nearly so, intervening fifths dark gray or brown; hind wings nearly white, with a dark median streak which is absent from base and extreme apex.

Head broad, nearly twice as wide as length in front of occipital line, broadest across eyes, ocellar area and vertex with faint lines of sculpture, bristles as usual in the genus. Eyes prominent, protruding, pilose, about 0.7 as wide as their interval, which is about equal to their length. Antennæ about 3.3 times as long as head in front of occipital line, segments formed as usual in the group, sixth not pedicellate. Mouth cone hardly attaining base of prosternum.

Prothorax with the pronotum about 1.6 times as long as head in front of occipital line and 1.5 times as wide as long, of the usual form; pronotum with the usual raised, anastomosing, transverse lines, which are closely spaced in the area of the pronotal blotch and *distant, tending toward reticulation, elsewhere*; bristle at posterior angles long and pale. Fore wings about 19 times as long as width at middle, which is about 0.54 the width just beyond base; costal margin with about 29 bristles, longitudinal vein with a basal group of 3 followed by about 20, the distal one of these in the white apical area and widely separated from the others; two additional bristles near tip of wing, in a series posterior to longitudinal vein. Legs not markedly long and slender.

Abdomen normal, the pubescence largely dark and distinct, absent from median portion of basal tergites; bristles slender, yellowish, inconspicuous.

Measurements of holotype (♀): Length 1.05 mm.; head, length to occipital line 0.084 mm., greatest width (across eyes) 0.162 mm., least width (at base) 0.140 mm.; eyes, length 0.067 mm., width 0.048 mm., interval 0.066 mm.; prothorax, median length of pronotum 0.136 mm., width 0.204 mm.; pterothorax, width 0.278 mm.; fore wings, length 0.780 mm., width at middle 0.040 mm., near base 0.074 mm.; abdomen, greatest width 0.300 mm.

Antennal segments:	1	2	3	4	5	6	7	8
Length (μ)	24	36	54	52	44	48	10	13
Width (μ)	27	28	22	18	18	18	7	6

Total length of antenna 0.28 mm.

Male (*macropterous*).—Length about 0.8 mm. Color of body and appendages as in female and pronotum similarly sculptured.

Described from four females and one male, as listed:

New York: Ithaca, August, 1926, on unidentified legume, L. O. Jackson; 2 ♀ (*holotype* and *paratype*).

Virginia: Falls Church, June 16, 1918, E. A. Chapin; 2 ♀ (*paratypes*).

Four Mile Run, April 25, 1915, on cherry foliage, L. O. Jackson; 1 ♂ (*allotype*).

No difficulty should be had in recognizing this species. The two dark wing bands, the dark seventh and eighth abdominal segments, the broken pronotal blotch, the annulate femora and tibiæ, and, especially, the sculpture of the pronotum, make it very distinct. It is related to *variabilis* (Beach).

Echinothrips subflavus sp. nov. (Pl. XX, Fig. 3.)

Female (*macropterous*).—Length about 1.3 mm. Color yellow, with antennal segments 1 and 2, apices of 3–5, distal two-thirds of 6, and all of 7 and 8 brown; or (presumably in older individuals) with the following additional brown markings: posterior half of occiput, all of prothorax, margins of pterothorax, a narrow transverse bar on metathorax, an irregular bar across each of abdominal tergites 3–6, all of abdominal sternites 2–6; wings pale at base, shading to brownish gray apically; ocellar pigment bright scarlet red.

Head shorter than its width across eyes, longer than width near base; cheeks straight, parallel; frontal costa broadly emarginate; surface subreticulate with anastomosing lines; postocular and interocellar bristles subequal, longer than diameter of ocelli. Eyes strongly protruding, about as long as their interval and about as wide as their distance from posterior margin of head. Ocelli nearly equidistant, opposite middle of eyes. Antennæ just twice as long as head, of normal structure for the genus; trichomes on segments 3 and 4 simple.

Prothorax about 0.7 as long as head and somewhat more than half as long as wide; notum with the usual subreticulate pattern of anastomosing lines; posterior angles with the two usual bristles pale, hardly pointed, and half as long as notum. Wings long and slender; costa with about 22 *pointed* bristles, those at middle of wing twice its width; longitudinal vein with about 16 similar but shorter bristles.

Abdomen typical of the genus; tergites finely pubescent in lateral fourth and with lines of sculpture that curve posteriorly along sides; bristles on apical segments short, pointed, yellow.

Measurements of holotype (♀): Length 1.26 mm.; head, length 0.165 mm., greatest width (across eyes) 0.173 mm., least width (at base) 0.156 mm.; eyes, length 0.080 mm., width 0.050 mm., interval 0.074 mm.; postocular bristles, length 0.032 mm.; prothorax, length 0.117 mm., width 0.210 mm.; pterothorax, width 0.300 mm.; abdomen, greatest width 0.308 mm.; fore wings, length 1.14 mm., width at middle about 0.052 mm., width just beyond scale 0.076 mm.

Antennal segments:	1	2	3	4	5	6	7	8
Length (μ)	20	44	59	50	54	66	16	27
Width (μ)	36	32	17	17	19	18	8	6

Total length of antenna 0.336 mm.

Measurements of paratype from Quicksand, Kentucky (♀): Head, length 0.166 mm., greatest width (across eyes) 0.172 mm., least width (at base) 0.156 mm.; eyes, length 0.084 mm., width 0.050 mm., interval 0.072 mm.; postocular bristles, length 0.032 mm.; prothorax, length 0.116 mm., width 0.212 mm.

Antennal segments:	1	2	3	4	5	6	7	8
Length (μ)	20				54	66	15	24
Width (μ)	34	32	17	18	18	18	8	6

Described from three females. The holotype was taken at Little Valley, New York, Sep. 17, 1925, under bark of beech sapling, by P. J. Chapman. The paratypes are from Nigger Pond (Oswego Co.), N. Y., Sep. 3, 1926, from larch, P. J. Chapman; and from Quicksand, Kentucky, June 25, 1925 (no data on habitat), C. R. Crosby and P. J. Chapman.

The pale color and the pointed wing bristles distinguish the species at a glance—in fact, the latter character deprives the genus itself of what has heretofore been its most important differentia. The dark colored New York specimens, taken in the autumn under bark, are probably old, mature individuals which were seeking places for hibernation; while the paler Kentucky specimen, taken in June, had quite possibly emerged only recently. I am positive that they represent the same species.

Tæniothrips salicis (Reuter).

1879. *Thrips salicis* Reuter, Öfv. Vet. Soc. Förh., Vol. XXI, p. 200. [Finland.]

1926. *Tæniothrips salicis* Priesner, Thys. Eur., p. 309; Taf. IV, Abb. 67 and 68. [Throughout Europe.]

Many years ago John J. Davis, Charles A. Hart, and I took this species in Illinois, but I have hesitated to record it from North America until actual comparison had been made with authentic European material. Such material has now come to hand in the form of a topotypic specimen from Reuter's own collection and labeled in his own hand, as well as twelve Austrian specimens from Dr. Priesner. The series before me is thoroughly homogeneous, even to the most minute details of color and structure. The American material is listed below:

ILLINOIS: Aurora, July 8, 1908, on willow leaves, J. J. Davis; 3 ♀.
Muncie, Aug. 21, 1908, on *Salix discolor,* C. A. Hart; 3 ♀.
Riverside, July 14, 1909, on *Salix* and *Cratægus,* J. D. Hood; 2 ♀, 1 ♂.

NEW YORK: Slaterville, May, 1926, on *Salix* sp., J. D. Hood; 1 ♀.

Thrips nigropilosus Uzel.

1895. *Thrips nigropilosus* Uzel, Mon. Ordn. Thys., p. 198, Tab. VI, fig. 105, 106. [♀, ♂, Bohemia, in turf, etc.]

1896. *Thrips lactucæ* Beach, Proc. Iowa Acad. Sci., Vol. III, p. 224. [♀, Ames, Iowa, on wild lettuce (*Lactuca*).]

1914. *Thrips lactucæ* Hood, Proc. Ent. Soc. Wash., Vol. XVI, p. 43. [Merely notes that the species was overlooked by Moulton.]

This species was overlooked by both Hinds[1] and Moulton.[2] I have seen Miss Beach's types of *lactucæ* and have compared them with well authenticated European material of *nigropilosus.* There are no differences. In greenhouses this thrips is frequently a source of much trouble because of its depredations upon chrysanthemums—

[1] Proc. U. S. Nat. Mus., Vol. XXVI, pp. 79–242; 1902.

[2] Bur. Ent., U. S. Dept. Agr., Tech. Ser., No. 21, pp. 1–56; 1911.

in fact, my own personal experience would indicate that it is our commonest greenhouse thrips. From *T. tabaci*, which, also, is a greenhouse species of no slight importance, it may be distinguished under a good hand lens by the bright red ocellar crescents (in *tabaci* these are yellow), the nearly black antennæ, and the almost invariable presence of short-winged forms.

In the very earliest spring days, while patches of snow were still lingering on the ground, I have found short-winged individuals out-of-doors, at the base of the leaves of *Verbascum thapsus*, the common mullein, many miles from any greenhouse. If the species has been introduced into America from Europe, it is firmly established. Unfortunately I have not saved samples of all the material (particularly from New York State) which has passed through my hands, or the following list of slides of American specimens now before me would be much more extended:

ILLINOIS:	Urbana, Nov. 3, 1907, in University greenhouse, R. D. Glasgow; 1 ♀.
	Urbana, May 8, 1909, in Insectary greenhouse, C. E. Sanborn; 1 ♀.
IOWA:	Ames, Oct. 20 and Nov. 16, 1893, and Mar. 21, 1894, on leaves of *Lactuca*, Alice M. Beach; 18 ♀ (*types* of *T. lactucæ* Beach).
	Ames, Dec. 14, 1926, on chrysanthemum in greenhouse, S. C. Jones; 2 ♀.
SOUTH DAKOTA:	Brookings, Jan. and Feb., 1925, on chrysanthemum in greenhouse, Geo. Gilbertson; 7 ♀, 3 ♂.
NEW YORK:	Berkshire, June 23, 1925, on lettuce, N. H. Eason; 2 ♀.
	Canastota, Aug. 5, 1912, on castor oil plant in greenhouse, J. C. Faure; 6 ♀.
	Ithaca, Jan. 25, 1913, on chrysanthemum in greenhouse, J. C. Faure; 4 ♀.
	Macedon, Apr. 13, 1924, on *Verbascum thapsus* (out-of-doors), J. D. Hood; 2 ♀.
	Rochester, Mar. 31, 1924, on lemon verbena in greenhouse, J. D. Hood; 1 ♀.
	Rochester, Jan. 14, 1927, on chrysanthemum in greenhouse, E. A. Maynard; 4 ♀.

Thrips monotropæ sp. nov. (Pl. XX, fig. 1; pl. XXI, fig. 1.)

Female (*macropterous*).—Length about 1.2 mm. General color blackish brown, pterothorax with orange-colored subhypodermal pigmentation, last two abdominal segments yellowish; antennæ blackish brown, concolorous with body, segments 1 and 2 inclined to be brownish rather than blackish, pedicels only of segments 3 and 4 paler; legs yellowish brown, slightly paler than body; wings brown, distinctly but not abruptly paler in basal third or fourth; ocellar pigment brick-red.

Head about 1.17 times as wide as median dorsal length, about equal in length to pronotum, broadest midway between eyes and base, and with about five moderately distinct anastomosing lines on occiput; cheeks rather strongly arched; vertex flattened, not forming an overhanging angulation above antennæ but sloping evenly to frontal costa, this last very shallowly and roundly notched at about 90°; interocellar and postocellar bristles short, subequal, somewhat longer than postoculars; ventral surface of head with the two pairs of long bristles near bases of antennæ, the inner pair reaching beyond base of second segment. Eyes about 0.55 as long as head and about 0.8 as wide as their interval, decidedly prominent and somewhat protruding, pilose as usual. Ocelli normal, about opposite middle of eyes. Antennæ moderately stout, about 2.26 as long as head, of normal structure; segment 3 stout, about twice as long as wide. Maxillary palpi three-segmented, as usual.

Prothorax about 1.7 times as wide as median dorsal length, without distinct lines of sculpture except near posterior margin, sides gently rounded; bristles at posterior angles subequal, long and slender, brown, about 0.8 the length of pronotum; a pair of bristles on posterior margin near middle and another at posterior third near lateral margins, distinctly longer and heavier than postocellars; pronotum with about twenty pairs of shorter bristles, most of them hardly equal to postocellars, excepting one pair near anterior margin and another near anterior angles. Wings of fore pair with about 23 rather long, dark brown bristles (some nearly black) on costal margin; anterior vein with an evenly spaced basal group of 8 (rarely 7 or even 6), followed by one just beyond middle, one at distal fifth, and another nearly at tip; posterior vein with about 12 similar bristles, the first of which is usually about opposite the penultimate one in the basal series of the anterior vein, and the last of which is nearly opposite a point midway between the last two bristles on the anterior vein.

Abdomen of normal form; tergite 8 with a complete comb of somewhat irregularly spaced minute spines on posterior margin; tenth segment divided above nearly to base; bristles on segments 9 and 10 long, slender, brown, hardly as long as the combined lengths of these segments; sternites with the usual three pairs of long bristles on extreme posterior margin, but without accessory bristles.

Measurements of holotype (♀): Length 1.23 mm.; head, length 0.128 mm., width at middle 0.150 mm., behind eyes 0.140 mm., at base 0.140 mm.; eyes, length 0.070 mm., width 0.046 mm., interval 0.058 mm.; prothorax, length of pronotum 0.125 mm., width 0.212 mm.; pterothorax, width 0.270 mm.; fore wings, length 0.740 mm., width at middle 0.056 mm., near base 0.084 mm.; abdomen, width 0.315 mm.

Antennal segments:	1	2	3	4	5	6	7
Length (μ)	30	40	52	51	39	58	20
Width (μ)	34	29	25	23	19	21	8

Total length of antenna 0.29 mm.

Described from three females taken by the writer at Sodus Point, New York, in a flower of *Monotropa uniflora,* August 10, 1924.

The dark color of the entire body, with the orange pterothoracic pigmentation and the stout, nearly black antennæ are distinctive.

Thrips veratri sp. nov. (Pl. XX, Fig. 2.)

Female (*macropterous*).—Length about 1.5 mm. General color brown (abdomen darkest), with head, legs (particularly the tarsi and apices of tibiæ), segment 3 of antenna, and pedicels of 4 and 5 paler; head darkest in ocellar area; wings nearly uniform brownish.

Head about 1.27 times as wide as median dorsal length, about 0.9 as long as pronotum, broadest midway between eyes and base, and with six or seven distinct anastomosing lines on occiput; cheeks distinctly arched; vertex flattened, evenly declivous, obtusely but decidedly angulate in front of eyes above antennæ, transversely roughened; frontal costa roundly and deeply notched at about 90°; interocellar, postocellar, and postocular bristles short, subequal; ventral surface of head with two pairs of long bristles near bases of antennæ, the inner pair reaching nearly to middle of second antennal segment. Eyes about one-half as long as head and two-thirds as wide as their interval, moderately prominent and protruding, pilose as usual. Ocelli normal, about opposite middle of eyes. Antennæ slender, about 2.4 times as long as head, of normal structure; segment 3 slender, nearly three times as long as wide. Maxillary palpi three-segmented, as usual.

Prothorax about 1.83 times as wide as median dorsal length, with distinct (but not prominent) anastomosing lines of sculpture, sides gently rounded; bristles at posterior angles subequal, long and slender, brown, about 0.8 the length of pronotum; four additional pairs of bristles, longer and stouter than postocellars, on anterior margin, at anterior angles, at posterior third of lateral margins, and near middle of posterior margin, respectively; pronotum with about twenty pairs of shorter bristles, about equal to postocellars. Wings of fore pair with about 21 rather long, brown bristles on costal margin; anterior vein with a basal group of 7, followed by one just beyond middle, one at distal fifth, and another nearly at tip; posterior vein with about 11 similar bristles, the first of which is usually opposite a point midway between the last two bristles in the basal series of the anterior vein, and the last of which is opposite a point nearly midway between the last two on the anterior vein.

Abdomen of normal form; segment 8 with complete comb of evenly-spaced spines on posterior margin; tenth segment divided above nearly to extreme base; bristles on segments 9 and 10 long, slender, brown, and about as long as the combined lengths of these segments; sternites with the usual three pairs of long bristles on extreme posterior margin, but without accessory bristles.

Measurements (principally of holotype): Length 1.49 mm.; head, length 0.134 mm.; width at middle 0.170 mm.; just behind eyes 0.156 mm.; at base 0.164 mm.; eyes, length 0.068 mm., width 0.048 mm., interval 0.072 mm.; pronotum, length 0.140 mm.; width of prothorax 0.256 mm.; pterothorax, width 0.336 mm.; abdomen, width 0.352 mm.

Antennal segments:	1	2	3	4	5	6	7
Length (μ)	30	48	62	54	47	60	23
Width (μ)	36	28	22	20	20	20	8

Total length of antenna 0.32 mm.

Described from several specimens taken at Ithaca, New York, on *Veratrum viride*, by Glenn W. Herrick (June 27, 1924) and by the writer (July, 1926).

The large size, dark color, and long pronotal bristles distinguish this species from all others known to occur in Eastern North

America. The figure illustrating this species defines it more satisfactorily, however, than any description could.

Thrips fuscipennis Haliday.

1852. *Thrips fuscipennis* Haliday, Walker, List Hom. Ins. Brit. Mus., Pt. IV, p. 1111. [♀, Britain.]

To this species, which is likewise an addition to the North American fauna, I refer without hesitation one female taken by Mr. L. O. Jackson at Ithaca, New York, in a flower of *Angelica atropurpurea,* in July, 1926. More than seventy slides of European material are before me, from England, Austria, Hungary, and Italy.

Thrips flavus Schrank.

1776. *Thrips flava* Schrank, Beyträge zur Naturgesch., p. 31, Tab. I, figs. 25 and 26.

This, another interesting addition to the North American fauna. Three females, taken by L. O. Jackson at Ithaca, New York, in July, 1926, in flowers of *Angelica atropurpurea,* are con-specific with a series of seven specimens bearing this name sent to me by Dr. Karny, from Bohemia.

Thrips calcaratus Uzel.

1895. *Thrips calcarata* Uzel, Mon. Ordn. Thys., p. 195, Tab. VI, fig. 104. [♀, Bohemia, in flowers, May.]

1914. *Bagnallia calcarata* Karny, Verh. k. k. zool.-bot. Ges. Wien, Bd. LXIV, p. 56. [Vallombroso, Italy, leaves of *Tilia.*]

1916. *Thrips* (*Bagnallia*) *calcarata* Williams, The Ent., Vol. XLIX, p. 282. [England, on opening leaves of *Tilia,* May 10.]

This species, structurally one of the most distinct and interesting in its genus, has not previously been reported from North America; but at the Lloyd-Cornell Reservation, near McLean, N. Y., it is in May the commonest thrips to be found. Dr. M. D. Leonard and I took hundreds of specimens on May 19, 1925, and observed it on nearly every plant on which we looked. It was abundant on grass and the leaves of various trees, and in the flowers of *Sambucus.* Two of Dr. Karny's specimens from Vallombroso, Italy (cited above), are available for comparison.

Baliothrips dispar (Haliday).

1836. *Thr.*[*ips*] *dispar* Haliday, Ent. Mag., Vol. III, p. 449. [♀, ♂, Britain, on grasses in autumn.]

1836. *Thr.* [*ips*] *brevicornis* Haliday, Ent. Mag., Vol. III, p. 449. [♀, Britain, on *Festuca fluitans.*]
1909. *Baliothrips basalis* Shull, Ent. News, Vol. XX, p. 224, fig. 5. [♀, ♂, Huron Co., Michigan, on grass, August.]
1911. *Bagnallia agnessæ* Bagnall, Journ. Econ. Biol., Vol. VI, pp. 7, 10. [♀, England, grass, October.]
1911. *Bagnallia halidayi* Bagnall, Journ. Econ. Biol., Vol. VI, pp. 8, 10. [♂, England, grass, September.]

Two cotypes (one male and one female) of Shull's *B. basalis* do not differ from a series which I have before me of 24 European specimens of *B. dispar* (Haliday). In America the species has been known only from Shull's types taken in Michigan, and it is therefore of interest to record the capture by Jacobus C. Faure, now Professor of Entomology in the Transvaal University College, of four females at Chester, New York, April 3, 1913, on grass.

Merothrips morgani Hood.

1912. *Merothrips morgani* Hood, Proc. Ent. Soc. Wash., Vol. XIV, p. 132, Pl. V, figs. 1–3. [♀, ♂, Illinois and Kentucky, under bark and in mushroom.]
1914. *Merothrips morgani* Hood, Ins. Insc. Menstr., Vol. II, p. 17. [Maryland and District of Columbia, under bark and in bird's nest.]
1917. *Merothrips morgani* Hood, Ins. Insc. Menstr., Vol. V, p. 60. [Florida and Maryland, under bark and in débris.]

It is not unlikely that this represents the only really new type of recent Thysanopterous insect described since the time of De Geer. This minute, rare, and singular insect is the type of its genus and family, and it is of interest to record the taking of one female at Macedon, New York, under the bark of a fallen elm tree, October 26, 1924, by the writer.

Cryptothrips (?) breviventris sp. nov. (Pl. XXI, fig. 6.)

Male (*brachypterous*).—Length about 1.3 mm. Color[3] nearly black, with tarsi, apices of fore tibiæ, antennal segment 3, basal two-fifths of 4, and basal third of 5, yellowish.

Head very slightly longer than wide, rounded, broadest at middle, cheeks curving to eyes and converging toward a

[3] The meager color description is due to the fact that the specimen was cleared in KOH and the color largely destroyed before the species was recognized as new.

slight neck-like constriction; vertex truncate, not at all produced, the anterior ocellus flush with anterior margin of eyes; dorsal and lateral surfaces with a few very faint anastomosing lines and several small bristles, of which a pointed occipital pair, midway between postoculars and base of head, are decidedly longest and only slightly shorter than anterior marginals; postocular bristles long and pointed, 0.45 as long as head. Eyes not at all protruding, short, only 0.28 as long as head and almost as wide as long, interval 1.32 times their width. Posterior ocelli with their hind margins opposite center of eyes. Antennæ two and one-third times as long as head; segment 3 clavate, sides almost exactly straight; 4–6 pedicellate; 7 narrowed at base, not pedicellate; 8 subconical, twice as long as greatest width, narrowed slightly in basal third, broadly united to 7; sense-cone formula: 3, 1–2; 4, 2–2; 5, $1\text{–}1^{+1}$; 6, $1\text{–}1^{+1}$; 7 with the usual one on dorsum near apex. Mouth cone broadly rounded; labrum pointed, surpassing labium and attaining posterior margin of prosternum.

Prothorax nearly three times as broad across coxæ as median length of pronotum, which is about 0.54 as long as head; epimeron almost completely fused with pronotum; pronotum smooth; all bristles present, pointed; midlaterals longest, the two pairs at posterior angles subequal and a little shorter, twice as long as those at anterior angles, which are twice as long as anterior marginals, these last slightly longer than an approximate pair near posterior margin. Legs noticeably slender, particularly the fore femora; fore tarsi with a minute triangular tooth at apex of first segment.

Abdomen short, broadest at segment 2, the seven proximal segments short and decidedly transverse, the tergite of 3 nearly six times as wide as long; length of abdominal tergites in microns: 2, 65; 3, 68; 4, 64; 5, 62; 6, 72; 7, 78; 8, 92; 9, 100; 10, 165; sternite 8 with an irregular transverse area occupying the middle third of its entire width, this band apparently partially membranous and sensory, with a stippled appearance. Tube 0.8 as long as head, about 2.2 times as long as basal width, which is 1.7 times the apical, distinctly narrowed at basal third and at apex; lateral bristles long, pointed; terminal bristles equal in length to tube, brown.

Measurements of holotype (♂): Length 1.28 mm.; head, length 0.206 mm., greatest width 0.197 mm., width near base 0.185 mm.; eyes, length 0.058 mm., width 0.056 mm., interval 0.074 mm.; postocular bristles, length 0.092 mm.; prothorax, median length of pronotum 0.111 mm., width across coxæ 0.324 mm.; pterothorax, width 0.345 mm.; abdomen, width 0.387 mm.; tube, length 0.165 mm., width near base 0.074 mm., at apex 0.043 mm.

Antennal segments:	1	2	3	4	5	6	7	8
Length (μ)	46	60	74	72	68	64	52	44
Width (μ)	45	36	38	40	38	35	30	21

Total length of antenna 0.48 mm.

Described from one male taken by the author at Macedon, New York, October 26, 1924, in moss on a fallen tree in a lowland (muck) woods. The most careful search possible, on many subsequent occasions, of the same tree and others like it, has failed to disclose further specimens.

The broadly-rounded mouth cone, slender legs, transverse abdominal segments, the form of the tube (narrowed at tip and at basal third), the antennal structure, the union of the proepimeron with the pronotum, the chætotaxy,—all indicate affinities with *Cryptothrips*, in which I have for the present, at least, placed it. It is hoped that the discovery of more material will soon follow, and that the species may then be given a positive generic assignment. It has no close North American relatives, within my knowledge, with which it may profitably be compared.

Cryptothrips rectangularis Hood.

1908. *Cryptothrips rectangularis* Hood, Can. Ent., Vol. XL, p. 307, fig. 18. [2 ♀, 2 ♂, Urbana, Ill., and Harrisburg, Pa., under bark and in burrows, willow and peach trees.]

1913. *Cryptothrips rectangularis* Morgan, Proc. U. S. Nat. Mus., Vol. 46, p. 45. [Bridgeville, Del., under peach bark.]

1921. *Trichothrips salicis* Watson, Bull. Brooklyn Ent. Soc., Vol. XVI, p. 80. [1 ♂, Cranberry Lake, N. Y., on willow.]

1923. *Gastrothrips salicis* Watson, Bull. 168, Fla. Agr. Exp. Sta., p. 67.

This is a true *Cryptothrips*, so closely related, indeed, to the genotype *C. latus* Uzel as to cause one to hesitate between considering it a valid species (as I have done) or reducing it to subspecific rank.

Through the kindness of Mr. George P. Engelhardt, Curator of the Brooklyn Museum of Arts and Sciences, I have been able to study the unique type of Watson's *Trichothrips salicis*, taken at Cranberry Lake, N. Y., July 14, 1919, on willow, by C. J. Drake. In all respects it is identical with my *Cryptothrips rectangularis* described fifteen years previously, in part from specimens taken on the same plant, willow.

The insect is common and widely distributed, as the following records of material now before me will show:

ILLINOIS:	Urbana, May 12, 1908, under dead bark on peach tree, J. D. Hood, 1 ♀ (*holotype*), 1 ♂ (*allotype*).
	Urbana, March 31–April 2, 1908, reared from nymph taken on willow, J. J. Davis; 1 ♂ (*paratype*).
	Bosky Dell, Oct. 22, 1908, on white oak branch, L. M. Smith; 1 ♂.
	Carbondale, Sep. 21 and 22, 1908, on *Ulmus* and peach branches, L. M. Smith; 5 ♀, 3 ♂.
	Chicago, Nov. 11, 1910, in Sesiid burrows in lilac, J. J. Davis; 1 ♀.
	Muncie, July 24, 1909, on dead willow branch, J. D. Hood and C. A. Hart; 1 ♂.
	Riverside, July 17, 1909, under willow bark, J. D. Hood; 2 ♀.
WISCONSIN:	Madison, April 20, 1912, under bark of elm, J. W. Brann; 1 ♀, 2 nymphs.
TEXAS:	Dallas, May 30, on Bermuda grass, W. A Hooker; 1 ♀.
VIRGINIA:	Vienna, May 25, 1913, sweeping at base of plum tree, R. A. Cushman; 1 ♀.
DIST. OF COLUMBIA:	Washington, May 22, 1913, running about on maple tree, J. D. Hood; 1 ♀.
PENNSYLVANIA:	Harrisburg, March 10, in burrows in willow twig, Pa. State Dept. Agr., Div. Zool., No. 5251h; 1 ♀ (*paratype*).
MASSACHUSETTS:	Forest Hills, Aug. 11, 1915, in galls on willow, L. T. Williams; 2 ♀.
NEW YORK:	Macedon, May 4, 11, 18, 21, 27, 30, and June 7, 1924, under willow bark, J. D. Hood; 32 ♀, 27 ♂, 5 nymphs, 4 prepupæ, 8 pupæ.
	Kenwood, July 20, 1912, on peach bark, J. C. Faure; 1 ♀.

Leptothrips mali (Fitch).

1855. *Phlœothrips mali* Fitch, First Rept. Nox. Ins. State N. Y., p. 102; also in Trans. N. Y. State Agr. Soc., Vol. IV, for 1854, p. 806.
1902. *Cryptothrips aspersus* Hinds, Proc. U. S. Nat. Mus., Vol. XXVI, p. 205, Pl. X, figs. 104–106.
1904. *Criptothrips* (sic!) *californicus* Daniel, Ent. News, Vol. XV, p. 293.
1909. *Leptothrips aspersus* Hood, Ent. News, Vol. XX, p. 249.
1910. *Liothrips mcconnelli* Crawford, Pomona Coll. Journ. Ent., Vol. II, p. 163, fig. 68, A–G.
1913. *Leptothrips aspersus macro-ocellatus* Watson, Ent. News, Vol. XXIV, p. 148.
1914. *Leptothrips mali* Hood, Proc. Biol. Soc. Wash., Vol. XXVII, p. 162.
1921. *Cryptothrips adirondacks* (sic!) Watson, in part only, Bull. Brooklyn Ent. Soc., Vol. XVI, p. 83.

Three specimens from Mr. Watson's type series of *Cryptothrips adirondacks* have been studied. One, a male, is in the collection of the Brooklyn Institute of Arts and Sciences, and is labeled "*Leptothrips adirondackis* [sic!], Type"; it is from Cranberry Lake, New York, and was taken July 1, 1919, on Yellow Birch, by C. J. Drake. Another is a female in the collection of the U. S. National Museum and bears exactly the same data, except that the name is given as "*Cryptothrips adirondackis.*" Both of these specimens are thoroughly typical *Leptothrips mali.* The third specimen which I have seen from his series of types is in my own collection, and was also taken at Cranberry Lake, N. Y., by Dr. Drake, but on *Viburnum alnifolium,* June 25, 1919. It is not this species at all, but a typical female of *Liothrips citricornis* (Hood).

The insect is an exceedingly common one, occurring throughout most of North America, usually on the leaves of various trees and bushes. It is generally solitary in its habits and is said to be predaceous.

Liothrips citricornis (Hood).

1908. *Phyllothrips citricornis* Hood, Can. Ent., Vol. XL, p. 305, fig. 15. [♀, Illinois and Pennsylvania, on hickory and wild grape leaves.]
1909. *Liothrips citricornis* Hood, Ent. News, Vol. XX, p. 249.

1916. *Liothrips flavoantennis* Watson, Ent. News, Vol. XXVII, pp. 129, 133, Pl. VI, figs. 7–9. [♀, Gainesville, Florida, on grape.]
1921. *Cryptothrips adirondacks* (sic!) Watson, in part only, Bull. Brooklyn Ent. Soc., Vol. XVI, p. 83. [♀, Cranberry Lake, New York, on *Viburnum.*]
1922. *Hoplandrothrips flavoantennis* Watson, Fla. Ent., Vol. VI, p. 39. [♂, Clayton, Georgia.]

As pointed out under *Leptothrips mali,* Mr. Watson's *Cryptothrips adirondacks* is a composite species, made up of *Leptothrips mali* and *Liothrips citricornis.* His *Liothrips flavoantennis,* which he later referred to the genus *Hoplandrothrips,* is known to me through one specimen in the U. S. National Museum, taken at Gainesville, Florida, May 20, 1920, on basswood, and determined by him.

The species is a very common one, and specimens are before me from many localities in Illinois, Texas, Connecticut, New York, Pennsylvania, Maryland, District of Columbia, and Virginia. It is frequently abundant on grape and hickory, on the leaves.

Hoplothrips major (Hood).

1914. *Trichothrips karnyi major* Hood, Proc. Biol. Soc. Wash., Vol. XXVII, p. 153. [♀, Pennsylvania.]
1915. *Hoplothrips karnyi major* Hood, The Ent., 1915, p. 105.
1921. *Trichothrips drakei* Watson, Bull. Brooklyn Ent. Soc., Vol. XVI, p. 78. [♀, Syracuse, New York, in Phylloxera galls on hickory, and under bark of black locust.]

Two of Dr. Watson's paratypes of *Trichothrips drakei* have been studied. One, a macropterous female, is labeled *Phlœothrips drakei,* and was taken at Syracuse, N. Y., in October, 1920, under bark of black locust, by Evelyn Osborn. It is in my collection. The other slide comprises an adult brachypterous (perhaps apterous) female and a nymph, taken at Syracuse, N. Y., September, 1919, in Phylloxera galls on hickory, by C. J. Drake. Although Mr. Watson does not compare *drakei* with *major,* which had been described and figured seven years previously, from material taken in Pennsylvania, it is identical with it in all respects.

I now consider *major* specifically distinct from *Hoplothrips karnyi.* It would be interesting to compare both with their European congeners.

Mr. Richard S. Bagnall has sent me specimens of this species taken at Beppis, Japan, April 22, 1915, from fungus on fir.

Phlæothrips[4] chapmani sp. nov. (Pl. XXI, figs. 4 and 5.)

Female (macropterous).—Length about 2.1 mm. Body not roughened dorsally, nearly shining. General color, by reflected light, dark mahogany red, *with a narrow, laterodorsal, snow-white stripe extending from the distal margin of the second abdominal segment to the distal margin of the eighth.* General color, by transmitted light, brown, with maroon subhypodermal pigmentation; legs and tube blackish brown, non-pigmented; antennæ nearly concolorous with body, the pedicels of 3–6 only slightly paler.

Head nearly 1.3 times as long as greatest width, sides converging rather abruptly to eyes and more gradually to the slight neck-like constriction at base; cheeks rather closely, but not deeply, transversely striate with anastomosing lines and with about four pairs of short bristles along sides, of which the basal pair is larger and is borne on a minute tubercle; postocular bristles wanting, or indistinguishable from the scattered, minute, pointed bristles on occiput; vertex not at all produced, the anterior ocellus about on a line with front of eyes. Eyes one-half as long as cheeks, about equal in width to their interval, and with about twelve facets making up the lateral outline. Ocelli equidistant, the posterior pair with their posterior margins slightly in advance of middle of eyes. Antennæ (Pl. XXI, fig. 4) about 1.5 times as long as head; segment 8 sharply conical, broadly united at base to 7; sense-cone formula:[5] 3, 1–2; 4, 2–2; 5, $1\text{–}1^{+1}$; 6, $1\text{–}1^{+1}$; 7 with one on dorsum near apex. Mouth-cone nearly attaining posterior margin of prosternum, sides straight.

Prothorax along median dorsal line about one-half as long as head and (inclusive of coxæ) about 2.3 times as wide as

[4] Haliday used the spelling given here. Uzel modified the name to *Phlœothrips* and this emendation has been accepted by nearly all subsequent workers.

[5] Since 1908 the author has used a formula to indicate the positions of the antennal sense-cones. In this formula, the number of the antennal segment is followed, first, by the number of sense-cones on its inner surface, and then by the number on its outer surface; rudimentary sense-cones are expressed by an exponent preceded by a plus sign. Thus 5, $1\text{–}1^{+1}$ means that on the fifth antennal segment there is one fully-developed sense-cone on either side, with an additional, rudimentary one on the outer surface.

long; all usual bristles present, dilated at apex, the outer pair at posterior angles much the longest, twice the length of the pair at anterior angles, three times the length of coxal pair. Pterothorax slightly wider than prothorax; sides nearly straight, roundly converging posteriorly. Wings of equal width throughout, perfectly colorless, fore pair with 6–9 accessory hairs on posterior margin near apex. Legs of normal form; fore femora not swollen, about 0.39 as wide as head; tooth of fore tarsus slender, slightly shorter than width of tarsus, straight or curved.

Abdomen of normal form. Tube about 0.64 as long as head, 1.7 times as wide near base as at apex, somewhat narrowed at basal two-fifths; terminal bristles about 0.8 as long as tube. Marginal abdominal bristles colorless, capitate.

Measurements of holotype (♀): Length 2.09 mm.; head, length 0.326 mm., greatest width 0.255 mm., least width 0.230 mm.; eyes, length 0.112 mm., width 0.080 mm., interval 0.076 mm.; prothorax, length along median dorsal line of pronotum 0.170 mm., width (inclusive of coxæ) 0.395 mm.; pterothorax, width 0.405 mm.; abdomen, greatest width 0.465 mm.; tube, length 0.210 mm., width at base 0.076 mm., at apex 0.044 mm.

Antennal segments:	1	2	3	4	5	6	7	8
Length (μ)	50	70	84	82	70	60	52	32
Width (μ)	41	35	40	40	36	31	27	18

Total length of antenna 0.50 mm.

Male (*macropterous*).—Slightly smaller than female (length 1.9 mm.), and essentially like it in structure; but with the posterior pair of cheek bristles longer and stouter; the pronotum with a thickened median line and the bristles at its anterior angles pointed and fully as long as its median length; the fore femora somewhat swollen and nearly one-half as wide as head; the tarsal tooth as long as width of tarsus; and the abdomen more slender.

Described from one female (holotype) taken by Mr. P. J. Chapman (Assistant Extension Entomologist at Cornell University), under bark on either poplar or cottonwood, Cinnamon Lake (near Beaverdams), N. Y., June 5, 1925; from one female (paratype) taken by Mr. Chapman on a dead limb (possibly maple), Ithaca, N. Y., August 6, 1926; and from one male taken by Mr. J. C. Faure (now Professor of Entomology, Transvaal University College), on tobacco foliage, Elmira, N. Y., July 2, 1912. The holotype was only one of many specimens seen by Mr. Chapman, and the species is of course a bark-inhabiting one, Mr. Faure's specimen being merely adventitious on tobacco.

This is an unusually colored and striking species, the two snow-white stripes along the sides of the abdomen contrasting sharply with the bright maroon background. Its congener *vittatus* and the related *Acanthothrips albivittatus* are very similar to it in the general plan of coloration. *Chapmani,* however, has the white stripes confined to the sides of the abdomen; in *vittatus* they extend along the sides of the prothorax and abdomen; while in *Acanthothrips albivittatus* they occupy the sides of the head, prothorax, pterothorax, and abdomen, with a brief interruption only on the first abdominal segment. It is particularly interesting to note that the antennal coloration of all three is almost identical, and that the types of all have come from species of the genus *Populus!*

Phlœothrips vittatus Hood.

> 1912. *Phlœothrips vittatus* Hood, Proc. Biol. Soc. Wash., XXV, 11. [2 ♂, Baldwin, Mich., under bark on poplar stump.]

This strikingly-colored species has previously been known from the two male types, taken by the writer at Baldwin, Michigan, August 17, 1908, under rotting poplar bark. Mr. P. J. Chapman found one female at Parkers, Lewis Co., N. Y., September 2, 1926. These three are the only specimens known.

Aside from the usual differences due to sex, such as the slightly larger size and stouter abdomen, the female is in all respects very much like the males. The conspicuous snow-white longitudinal band on either side of the pronotum and abdomen terminates on the eighth abdominal segment as a short basal dash, while in the two males this band appears more commonly to end on the seventh segment, one of the specimens having it prolonged onto the eighth on one side only. The reticulation of the dorsal surface shows more plainly in this specimen because it has been cleared in KOH, and exhibits a district tendency to become asperate, particularly on the pronotum and in a patch at each side of abdominal tergites 2–7. The postocular bristles are actually present in both sexes, but are reduced in size, being about twice as long as diameter of ocelli and only a little more widely separated than the eyes. The head is somewhat excavated in front, so that the median ocellus is situated on an almost vertical wall and directed forward. The fore tarsus bears a small pointed tooth. The tube is about 0.85 as long as the head.

Genus HOPLANDROTHRIPS Hood

Following Bagnall and disagreeing with Priesner, I have assigned generic rank to this group of species, but with what justice I am not sure. Specific separation, too, is difficult, indeed, and for some years I have busied myself in studying the species alive in the laboratory, and in rearing them; but the results accomplished lie more in the number of slides available for study than in any definiteness of concept regarding specific limitation. Certain it is, however, that the various groups of individuals before me are worthy of names, but whether binomial or trinomial I am not sure. Perhaps they represent "formas," as the term is used by Priesner; but in a time of uncertainty like this, a binomial seems preferable because of its brevity.

Hoplandrothrips proximus sp. nov. (Pl. XXI, figs. 3 and 7.)

Female (*macropterous*).—Length about 2 mm. Color dark blackish brown, with maroon subhypodermal pigmentation disposed in large patches, not forming a nearly continuous layer; antennæ with segment 3 and pedicels of 4 and 5 yellowish, 3 more or less infuscate apically; wings nearly or quite colorless.

Head about 1.25 times as long as wide, broadest at middle; cheeks rounded abruptly to eyes and gently to near base, thence slightly diverging, forming a neck-like constriction which is equal in width to greatest distance across eyes, or to about 0.9 the greatest width of head; lateral and dorsal surfaces *distinctly roughened with anastomosing lines, so that the cheeks have a distinctly serrated profile;* cheeks each with about three small bristles arising from minute tubercles; vertex subconical, *decidedly produced*, overhanging; postocular bristles alone prominent, about 0.6 as long as eyes, dilated apically. Eyes one-third as long as head, slightly narrower than their interval. Ocelli of moderate size, distance between posterior ocelli slightly less than that between them and anterior ocellus; posterior margin of posterior ocelli on line with center of eyes. *Antennæ 1.8 times as long as head*, quite slender; segment 3 clavate, *2.3 times as long as wide,* deeply sinuate on inner surface, pedicel curved outward; 4 slightly *more than twice as long as wide;* 8 subconical, truncate and slightly narrowed at base; sense cones: 3, 1–2; 4, 2–2; 5, $1\text{–}1^{+1}$; 6, $1\text{–}1^{+1}$; 7 with the usual one on dorsum near apex. Mouth cone about attaining mesosternum, labium broadly rounded and slightly surpassed by the acute labrum.

Prothorax about 2.5 times as broad across coxæ as median length of pronotum, which is about 0.55 that of head; pronotum nearly smooth; all usual bristles present, rather short, expanded apically, brownish, the two pairs at posterior angles slightly the longest, exceeding postoculars; others shorter, particularly the anterior marginals. Pterothorax slightly wider than prothorax across coxæ, sides nearly straight, converging posteriorly; metanotum longitudinally striate, except at center of extreme base, this striation being due to the great elongation of the separate reticles. Wings of fore pair colorless, distinctly broader in basal than in apical half, slightly narrowed at middle, *moderately closely fringed (posterior margin with about 70 hairs), and with about eleven accessory hairs.* Legs rather long, fore femora moderately enlarged, *fore tarsus with a large, stout tooth.*

Abdomen slightly broader than pterothorax, *tube two-thirds as long as head, usually about 2.4 times as long as basal width,* and about twice as wide at base as at apex, sides straight. Lateral bristles of moderate length, knobbed, yellowish; *terminal bristles distinctly shorter than tube,* brown.

Measurements of holotype (♀): Length 1.98 mm.; head, length 0.30 mm., greatest width (at middle) 0.24 mm., least width (near base) 0.21 mm.; eyes, length 0.10 mm., width 0.068 mm., interval 0.076 mm.; postocular bristles, length (somewhat foreshortened) 0.056 mm.; prothorax, median length of pronotum 0.16 mm., width across coxæ 0.41 mm.; pterothorax, greatest width 0.46 mm.; abdomen, greatest width 0.47 mm.; tube, length 0.20 mm., width at base 0.082 mm., at apex 0.043 mm.

Antennal segments:	1	2	3	4	5	6	7	8
Length (μ)	48	66	104	89	77	68	56	40
Width (μ)	46	40	45	43	37	32	31	17

Total length of antenna 0.55 mm.

Male (macropterous).—Much like female in color and general structure, but smaller and slenderer (particularly the abdomen), with the postocular and anterior angular bristles elongated (as is usual in the male), and with the usual armature of the fore femora and tibiæ.

Described from 13 females and 4 males, as follows:

NEW YORK: Macedon, May 18–31, 1924, under dead *Salix* bark, J. D. Hood; 7 ♀ (*holotype* and *paratypes*), 1 ♂ (*allotype*).

Ithaca, May 27, 1926, under dead *Salix* bark, J. D. Hood; 1 ♂ (*paratype*).

MARYLAND: Plummer's Island, April 17, 1913, under dead bark on *Carpinus caroliniana*, J. D. Hood; 1 ♂ (*paratype*).

ILLINOIS: Monticello, August 1, 1908, from grape vine on elm, C. A. Hart; 1 ♀ (*paratype*).

Riverside, July 14, 1909, under dead bark on *Salix* stump, J. D. Hood; 5 ♀, 1 ♂ (*paratypes*).

Though evidently very closely related to *juniperinus,* the specimens here described would seem to represent a distinct species, separable by the characters which have been italicized in the above description.

Hoplandrothrips gynandrus sp. nov. (Pl. XX, fig. 5; pl. XXI, fig. 2.)

Female (*macropterous*).—Length about 2.6 mm. Color dark blackish brown (almost black), sometimes with tarsi and extremities of tube slightly paler; subhypodermal pigmentation red (purplish when seen through the brown integument), not particularly dense nor extending into legs; antennæ dark blackish brown, with base of segment 1 and apex of 2 paler; 3 yellow, clouded with brown in distal two-fifths or less; 4 (and sometimes 5) irregularly paler basally and mottled, though largely dark blackish brown, as are 7 and 8; wings clear, or fore pair very faintly brownish in basal half.

Head long, about 1.4 times as long as greatest width, broadest at middle, cheeks subparallel, rounded to eyes and more gently to near base, thence slightly diverging, forming a neck-like constriction which is slightly narrower than the greatest width across eyes or about 0.9 the greatest width of head, set with about three small, dark, pointed bristles; entire dorsal and lateral surfaces reticulate, faintly in occipital region, more strongly at sides, so that the genæ are minutely serrate in profile; vertex slightly produced and overhanging, distinctly reticulate; postocular bristles less than half as long as eyes, dilated apically, situated near sides of head, their interval more than twice that of eyes. Eyes about one-third as long as head, less than 0.9 as wide as their interval. Ocelli almost exactly equidistant, those of posterior pair with their posterior margins opposite center of eyes. Antennæ long, about 1.8 times the length of head, slender; segment 3 clavate, more than 2.5 times as long as greatest width, distinctly sinuate on inner surface, pedicel curved outward at base; 4 and 5 elongate, decidedly more than twice as long as wide; 8 only slightly narrowed at base, hence rather closely united with 7; sense cones: 3, 1–2; 4, 2–2; 5, $1\text{–}1^{+1}$; 6, $1\text{–}1^{+1}$; 7 with the usual one on dorsum near apex. Mouth cone nearly attaining posterior margin of prosternum, labium broadly rounded and slightly surpassed by the acute labrum.

Prothorax about 2.4 times as broad across coxæ as median length of pronotum, which is hardly 0.6 that of head; pronotum nearly smooth, without evident reticulation; all usual bristles present, short, expanded apically, brown, anterior marginals a little slenderer and shorter than postoculars, the others about comparable with postoculars, excepting the coxal, which is shorter. Pterothorax slightly wider than prothorax, broadest across front margin, narrowest at posterior margin, sides nearly straight; metanotum reticulate, *in basal half with the polygonal reticles nearly equilateral.* Wings slenderer in distal half, with about 13 accessory hairs; subbasal bristles pale, equal in length to postoculars, distal one pointed. *Legs of fore pair rather stronger than usual, the fore femora broad and with two large teeth on inner surface near apex, the fore tibiæ narrowed at base and sometimes with a distinct tooth beyond;* fore tarsi with a stout, usually curved, tooth.

Abdomen very little broader than pterothorax. Tube somewhat more than 0.6 as long as head, about 2.4 times as long as greatest subbasal width (which is about twice the apical), sides nearly straight. Lateral abdominal bristles pale, rather shorter than usual, mostly knobbed; terminal bristles brown, nearly as long as tube.

Measurements of holotype (♀): Length 2.55 mm.; head, length 0.37 mm., greatest width (at middle) 0.26 mm., least width (near base) 0.23 mm.; eyes, length 0.120 mm., width 0.076 mm., interval 0.088 mm.; postocular bristles, length 0.048 mm.; prothorax, median length of pronotum 0.20 mm., width across coxæ 0.48 mm.; pterothorax, width 0.55 mm.; abdomen, width 0.58 mm.; tube, length 0.23 mm., width at base 0.094 mm., at apex 0.048 mm.

Antennal segments:	1	2	3	4	5	6	7	8
Length (μ)	60	76	134	118	110	78	68	45
Width (μ)	58	44	52	53	44	36	32	20

Total length of antenna 0.68 mm.

Described from 4 females.

New York: Macedon, May 18 and 29, 1924, under dead bark of *Salix* sp. infested with *Cryptorhynchus lapathi*, J. D. Hood; 4 ♀ (*holotype* and *paratypes*).

This large species is remarkable in that the fore legs of the female are armed in the same fashion as those of the males of most, if not all, of its congeners. At first glance it might seem better, because of the toothed femur, to place the species in *Acanthothrips*, to which genus it naturally runs in most keys; but the armature is really that of a *male Hoplandrothrips*, consisting as it does of two femoral teeth and a single tibial one. The antennæ are distinctly not those of an *Acanthothrips*, but of a *Hoplandrothrips*, and, save for the unusual structures described, the species is very like *juniperinus*. That species is much smaller, however, has a shorter head, stouter antennæ, and a differently sculptured metanotum. The discovery of the species contributes still more to the increasing uncertainty which surrounds the recognition of those genera related to *Phlœothrips*.

Pœcilothrips ornatus (Hood).

1913. *Phlœothrips ornatus* Hood, Proc. Biol. Soc. Wash., XXVI, 165. [Many ♀, Washington, D. C., on dying red oak tree.]

I have for some years suspected that my *Phlœothrips ornatus* might be congeneric, perhaps even con-specific, with Uzel's *Pœcilothrips albopictus*, described and still known from only the unique type taken in Bohemia. Dr. Priesner (in litt.) has suggested the same thing, but he has not yet been able to make a direct comparison. Though differing in several minor points from the description of *albopictus*, *ornatus* is almost certainly a *Pœcilothrips*, and is quite possibly a distinct species. That it is commoner in America than is *albopictus* in Europe would appear to be shown by the enumeration given below of material before me. The species has not heretofore been recorded from New York.

Dist. of Columbia: Washington, May 22, 24, 27, and June 5, 7, 12, 16, 18, 21, and 24, on trunk of red oak tree, H. E. Burke, J. R. Malloch, J. D. Hood; 37 ♀, 5 nymphs.

PENNSYLVANIA:	Harrisburg, August, 1915, pupa under dead bark on hickory tree August 10 became adult August 13, W. S. Fisher; 1 ♀.
NEW YORK:	Macedon, April 13, 1924, under bark on hickory stump, J. D. Hood; 2 nymphs.
	Rochester, July 9, 1924, flying, J. D. Hood; 1 ♀.
	Sodus Pt., Sept. 1, 1924, flying, J. D. Hood; 1 ♀.

Megalothrips spinosus Hood.

1908. *Megalothrips* (?) *spinosus* Hood, Can. Ent., XL, 306, figs. 16 and 17. [3 ♀[9] (holotype and paratypes), Harrisburg, Pa., in burrows in dead willow stem.]
1909. *Megalothrips* (?) *spinosus* Franklin, Ent. News, XX, 321. [2 ♀, 2 nymphs, St. Paul, Minn., under dead bark on white birch.]
1910. *Idolothrips spinosus* Crawford, Pomona Coll. Journ. Ent., II, 170. [Merely refers the species to *Idolothrips.*]
1914. *Megalothrips spinosus* Hood, Proc. Biol. Soc. Wash., XXVII, 170. [Both sexes, Pa., N. Y., Md., Va., Ill., Minn.; refers the species positively to *Megalothrips.*]
1921. *Idolothrips fuscus* Watson, Bull. Brooklyn Ent. Soc., XVI, 84. [5 ♀, N. Y. and Mass., in Cerambycid burrows in basswood.]
1923. *Gigantothrips fuscus* Watson, Bull. 168, Fla. Agr. Exp. Sta., 71. [Merely refers the species doubtfully to *Gigantothrips.*]

With the exception of *Elaphrothrips tuberculatus* (Hood), which is recorded from New York for the first time in this paper, this is the largest species of thrips known to occur in northeastern America. It may be found in one stage or another the whole year through, in hollow twigs, under loose bark, in stem galls on goldenrod, and in various other situations of the sort. The adult is readily known by its large size (females average nearly 4 mm. in length), the nearly uniform piceous black color, the elongate head with its elevated, arched occiput, and the spinose tube; while the large nymph, with its deep red body contrasting sharply with the nearly

[9] Though given as two in the original description, the number of types is actually three.

black head, prothorax, appendages, and last two abdominal segments is recognizable even to the naked eye by the paler meso- and metathorax, which are pink rather than red and give the insect a faintly banded appearance.

The better part of a year appears to be spent in the adult condition. A female which has spent the winter in a hollow twig or golden-rod gall, moving about within her confines on a warm day and relapsing into total inactivity on cold ones, proceeds in early spring to lay her eggs at intervals of every few days. Before the last eggs are laid, the first ones have hatched and the eldest in her growing family may even be well on their way toward maturity. When the adult finally dies I do not know; but they have been found in every month of the year, surrounded by offspring of assorted sizes, and unhatched eggs, indicating a family life of some duration. Nymphs of the first stadium have been taken as early as May 4 and as late as November 1, and the species appears to hibernate quite as readily in one instar as another.

At Macedon, New York, I once found a colony of fifteen adult females clustered about a patch of empty egg shells under the bark on a maple sapling which was serving as a fence rail. They had evidently developed from the eggs about which they were gathered and, as the time was in April, before the coming of spring, had apparently spent the winter as adults.

Another time, at Great Falls, Maryland, a female was found close beside a single egg which it had apparently just deposited, fully exposed, on the upper surface of an herbaceous plant (*Lactuca*) growing in an open woods—a most unusual situation, it would seem, for oviposition. Though disturbed by the handling of the leaf she was apparently loath to leave the vicinity and wandered about the egg in the deliberate manner of the species until, touched by the camel's-hair brush I was carrying, she spread her wings preparatory to flight.

This is a close relative of the European *M. bonannii* Uzel, the type of the genus, from which it may be known at a glance, however, by the uniform black antennæ. It is surprising that Mr. Watson should have failed to recognize this common species. The following material is now before me:

PENNSYLVANIA: Harrisburg, March 10, in burrows in dead willow, Pa. State Dept. Agr., Div. Zool., No. 5251 h; 3 ♀ (*holotype* and *paratypes*).

Rockville, Nov. 10, 1912, in Cerambycid burrow in oak, A. B. Champlain; 15 ♀, 2 ♂.

NEW YORK: Syracuse, Oct. 6, 1920, in Cerambycid burrows in basswood, C. J. Drake; 2 ♀ (*holotype* [coll. Watson] and *paratype* [coll. Hood] of *Idolothrips fuscus* Watson).

Ithaca, March 24, 1905, from hole in dead twig, Philena B. Fletcher; 1 ♀.

Macedon, March 22, 1924, in stem gall on golden-rod, J. D. Hood; 1 ♀. April 20, 1924, under dead maple bark, J. D. Hood; 7 ♀. May 4 and June 7, 1924, under dead bark of willow infested with *Cryptorhynchus lapathi,* J. D. Hood; 4 ♀, 4 nymphs.

Rock City, Sept. 16, 1925, under dead maple bark, P. J. Chapman; 1 ♀.

Sea Cliff, L. I., Sept. 6, 1925, dead oak branches, P. J. Chapman; 5 ♀.

MASSACHUSETTS: Forest Hills, August 25, 1915, in galls on willow, L. T. Williams; 7 ♀, 1 ♂, 1 nymph.

South Framingham, August 8, 1913, under bark of *Fagus sylvatica,* R. R. Parker; 1 nymph.

MARYLAND: Great Falls, May 23, 1915, on leaf of *Lactuca,* J. D. Hood; 1 ♀.

Plummer's Island, May 24, 1914, on willow, W. L. McAtee, 2 ♀; June 8, 1913, on willow, W. L. McAtee, Alexander Wetmore, J. D. Hood, 2 nymphs; Oct. 12, 1913, on willow, W. L. McAtee and J. D. Hood, 2 ♀, 3 ♂.

Plum Point, Aug. 10, 1913, sweeping, W. L. McAtee; 1 ♀.

VIRGINIA: Bluemont, Aug. 31, 1913, on spice bush, W. L. McAtee; 1 ♀.

Falls Church, Feb. 21, 1915, in dry chestnut leaf, W. L. McAtee, 1 ♀; June 28, 1918, sweeping, E. A. Chapin; 1 ♀.

	Rosslyn, Nov. 1, 1914, on dead willow, C. B. Williams and J. D. Hood; 1 ♀, 1 ♂, 3 nymphs.
	Vienna, Apr. 7 and 19, 1913, in stem gall on golden-rod, R. A. Cushman; 2 ♀.
ILLINOIS:	Carbondale, July 30, 1909, on persimmon twigs, L. M. Smith; 1 ♀.
	Muncie, July 24, 1909, in burrow in willow twig, J. D. Hood; 1 ♀.
MINNESOTA:	St. Paul, Sept. 19, 1908, under dead bark on white birch, H. J. Franklin; 1 ♀.
TEXAS:	Dallas, May 12, 1906, from *Callirhoe involucrata*, W. D. Pierce; 1 ♀.
CONNECTICUT:	Ellington, Aug. 15, 1924, M. P. Zappe; 1 ♀.
NEW JERSEY:	Norwood, April 6, 1916, under beech bark, E. R. Kalmbach; many ♀.
GEORGIA:	Bainbridge, June 1, 1911, J. C. Bradley; 1 ♀.
QUEBEC, CANADA:	E. Hereford, Aug. 31, 1923, in Cecidomyid gall on *Salix*, T. C. Barnes; 1 ♀.

Genus ELAPHROTHRIPS Buffa
(*Idolothrips* auctores, partim)

1909. *Elaphrothrips* Buffa, Redia, V, 162. [Type not designated; six species: *Idolothrips quadrituberculatus* Bagnall, *I. assimilis* Bagnall, *I. coniferarum* Pergande, *I. flavipes* Hood, *I. longiceps* Bagnall, and *E. uniformis* nov. sp.]

1909. *Dicaiothrips* Buffa, Redia, V, 169. [Type not designated; two species: *Thrips Schottii* Heeger and *D. bottegii* nov. sp.]

The only character which has been pointed out for the separation of *Elaphrothrips* from *Dicaiothrips* is the presence, in the males of the latter genus, of a curved bristle at the apex of the fore femur. Such a bristle is of quite general occurrence, however, throughout the family. It is found in both sexes in many genera—though, to be sure, it is usually straight or nearly so. In *Dicaiothrips,* then, we have a genus whose sole diagnostic character lies in the *form* of a certain bristle which must be studied in the male sex only! Notwithstanding this, the separation might still be tenable were the character constant; but in a series of several species before me (and I believe it will be found true of all of the species of this so-called genus when large series become available for study) it is noted that the smaller and more slender-legged males have a weak, straight bristle in place of the large curved one which is so conspicuous in those with enlarged femora. In other words, the size and degree of curvature of the bristle varies directly as the size of the fore legs, which in turn is usually directly related to the size of the individual. Perhaps the difference is merely indicative of the amount of food available to the growing nymph.

I have accordingly had no hesitation in placing *Dicaiothrips* Buffa as a synonym of *Elaphrothrips* Buffa, which has a few pages priority. The United States species of the genus are as follows:

1. *Elaphrothrips coniferarum* (Pergande), Ent. News, VII, 63; 1896 (*Idolothrips*).
2. *Elaphrothrips flavipes* (Hood), Bull. Ill. State Lab. Nat. Hist., VIII, 377, fig.; 1908 (*Idolothrips*).
3. *Elaphrothrips armatus* (Hood), Ann. Ent. Soc. Amer., I, 285, figs.; 1908 (*Idolothrips*).
4. *Elaphrothrips tuberculatus* (Hood), Ann. Ent. Soc. Amer., I, 287, figs.; 1908 (*Idolothrips*).
5. *Elaphrothrips parallelus* Hood, Ent. News, XXXV, 315; 1924.

Of these, the first two (*coniferarum* and *flavipes*) have the femoral bristle always straight; *armatus*, at least in the series before me, has this bristle always curved; while *tuberculatus* varies in the same colony of individuals from one extreme to the other. The male of *parallelus* is not known.

Elaphrothrips tuberculatus (Hood)

1908. *Idolothrips tuberculatus* Hood, Ann. Ent. Soc. Amer., I, 287, fig. 9 (3b), fig. 10. [4 ♀, 1 ♂, White Heath and Bosky Dell, Ill., on white oak.]

1917. *Idolothrips tuberculatus* Hood, Ins. Insc. Menstr., V, 63. [Additional distribution: Mo., Md., D. C., Va.]

1922. *Idolothrips tuberculatus* Watson, Fla. Ent., VI, 21. [1 ♂, Gainesville, Fla., on *Tilia.*]

This, the largest species of thrips known from eastern North America, was taken in numbers last autumn by Prof. C. R. Crosby and Mr. P. J. Chapman, in North Carolina and New York, respectively. It is a noteworthy addition to the New York fauna. The species is usually found among dead, curled oak leaves attached to broken branches, and is sometimes exceedingly abundant in such situations. The material now before me is as follows:

ILLINOIS:	White Heath, Aug. 26, 1908, leaves of *Quercus alba,* C. A. Hart; 2 ♀ (*holotype* and *paratype*), 1 ♂ (*allotype*).
	Bosky Dell, Oct. 22, 1908, *Quercus alba,* L. M. Smith; 1 ♀ (*paratype*).
MISSOURI:	Wittenberg, July 12, 1909, on walnut, C. A. Hart; 1 ♀.
ARKANSAS:	Stuttgart, Dec. 18, 1917, under hickory bark, Alexander Wetmore; 1 ♀.
NORTH CAROLINA:	Big Bald, Pisgah Range, Oct. 13, 1926, in dead oak leaves, C. R. Crosby; 4 ♀, 4 ♂.
	Mt. Pisgah, Oct. 14, 1926, in dead leaves, C. R. Crosby; 2 ♀.
	Nantahala Gap, Macon Co., Oct. 16, 1926, in dead leaves, C. R. Crosby; 7 ♀, 9 ♂.
	Wayah Bald, Macon Co., Oct. 16, 1926, in dead leaves, C. R. Crosby; 1 ♀, 4 ♂.
VIRGINIA:	Falls Church, May 25, 1913, on oak leaf, A. N. Caudell; 1 ♂.
	Black Pond, June 21, 1914, on dead stump, W. D. Appel; 2 ♀, 1 ♂.
	Glencarlyn, July 18, 1915, W. L. McAtee; 1 ♀, 1 ♂.
	Mt. Vernon, June 2 and 21, 1915, among dead oak leaves, W. L. McAtee, 4 ♀, 2 ♂, 6 nymphs; Aug. 1, 1915, among dead oak leaves, L. O. Jackson; 2 ♀, 1 ♂.
	Scott's Run, Fairfax Co., May 20, 1914, flying, R. C. Shannon; 1 ♂.
MARYLAND:	Beltsville, May 17 and June 14, 1914; May 2, June 9, and Sept. 12, 1915, in dead oak leaves, J. D. Hood, W.

L. McAtee, L. O. Jackson, 15 ♀, 16 ♂, 18 nymphs, 3 prepupæ, 9 pupæ; Aug. 14, 1914, on *Pinus virginiana,* W. L. McAtee, 1 ♀.

Odenton, July 12, 1914, on chestnut, J. D. Hood; 1 ♀.

Plummer's Island, June 29, 1913, on oak, J. D. Hood; 1 ♂.

DIST. OF COLUMBIA: Washington, 1900, A. N. Caudell, 1 ♀; April 23, 1913, flying, W. L. McAtee; 1 ♀.

NEW YORK: Long Pond, Suffolk Co., Sept. 19, 1926, in dry oak leaves on broken limb, P. J. Chapman; 9 ♀, 5 ♂.

Wading River, Long Island, Sept. 19, 1926 [no further data], P. J. Chapman and A. M. Boyce; 2 ♀.

The variation in the male sex is worthy of note. Some individuals are fully twice as large as others, and these have the fore femora tremendously enlarged. Such males are always provided with a large, hook-shaped bristle on the fore femur, arising on the dorsal surface near the apex and curving outward and downward. The smaller males have slender fore femora, and the bristle at the apex is small and straight, though directed outward. These characters have heretofore been considered of generic rank.

PLATE XX

(Clara Husted et J. D. H., del.)

Fig. 1.—*Thrips monotropæ* Hood, ♀, holotype, head and prothorax. (All leg bristles omitted.)

Fig. 2.—*Thrips veratri* Hood, ♀, paratype, head and prothorax. (All leg bristles omitted.)

Fig. 3.—*Echinothrips subflavus* Hood, ♀, holotype, head and prothorax. (All leg and antennal bristles omitted.) Note that there is only one bristle on the left side of the prothorax at the posterior angle.

Fig. 4.—*Sericothrips annulipes* Hood, ♀, holotype, pronotum.

Fig. 5.—*Hoplandrothrips gynandrus* Hood, ♀, holotype, head and prothorax. (All leg and antennal bristles omitted.)

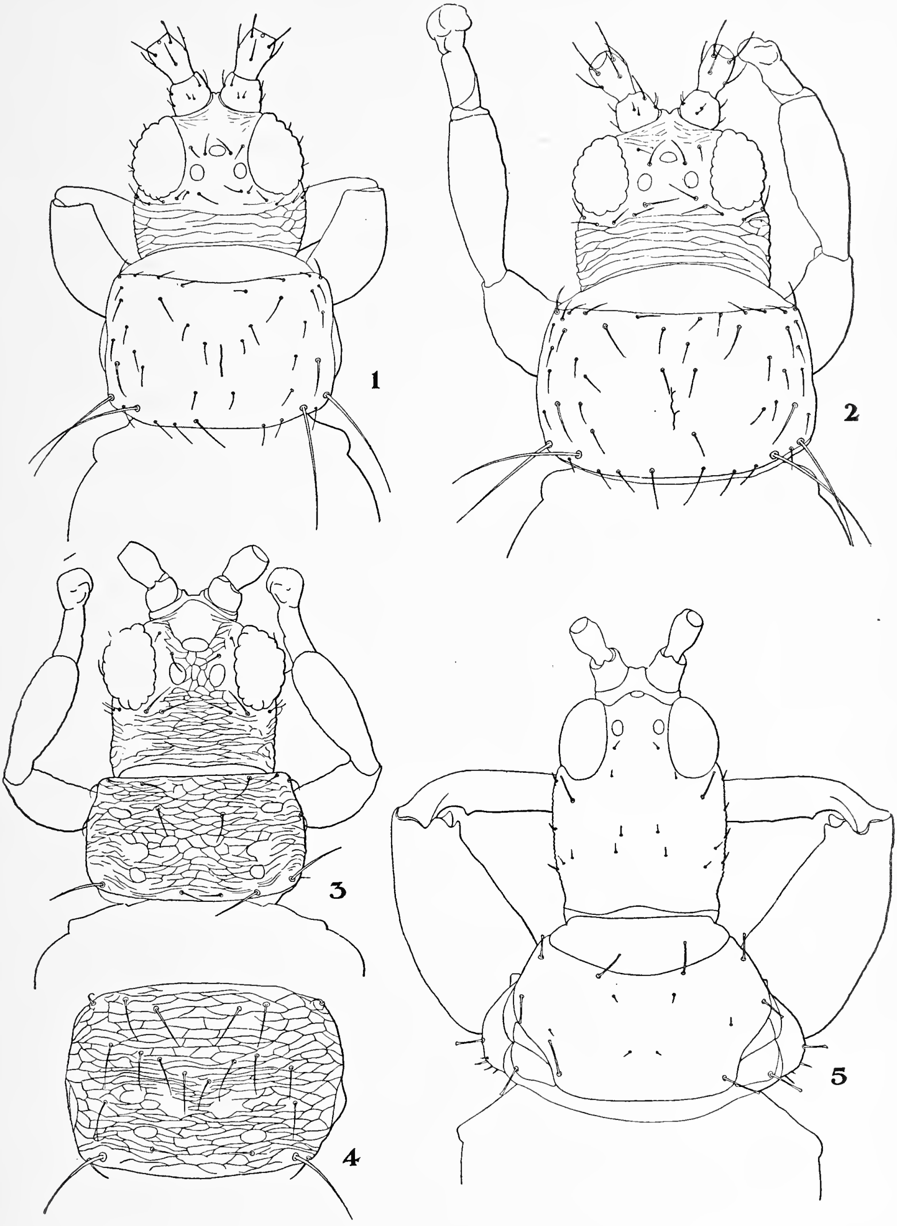
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PLATE XXI

(Clara Husted, Inez d'Amanda, et J. D. H., del.)

Fig. 1.—*Thrips monotropæ* Hood, ♀, holotype, left antenna. (All bristles and sense cones omitted.)

Fig. 2.—*Hoplandrothrips gynandrus* Hood, ♀, holotype, third segment of right antenna. (All ventral bristles and the ventral trichome on outer surface omitted.)

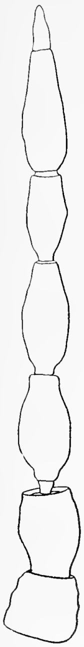
Fig. 3.—*Hoplandrothrips proximus* Hood, ♀, paratype, third segment of right antenna. (All ventral bristles and the ventral trichome on outer surface omitted.)

Fig. 4.—*Phlæothrips chapmani* Hood, ♀, holotype, left antenna.

Fig. 5.—*Phlæothrips chapmani* Hood, ♀, paratype, head and prothorax. (Nearly all minor bristles omitted.)

Fig. 6.—*Cryptothrips (?) breviventris* Hood, ♀, holotype. (All leg and antennal bristles omitted.)

Fig. 7.—*Hoplandrothrips proximus* Hood, ♀, holotype, head and prothorax. (All minor bristles omitted.)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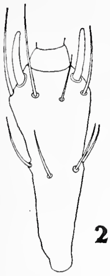
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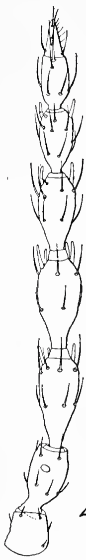
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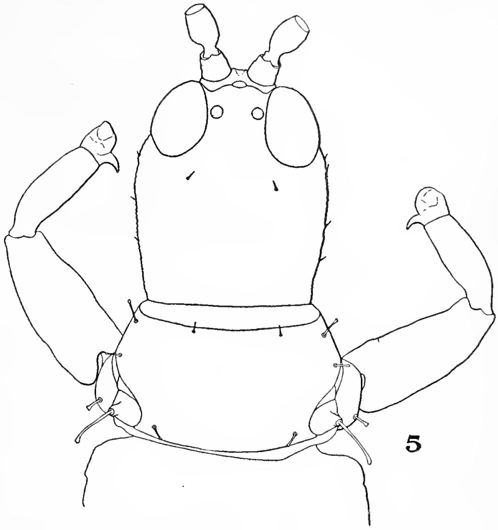
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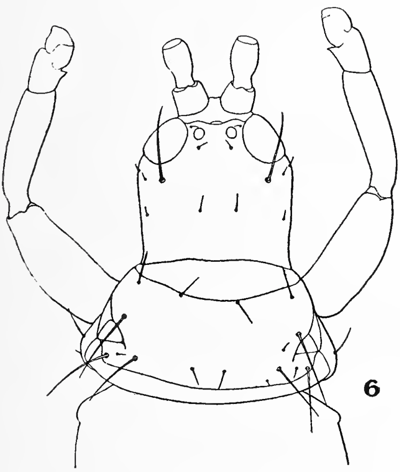
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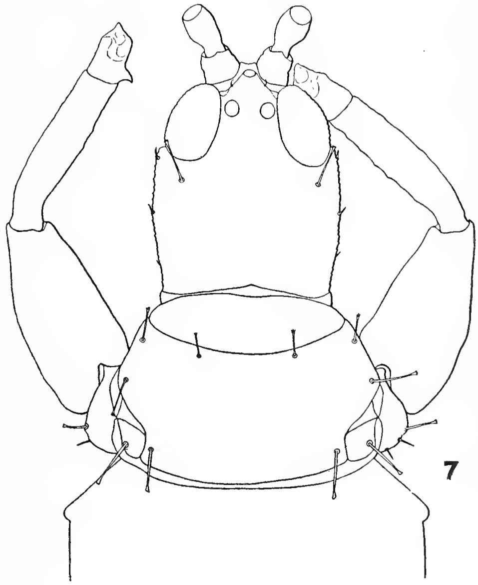
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Vol. VII (n. s.), 1926–1927

INDEX TO GENERA AND SPECIES

(Valid species in Roman; new species in **bold face**; synonyms in *italics*; other animals than insects indicated by *; plants by †)

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ENTOMOLOGICA AMERICANA

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THE SPECIES OF PHYLLOTRETA NORTH OF MEXICO

By F. H. Chittenden

BUREAU OF ENTOMOLOGY, U. S. DEPARTMENT OF AGRICULTURE

The species of the genus *Phyllotreta*[1] occurring in America north of Mexico have not hitherto received serious study, nor have they been diligently collected. Prior to 1873 only two species, the Fabrician *bipustulata* and *vittata,* were recognized in this country. At about that time Crotch added five new species and Leconte described three. In 1889, in Horn's revision, 15 species were considered (omitting *picta*[2]), four being described as new. Still later Dury and Schaeffer each described a new species and the writer has added three, one new to science. In Europe 37 species are catalogued, many of them so closely related as not to be easily distinguished without most careful study. When all of the forms occurring in our fauna have received proper attention, the list will probably exceed that.

The genus *Phyllotreta* was defined by Foudras in 1859, but was evidently used, presumably as a manuscript name, by Chevrolat much earlier.[3] *Ph. armoraciae,* being the first species mentioned, both in the catalogue and by Foudras, would naturally be the type.

[1] Order Coleoptera; family Chrysomelidae; subfamily Halticinae.

[2] Not *Phyllotreta,* but *Trachymetopa* Weise (L. G. Gentner in lit.).

[3] Chevrolat, *In* Catalogue Coleoptera Dejean, 1833 (1836), p. 391.

Following the law of priority of publication, Dejean should be credited with the generic name.

PHYLLOTRETA Dejean

Phyllotreta Dejean, Cat. Col., ed. 3, 1833 (1836), p. 391.

Phyllotreta Foudras, Ann. Soc. Linn. Lyon, ser. 2, 1859, p. 230; Leconte, Proc. Am. Phil. Soc., 1878, p. 615; Horn, Trans. Am. Ent. Soc., 1889, pp. 292, 293.

Phyllotrata (Chevrolat), Stephens, Man. Brit. Coleop., 1839, p. 291.

Orchestris Kirby, Fauna Boreali-Americana, 1837, p. 217; Crotch, Proc. Acad. Nat. Sci. Phila., 1873, p. 65; Leconte, Proc. Am. Phil. Soc., 1878, p. 614.

> Head small, deeply inserted in the thorax; eyes convex, prominent; front distinctly carinate between the antennae. Last joint of maxillary palpi as long as the preceding, elongate conical. Antennae half as long as the body, sometimes slightly longer or shorter, slender, the apical joints wider than the basal ones (omitting the wide first joint), in many species different in the sexes in the form of the basal joints, especially in the fifth and frequently the fourth and sixth. Prothorax transverse, narrower at the apex; apex not emarginate; base very slightly arcuate. Prosternum narrowly separating the coxae, slightly dilated behind them; coxal cavities open posteriorly, angulate externally, exposing the trochanter. Elytra oval, moderately convex; humeri seldom prominent. Legs moderate in length, posterior femora stout, posterior tibiae narrow, gradually broader to the apex, not sulcate on the outer edge, although slightly excavate near the apex. Posterior tarsi shorter than the tibiae, first joint about one-third the length of the tibia and equal to the other three; claws simple.

The species of our fauna are of small size, varying from about 1.5 to 3.5 mm. in length, usually elongate oval in outline, the length approximately twice as long as the width. Less than half are ornamented with a yellow or whitish longitudinal vitta on each elytron, three forms are spotted, and one, the imported *armoraciae,* is mostly yellow, while the remainder are unicolorous or nearly so. It is obvious that the forms with two spots on each elytron were originally vittate and that the vittae are merely interrupted near the middle, since many individuals, notably in *vittata,* bear evidence in the more or less narrow lines, sometimes partially obliterated, connecting these vittae. The body is usually moderately convex but sometimes depressed, as in *pusilla* and *prasina.*

It is the purpose of this paper to present as concise an account of the species of the genus *Phyllotreta* occurring north of Mexico as will enable the student of the group to identify them. At the same time their known geographical distribution is indicated, together with such data as are available in regard to their food habits.

The study of all species available enables the writer to amplify the generic description as previously published.[4]

The head has usually above the antennae a short interocular fovea or impressed line extending as far as the top of the eyes, but this character is too frequently obsolete or absent to be of definite value for purposes of classification. The eyes exhibit only a moderate degree of variation, from species in which they are comparatively large and prominent to others where they are relatively small or inconspicuous.

The simplest form of antennae are those in which the sexes are alike, as in the eastern *armoraciae* and *bipustulata* and in the western *ramosa, aeneicollis* and *pusilla.* The first joint is always wide and long, but usually less than twice as long as the second and third together. The second joint is generally wider at the base than the third and fourth. The third and fourth are, as a rule, subequal in length and width, but in the male the fourth, fifth and sixth are apt to be quite variable in their proportions, as has been previously stated. A more complex form of antennae occurs in the species where the fifth joint ♂ is more or less enlarged. When this joint is strongly inflated, it is usually longer as well, in which case the sixth joint is correspondingly small, as in such species as *denticornis* and *zimmermanni,* where it is extremely short, and in others like *oregonensis, utana* and *liebecki,* where it is a little larger. Other extremes in antennal development are exemplified in *denticornis,* where the lower angle of the sixth joint is prolonged into an acute process, and *robusta,* in which the apical free angle of the fifth joint is prolonged.

The prothorax and elytra exhibit moderate variation in the different species, such differences taking the form of relative convexity, length, width, degree of lateral arcuation, and punctation. In this connection two hitherto undescribed species may be mentioned as distinctly shorter and of more robust form than any others, namely

[4] A single species, *Ph. ulkei* Horn, is the only one that has not been examined.

obtusa and *transversovalis*. *Ph. chalybeipennis* is remarkable for the dual nature of the elytral punctation, extremely large punctures intermingled with much smaller ones.

The pygidium is normally covered (in dried specimens) by the elytra, but in some species, *e.g., lewisii,* it is sometimes exposed on the dorsal surface. Here it is seen to be distinctly covered with piliferous punctures, the pile being very delicate and gray. On the ventral surface the pygidium is frequently strongly inflexed, in some males of certain species, *e.g., chalybeipennis, pusilla, herbacea* and others, forming with the extreme apex of the fifth segment a semicircular concavity.

The ventral surface exhibits many important characters, especially in the last segment. The punctation of the first ventral segment is not always so dissimilar to that of the fifth, and the second, third and fourth, as a general rule, each bears a single row, sometimes a partial second, of punctures, which in turn bear each a single fine hair, usually most apparent on the sides of the last segments.

In the male the fifth segment at the sides is usually more or less impressed, this impression sometimes becoming distinctly concave. Exceptionally, the concavity extends across the segment. The middle, at least in the apical half, is usually impressed in varied shapes and lengths, sometimes concavely as in *bipustulata,* sometimes taking the form of a simple impressed line, occasionally subtriangular at the extreme apex, as in *pusilla,* or this impression may be present at the base of the segment and not extend to the apex as in *chalybeipennis.* Finally, in many species there is at each side of the apex a tubercle of variable outline and size, usually when strongly developed more or less transverse, as in *armoraciae, zimmermanni, chalybeipennis* and others. The tubercles tend to obsolescence or obliteration in some specimens.

A study of the primary male sexual characters by dissection might be of assistance in the determination of the status of some uncertain forms, whether species or variants. This, however, would entail additional specimens, and with such material at command their study might solve the problem beyond reasonable doubt, although study of the internal characters might serve as confirmation of an expressed opinion. In the female the fifth segment is, as a general rule, simple, but it is impressed at the sides in exceptional specimens and species. The apex of this segment is frequently more acute than in the male, and the extreme apex is sometimes more or less feebly impressed, and in some exceptional individuals of a species it may be distinctly impressed.

The species of *Phyllotreta* are practically confined to the Cruciferae as food plants, although certain ones also attack the Capparidaceae and Resedaceae, closely related botanical families. The commoner forms are injurious, the principal injury being due to the beetles destroying the cotyledons and seedlings of such crops as cabbage, turnip, radish, mustard, horse-radish, cress, and the like. On older plants the work of the beetles varies according to the nature of the vegetation attacked. On the foliage of plants like cabbage, when of considerable growth, they eat out small pits, usually from the lower surface of the outer leaf, and this form of injury, although obvious, is not, as a general rule, serious. In the case of thin-leaved plants, such as turnip, radish and mustard, the foliage attacked becomes riddled with minute holes, and dries, thus lessening the yield. When the plants are young and the growing conditions are unfavorable, severe injury may be accomplished by the beetles. Such pernicious species as *Ph. pusilla* and *vittata* in some years severely injure cole crops, destroying entire plantings, and damage is particularly severe in seed beds. The former species, when especially numerous, attacks various vegetable crops, and the latter sometimes feeds to a slight extent on plants not related to the Cruciferae.

The larvae, as a general rule, live on the roots or mine the leaves of cruciferous weeds, and both root-feeders and leaf-miners not infrequently attack cultivated crucifers.

Among North American species that are more or less periodically injurious are *armoraciae, oregonensis, zimmermanni, vittata, ramosa, bipustulata, albionica, decipiens, aeneicollis, pusilla* and *aerea*. All of our species are believed to be native with the exception of *armoraciae, vittata,* and *aerea,* three forms introduced from Europe.

In the Old World there are several other Phyllotretas known to attack cruciferous crop plants, the list including the common European *nemorum, exclamationis, undulata, cruciferae, nigripes, atra, consobrina, variipennis* and *vittula*. There is not only danger of the introduction of these into the United States and Canada, but it it surprising that some have not already found a foothold here. Even other foreign species of the genus not recorded as pests abroad might be troublesome if introduced. The same is true of many, if not most of our common native forms, should they become attracted to cultivated crucifers through the loss by cultivation of their wild food plants or other cause and be permanently introduced into other regions. Of such are *liebecki, herbacea, prasina, laticornis,* and possibly *robusta, inconspicua* and *columbiana*.

The unicolorous species, *i.e.*, those without vittae or spots, in which the fourth and fifth antennal joints are similar in the sexes, are difficult of definition and of separation by means of tables. Where the antennal joints are so nearly uniform in length, some individual difference must be expected, and in small series some difficulty may be experienced in the detection of such characters as the minute apical tubercles in the last ventral segment. While many of these species are quite distinct, at least an equal number are very closely related to some similar one. With a good series of specimens and species available, however, it is hoped that the tables submitted may be found useful.

In writing of the Halticini in 1889,[5] Doctor Horn remarked, "The entire tribe is one which presents many difficulties in its study. The characters of taxonomic importance are few, and these are so often interlinked as to make it almost impossible to decide to which priority of importance should be given." Doctor Horn might have gone much further in the discussion of some of the genera and especially of *Phyllotreta*. Great difficulty is experienced in separating the females of some species from related ones, and even in separating the males from the females of a given species, and there is an almost utter lack of uniformity in the case of the structure of the fifth ventral segment in the males of such common species as *pusilla*, while the equally common *vittata* presents characters which are almost baffling without minute study of a large series.

In the preparation of the present paper the writer has had access to the collection of the U. S. National Museum, including the recent bequest of Col. Thomas L. Casey, and to a reference collection of the Bureau of Entomology. He is especially indebted to Dr. J. McDunnough for the loan of the collection of the National Museum of Canada, and to Dr. Nathan Banks for material from the Museum of Comparative Zoology, of Cambridge, Mass.; also to L. L. Buchanan, F. S. Carr, N. Criddle, Prof. R. A. Cooley, D. K. Duncan, Dr. C. P. Gillette, Ralph Hopping, M. C. Lane, J. B. Wallis, Prof. H. F. Wickham, and Dr. E. C. Van Dyke, and to others who will be mentioned in connection with the descriptions of the various species.

Statement is duly made where a new species is described from a single specimen or from a single sex represented by more than one specimen. In cases where no remarks are made, it may be assumed that the amount of material of each species available was deemed sufficient for the purpose of description, and that the holotypes, as

[5] Trans. Amer. Ent. Soc., Vol. XVI, 1889, p. 165.

also the allotypes, where described, are deposited in the U. S. National Museum unless otherwise stated.

TABLES

Our North American species of *Phyllotreta* may be conveniently divided into two main groups or divisions, as follows:

Elytra cream-colored or with yellowish stripes or spots .... Table A
Elytra without vittae or large spots .... Table B

Table A

Elytra cream-colored or with yellowish stripes or spots

Elytra cream-colored with narrow black sutural stripe.
Antennal joints of ♂ subequal, fifth not inflated; Northern U. S., Canada, Northern Europe .... I. 1. *armoraciae* Koch
Elytra black, each with a median yellow vitta or stripe.
Fifth antennal joint of ♂ notably enlarged and thickened .... II. *lepidula* group
Fifth antennal joint of ♂ feebly or not at all enlarged .... III. *alberta* group
Elytra black, each with one or two yellow or reddish spots .... IV. *bipustulata* group

II. lepidula group

Elytra each with a median yellow vitta. Fifth antennal joint of ♂ notably enlarged and thickened

Elytral vittae without branches, narrow.
Surface highly polished, vittae distinct, nearly as in *Systena;* Calif. .... 2. *lepidula* Lec.
Elytral vittae not sinuous, each with one or two branches.
Vittae wide, dilated at both ends, not constricted at middle.
Vitta at middle about as wide as space between it and suture.
Antennal joints ♂ 4 and 5 black, greatly enlarged, 5 not prolonged; length 1.8–3.0 mm.; Northwest U. S., Colo., Kans., Tex. .... 3. *oregonensis* Horn
Antennal joint ♂ 4, 5 yellow, 4 not greatly enlarged, 5 more enlarged, apically produced; length 1.5–2.5 mm.; Northwest U. S., Colo., Wis., Ind. ... 4. *robusta* Lec.

Vittae narrow, distinctly sinuous, not noticeably widened at the ends.

Vittae subparallel at base only, strongly incurved apically.

Antennal joints ♂ 4, 5 black, 5 greatly enlarged, concave on lower surface, 4 much smaller; vitta branched at both ends; length 2.5 mm.; Atlantic States, Can. .... 5. *zimmermanni* Cr.

Antennal joints ♂ 4, 5 yellow, both greatly enlarged, 5 flat; vitta branched only at base; length 2.5–3.0 mm.; Utah, Nev., Oreg. .... 6. *utana* Chttn.

Vittae irregular in width, more or less distinctly constricted at middle and incurved toward suture at either end, not branched apically.

Vittae strongly incurved at base, not reaching suture toward apex; legs dark; length 1.8–2.0 mm.; N. Amer., Eur. .... 7. *vittata* Fab.

Vittae feebly incurved at base, attaining suture at apex; legs yellow; length 1.6–1.8 mm.; Fla.–Tex. .... 8. *liebecki* Schf.

III. ALBERTA group

Fifth antennal joint ♂ feebly or not at all enlarged

Fifth antennal joint ♂ and ♀ about as long as 3 and 4 together.

Form elongate oval.

Vittae moderately, nearly uniformly wide, distinctly sinuous, abruptly constricted near middle, distinctly branched at both ends.

Prothorax moderately coarsely and sparsely punctate; length 2.4 mm.; Alberta, Can. .... 9. **alberta** n. sp.

Vittae nearly uniformly narrow, moderately sinuous, somewhat feebly branched at the ends.
Prothorax finely, distinctly and densely punctate; Oreg. .... 10. **perspicua** n. sp.
Form oblong oval, less than twice as long as wide.
Vittae very narrow, sinuous, humeral branch short, apical branch not distinct; length 1.6 mm.; Colo. .... 11. **obtusa** n. sp.
Fifth antennal joint ♂ short, not as long as 3 and 4 together.
Vittae strongly constricted at middle with distinct branches each end.
Vittae wide, parallel with suture on inner margin, not distinctly incurving at base, wide and not appendiculate at apex; length 2.4 mm.; Alberta, Can. .... 12. **oblonga** n. sp.
Vittae narrow and sinuous, humeral branch short, apical one appendiculate; length 1.8–2.0 mm.; Calif., Nev. .... 13. *ramosa* Cr.

IV. BIPUSTULATA group

Elytra each with one or two yellow or reddish spots

Elytra each with two yellow or reddish spots.
Fifth antennal joint ♂ inflated, in ♀ not inflated.
Elytral spots wide, light yellow, subapical one incurved; Southern States, Eur. .... 7*b*. *vittata discedens* Weise
Elytral spots narrow, reddish or dark yellow, subapical incurved; Northern States, Alaska, Can. .... 7*c*. *vittata* **lineolata** n. var.
Fifth antennal joint ♂ not inflated as in ♀.
Elytral spots large, yellow, subapical one not incurved; Northeastern U. S., Can. .... 14. *bipustulata* Fab.

Elytra each with only one small, more or less indistinct reddish subapical spot or exceptionally with a similar subhumeral spot; elytral punctures serial; Nev., Mont., Idaho, Calif. ...... 18*a*. *decipiens* **ordinata** n. var.

TABLE B

Elytra unicolorous, without vittae or large spots

Fifth antennal joint of ♂ distinctly wider than adjacent joints .... V. *denticornis* group

Fifth antennal joint of ♂ and ♀ similar, not wider than other joints... VI. *chalybeipennis* group

V. DENTICORNIS group

Elytra without vittae or each with a single small spot
Antennal joints 4 and 5 dilated, 7–11 generally wider than preceding

A. Black, without metallic luster.

Antennae ♂ with joints 4 and 5 much dilated, 5 longer and more strongly dilated, length 2.2–2.5 mm.

Form elongate oval. Lower angle ♂ antennal joint 6 very short, prolonged in an acute process; Calif., Oreg. .... 15. *denticornis* Horn

Form ellipsoid oval, slender. Lower angle ♂ antennal joint 6 suboblong, subequal to 7 in length, not prolonged; Wash. ... 16. **amplicornis** n. sp.

Form oblong oval, robust. Antennal joints 1–3 pale, 6 equal to 4; legs reddish brown; Ohio... 17. *ulkei* Horn

Antennae ♂ with joint longer than others, but less strongly dilated; distinctly convex, coarsely punctate; prothorax nearly twice as wide as long; length 1.8 mm.

Elytral punctures not, or somewhat indistinctly, serially arranged, subapical red spot more or less constant; Pacific States, Colo., Western Canada... 18. *decipiens* Horn

B. Aeneous, green, or black with metallic luster. Feebly convex, finely punctate, prothorax less than one-third wider than long.
  - Fifth antennal joint of ♂ one-third wider to twice as wide as fourth.
    - Fourth ventral segment of ♂ distinctly wider than 3; 5th deltoid.
      - Ventral segments especially ♀ all with distinct gray pile. General color black or dark aeneous; Western U. S. .... 19. *albionica* Lec.
    - Fourth ventral segment of ♂ subequal in width to preceding.
      - Ventral segments ♀ with less distinct, more setiform hairs.
        - Fifth antennal joint of ♂ elongate oval, second shorter than third.
          - Body metallic dark green; Colo. .... 20. **herbacea** n. sp.
      - Ventral segments ♀ feebly gray pilose.
        - Fifth antennal joint of ♂ very feebly dilated.
          - Body green, bronze or black; Southern Calif., Southern Tex., Ariz. .... 21. **prasina** n. sp.

Subgroups of *chalybeipennis* group

Antennal joints 4 and 5 similar in the sexes, not dilated

Antennal joint 5 very little longer than 4 or 6
  - Fifth ventral segment with tubercles each side of apex in ♂ only.
    - Elytral punctures of two distinct sizes; colors bright blue, green, purple or aeneous. *chalybeipennis* subgroup
    - Elytral punctures equal and uniform .... *lewisii* subgroup
  - Fifth ventral segment ♂ and ♀ with tubercles at apex .... *pusilla* subgroup

Antennal joint 5 more distinctly longer than preceding.
  Fifth ventral segment without tubercles .... *viridicyanea* subgroup

chalybeipennis subgroup

Elytral punctures of two distinct sizes, larger with tendency to form striae; colors bright blue, green, purple or aeneous, basal antennal joints yellowish.
  Elytra with small punctures interspersed with very large ones; length 2.3–2.8 mm.; Atlantic seacoast .... 22. *chalybeipennis* Cr.
  Elytral punctures not so diverse in size; length 1.2–2.0 mm.; Colo., Kans., La., Tex. .... 23. *aeneicollis* Cr.

lewisii subgroup

Elytral punctures equal and uniform

A. Body elongate oval, about twice as long as wide.
  a. Form depressed or subdepressed.
    Antennae more than half as long as the body.
      Dorsum notably blue or greenish, exceptionally black.
        Elytral punctation without serial tendency; length 2.0–2.7 mm.; Western U. S. .... 24. *lewisii* Cr.
    Antennae approximately half as long as the body.
      Antennae fully half as long as the body.
        Dorsum and prothorax with distinct green luster; elytra dark blue.
          Elytral disc with decided tendency to serial punctation; length 1.8–2.3 mm.; B. C., Can. .... 25. **columbiana** n. sp.
    Antennae less than half as long as the body.

Head with small eyes, not prominent; prothorax short; elytra long and slender.
Fifth ventral segment ♂ flat at apex; Southern Calif., N. Mex., Nev. .... 26. **subnitida** n. sp.
Antennae very slender, slightly more than half as long as the body.
Head with large eyes, prominent; prothorax large; elytra rather shorter.
Fifth ventral segment ♂ transversely concave at middle; N. Y., Eur. .... 27. *aerea* All.
b. Form convex.
Antennae less than half as long as the body; joints 7–11 gradually and strongly widened to apex.
Dorsum entirely with faint metallic luster.
Prothorax not deeply punctate, elytra not serially punctate; length 1.3–1.5 mm.; Western Can., Wash. 28. **inconspicua** n. sp.
Antennae a little more than half as long as the body, slender, joints 7–11 scarcely wider.
Prothorax rather strongly arcuate at the sides.
Dorsum brightly shining black with metallic luster; Southern Calif., Ariz., Colo., N. Mex. .... 29. **fulgida** n. sp.
B. Body short oval, less than twice as long as wide.
Prothorax large, distinctly densely punctate; antennae very slender.
Fifth ventral segment ♂ with a large transverse oval concavity; body blue black with faint luster; Utah .... 30. **transversovalis** n. sp.

Fifth ventral segment ♂ flat at apex; body with prothorax aeneous green, elytra black without color luster, length 1.7 mm.; Manitoba, Can. .... 31. **brevipennis** n. sp.

pusilla subgroup

Fifth ventral segment ♂ and ♀ with tubercles at apex

Body depressed, elongate subovate; prothorax very narrow, ventral segments not or feebly rugose; fifth ventral ♂ narrowly flattened at apex; Western U. S. .... 32. *pusilla* Horn

Body convex, elongate oval; prothorax wide, ventral segments strongly rugose; fifth ventral ♂ narrowly transversely concave; Ariz. .... 33. **laticornis** n. sp.

viridicyanea subgroup

Antennal joint 5 more distinctly longer than preceding ones
Fifth ventral segment without tubercles at apex in either sex

Antennal joint 5 of ♂ nearly as long as 3 and 4 together, metallic green, basal joints of antennae bright yellow or red; Calif. .... 34. **viridicyanea** n. sp.

Antennal joint 5 of ♂ only one-fourth to one-third longer than 3; elytra polished or varnished black.

Dorsum strongly but finely punctate; elytra with metallic luster.

Fifth ventral segment ♂ with a large deep deltoid concavity at apex; Oreg., Utah .... 35. **polita** n. sp.

Dorsal punctation feeble; elytra without metallic luster.

Fifth ventral ♂ with small distinct circular concavity at apex; Tex. .... 36. **inordinata** n. sp.

1. *Phyllotreta armoraciae* (Koch) (Fig. 1)

Haltica armoraciae Koch, Entom. Hefte, v. 2, 1803, p. 75.
Haltica vittata Stephens, Mandibulata, v. IV, 1831, p. 297.

Phyllotreta armoraciae Koch, *in* Erichson, Naturw. Ins. Deut., v. 6, 1893, pp. 865, 866; Chittenden, Insect Life, v. VII, 1895, pp. 404–406; Chittenden & Howard, N. F., Bul. 535, 1917, pp. 1–16; Chittenden, Proc. Ent. Soc. Wash., 1923, p. 139.[6]

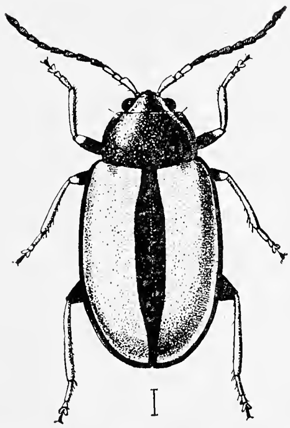

Fig. 1.—*Phyllotreta armoraciae* ♂ The horse-radish flea-beetle, highly magnified.

Elongate oval, strongly convex, black, shining; elytra cream-colored or buff with a black sutural stripe. Antennae half as long as the body, three basal joints yellow. Head finely sparsely punctate. Prothorax one-fourth wider than long, much wider at apex than head, moderately arcuate at the sides; disc rather coarsely and sparsely punctate. Elytra cream-colored or buff, wider at base than the prothorax, humeri rounded, umbone not prominent, anterior two-thirds of sides subparallel, posterior arcuate; disc with a narrow sutural black stripe, widened at the middle, a marginal thin black stripe each side; surface finely punctate, punctures not deep, rather dense. Ventral segments shining black, punctate, fifth strongly so, pilose. Femora black, apices yellow, tibiae and tarsi yellow.

♂.—Antennal joints slender; 2 short, subovate; 3 one-third longer, 4, 5, 6 subequal; 7–11 a little wider, twice as wide as 2, 3, 4. Fifth ventral segment with small concavity at the middle.

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[6] European references, of which there are many, have been largely omitted.

♀.—Antennal joints as in the male. Fifth ventral segment widely but not deeply concave transversely, otherwise simple.

Length 2.6–3.4 mm.; width 1.3–1.9 mm.

A European species quite distinct from any native form. It was introduced into this country and first recognized by the writer in 1893 at Chicago, Ill. It now inhabits the Eastern States from Massachusetts, New York and New Jersey to Wisconsin, Iowa and Nebraska and occurs also in Ontario and Quebec, Canada.

This species, known as the horse-radish flea-beetle, is an economic factor in the growing of horse-radish (*Radicula armoracia*) in our Northern States. The larvae as well as beetles live on the leaves and petioles and when numerous injure the plant so as materially to reduce the root crop. The larvae mine the petioles or midribs while the adults feed on the leaves, causing characteristic flea-beetle injury, withering and dying, or they gouge pits in the petioles or midribs. A general article on this species was published in 1917 (l. c.), to which the reader is referred for more detailed information in regard to its distribution and biology.

1*a*. *Phyllotreta armoraciae* **biplagiata** n. var.

A male specimen collected at Green Bay, Wis., May 29, 1915, by N. F. Howard, may be described as follows:

> Of the same form as normal *armoraciae*, differing in having two narrow yellow elytral vittae. The subsutural one is subparallel in the anterior two-thirds and leaves a wider sutural black area. The humeri are black and behind them this vitta widens and unites with the lateral vitta for a short distance, then narrows and separates but unites with the subsutural vitta near the apex. The area between the vittae is black on one elytron but shows some tendency to unite the two vittae on the other.

Type ♂.—Cat. No. 28,792, U. S. National Museum. Unique.

The writer is inclined to the belief that *armoraciae* was originally bivittate, *i.e.*, bore two pale vittae on each elytron.

2. *Phyllotreta lepidula* (Lec.)

Haltica lepidula Leconte, Pacific R. R. Rept., 1857, p. 68.

Orchestris lepidula Lec., Crotch, Proc. Acad. Nat. Sci. Phila., 1873, p. 65.

Phyllotreta lepidula Lec., Horn, Trans. Am. Ent. Soc., 1889, pp. 294, 295.

Oblong oval, moderately convex, shining black, surface with faint aeneous luster, each elytron with a narrow, simple, yellow vitta, nearly straight, incurved at apex. Antennae less than half as long as the body, shining black, joints 1–4 usually paler. Head rather coarsely and closely punctate. Prothorax not quite twice as wide at base as long, sides arcuately narrowing to the front, disc convex, coarsely and moderately closely punctate, surface faintly alutaceous. Elytra slightly wider at base than prothorax, surface more finely and sparsely punctate than prothorax, smoother at apex, the yellow vitta nearly exactly median, rather narrow, of equal width throughout, slightly incurved at apex. Ventral segments shining black with a faint aeneous luster, sparsely, finely punctate. Femora similar in color, tibiae paler at base, tarsi yellowish.

♂.—Antennal joints 2, 3, 4 subequal in length; 4 distinctly wider; 5 much wider, equal in length to 3 and 4 together; 6 very short, a little wider than long, deltoid; 7–11 gradually wider, 11 longer. Fifth ventral segment notched each side with impressed median line, sometimes extending the entire length of the segment.

♀.—Antennal joint 5 about as long as 3 and 4 together, not wider; 6 a little shorter than 2, otherwise as in male. Fifth ventral segment simple.

Length 2.0–2.5 mm.; width 1.0–1.2 mm.

Described from San Jose and San Diego, Calif. The writer has seen specimens from Los Angeles and Humboldt Co., Calif. The species does not appear to be recorded outside of California and is most commonly found in the southern part of that state.

3. *Phyllotreta oregonensis* (Crotch)

Orchestris oregonensis Crotch, Proc. Ac. Sci. Phila., 1873, p. 66.

Phyllotreta oregonensis Crotch, Horn, l. c., p. 296, pl. VI, fig. 16; Chittenden, l. c., p. 135.

Oblong oval, moderately robust, shining black, surface aeneous; prothorax dark green; elytral vitta broad, sinuous, somewhat incurved at base, strongly so at apex. Antennae nearly half as long as the body, black, two or three basal joints a little paler. Head rather closely, not coarsely punctate. Prothorax nearly twice as wide at base as long, narrowed in front, sides strongly arcuate; disc convex, punctures moderate and rather closely placed. Elytra a little wider at base than prothorax, humeri rounded, disc convex, punctation a little coarser and closer than on the prothorax, without distinct serial arrangement, the vitta broad, as wide at middle as the distance to the suture, at base incurved, a broad, short, post-humeral branch, apical third strongly arcuate and incurved. Ventral surface piceous, abdomen sparsely punctate. Femora piceous, tibiae pale, brown at middle, tarsi pale.

♂.—Antennal joints 2, 3, 4 subequal; 4 short ovate, narrow; 3 distinctly wider, deltoid; 4 wider than 3; 5 wider than 4, as long as 3 and 4 combined and longer than 6 and 7 together, feebly convex on dorsal, convex on lower surface; 6 about as wide as long; 7–10 wider, subequal in length, 11 a little longer. Fifth ventral segment rather deeply concave each side, somewhat deeply, roundedly subdeltoidly concave at apex with a small distinct tubercle each side.

♀.—Antennal joint 4 equal to 3 in length and width; 5 not quite as long as 3 and 4 together and not wider; 6 as long as 4, wider at apex; remaining joints as in the male. Fifth ventral segment concave each side, but not concave at apex or middle.

Described from Oregon and stated by Horn to occur in Nevada. Specimens also from Rocky Ford, Fort Collins, Paonia, Fowler, Grand Junction and Montrose, Colo.; Laramie, Wyo.; Logan, Utah; "Utah"; Childress, Tex. (on turnip); Garden City, Hayes, Kans. (on turnip); Medicine Hat, Alberta, Canada (F. S. Carr).

Subject to very unusual variation in size and considerable variation in the width of the elytral vittae. Horn's definition of the male "antennae as in *vittata*" is incorrect, as will be noted from description above, the fourth and fifth joints in particular being widely dilated.

Reported in Colorado feeding on leaves, seed-heads and flowers of sugar beet, on foliage and flowers of peppergrass, *Lepidium* (*scopulorum*) *spathulatum*, and on *Cleome serrulatum*. The leaves of these weeds were extensively mined by the larvae, which were reared to adults July 8. Observed also feeding on radish, turnip and marsh-cress (*Radicula palustris* and *terrestris*).

4. *Phyllotreta robusta* Lec.

Phyllotreta robusta Leconte, Proc. Am. Phil. Soc., 1878, pp. 614, 615; Horn, l. c., p. 297, pl. VI, fig. 18.

Elongate oval, moderately convex, shining black, aeneous, elytra with a broad yellow vitta dilated at humerus and broadly at apex, reaching the sides and apex. Antennae as long as half the body, black, three or four basal joints pale. Head alutaceous, somewhat indistinctly punctate. Prothorax nearly twice as wide as long, slightly narrowed in front; sides arcuate; disc convex, alutaceous, coarsely, deeply and closely punctate. Elytra scarcely wider at base than the prothorax, humeri obliquely rounded, surface rather more coarsely punctate at base than the prothorax, gradually more finely to apex, the yellow vitta broad, parallel with the suture the greater part of its length, incurved at the scutellum, a broad post-humeral process, the apical third broadly expanded, reaching the apex and side margin. Lower surface black, aeneous, ventral segments sparsely punctate. Femora black, tibiae and tarsi paler.

♂.—Antennal joints 2, 3, 4 subequal in length; 4 slightly wider, 5 as long as two preceding, apical free angle subacutely produced; 6 short and narrow, about as wide as long; 7–10 subequal; 11 longer. Fifth ventral segment sinuate each side, deeply impressed at middle, concavity thus formed extending nearly to the base of the segment.

♀.—Antennal joints about as in *oregonensis*. Fifth ventral segment slightly sinuate each side, otherwise simple.

Length 1.5–1.8 mm.; width 0.7–0.9 mm.

Originally described from Detroit, Mich., this species has been recorded from Lake County, Ind., and Garland, Colo. Specimens have been examined in the National Museum and other collections from Alamosa, Colo.; Lake Okoboji, Iowa (L. Buchanan); Marquette, Mich. (Hubbard and Schwarz); Medina (C. C. Sperry), University, N. D. (R. P. Currie); Salt Lake City (T. D. Urbans), Provo, Utah (Wickham); Elko, Nev. (Wickham); Assiniboine (Hubbard and Schwarz); Helena, Mont. (W. M. Mann); Jerome, Idaho (C. F. Stahl); Aweme, Onah, Teulon, Manitoba (N. Criddle); Ogema (N. Criddle), Saskatoon, Saskatchewan, Can. (K. M. King). The distribution probably ranges through intervening territory.

The beetles have been observed at Madison and Waupaca, Wis., on radish by L. G. Gentner, and at Knox, Ind., on turnip, June 27, 1911, by M. M. High.

Normal variation in this species is inconsiderable. A single female measures 2.2 mm. in length, otherwise the species is, with *liebecki* and *vittata,* one of the smallest of our vittate series.

5. *Phyllotreta zimmermanni* (Crotch) (Pl. I, Fig. 3)

Orchestris zimmermanni Crotch, Proc. Acad. Sci. Phila., 1873, p. 66.

Phyllotreta (*Haltica*) *sinuata* (*nec* Steph. *et auct.*) Horn, Trans. Amer. Ent. Soc., vol. XVI, 1889, p. 295, pl. VI, fig. 15.

Phyllotreta zimmermanni Cr., Riley, C. V., Rept. Comm. Agr. f. 1884 (1885), pp. 305, 306; Heikertinger, Verhandl. Zool. bot. Gesells. Wien., vol. LXI, 1911, pp. 12, 13, 19, fig. 7; Chittenden, Proc. Ent. Soc. Wash., v. 25, 1923, p. 132, 133.

Elongate oval, moderately robust, shining black, scarcely aeneous; each elytron with a narrow sinuous vitta, feebly incurved toward the suture at base. Antennae nearly half as long as the body, black, the three or four basal joints mostly paler. Head sparsely, finely punctulate. Prothorax nearly twice as wide at base as long, sides rather strongly arcuate and distinctly narrowed at apex; disc convex; surface very finely alutaceous, punctures distinct, not coarse, more widely placed than their own diameters. Elytra scarcely wider than the prothorax, humeri obliquely rounded, disc convex, punctures coarser and closer than those of the thorax, finer near the apex, with strong tendency to serial or linear arrangement on the disc; vitta narrow, subparallel with the suture in basal half, very feebly incurved at base, with a short, broad, post-humeral branch, apical third strongly sinuous, recurving toward but not quite reaching the suture. Ventral surface black, abdomen sparsely punctate. Femora piceous, tibiae and tarsi partly brown.

♂.—Antennal joints 2, 3, 4 subequal in length; 3 wide, deltoid; 4 one-third wider than 3, much widened at apex; 5 as long as 3 and 4 combined, and much wider, irregularly oblong oval, distinctly convex on upper, concave on lower surface; 6 very small, nodiform; 7–11 subequal in length and wider. Fifth ventral segment deeply concave each side and in middle, the latter concavity deltoid with a median impressed line extending the entire length of the segment.

♀.—Antennal joint 5 nearly as long as the preceding or following two, but not wider. Fifth ventral segment usually simple, sometimes faintly to distinctly impressed at the sides.

Length 1.8–2.4 mm.; width 0.9–1.2 mm.

This species is distinct from *sinuata* Steph., which does not occur in America. The distribution extends from New England to Mississippi and westward to Manitoba. Specimens examined from Mashpee, Mass.; Norwalk, Conn.; Bloomington, Ill.; St. Louis and Charleston, Mo.; Knox, Independence, Ind.; Rosslyn, Arlington, Va.; Washington, D. C.; Berwyn, Md.; Chadbourn, Biltmore, N. C.; Natchez, Miss.; Omaha, Nebr.; Iowa City, Ia.; Baldwin, Lawrence, Topeka, Kans.; Elkins, Ark.; Madison, Green Bay, Wis.; Florence, Mont.; St. Anne, Quebec, Canada; Bandon, Aweme, Miami, Rosebank, Winnipeg, Thornhill, Manitoba.

In the male the fifth antennal joint is distinctly bowed. The impressed line in the male ventral concavity is sometimes shorter than described.

Two examples, from Iowa, of what appear to be otherwise normal *zimmermanni*, differ in such a remarkable manner as to appear deserving of notice. The antennae are as in the female, the fifth ventral segment is distinctly concavely impressed at the sides, as in the male, and the apex distinctly, but not deeply impressed at the middle, the impression extending nearly half the length of the segment. Two females of *zimmermanni* from the District of Columbia show impressions on the fifth ventral segments at the sides only.

Ph. zimmermanni, called ''Zimmermann's flea-beetle,'' occurs in numbers on *Lepidium* and *Arabis*, the larva mining the leaves. In 1913 and 1914 the larva was observed mining the leaves of cultivated cress and the beetles feeding on the foliage of cress, radish, turnip and cabbage at Quebec, Canada; the cress was practically destroyed by the beetle and its larva. In May, 1919, the species was reported on cabbage, radish and horse-radish at Madison, Wis. In June, 1920, this species, in company with *Ph. vittata*, destroyed an entire planting of mustard at Arlington, Va., eating the plants to the ground.

A biological account of this species was published by Riley in 1885 (l. c.), including a description of the egg, larva, pupa, and of the adult in comparison with *vittata*. Of the larvae Riley remarked that although the two species are quite similar, they ''differ widely in habit,'' and at first sight it might appear quite a step from a leaf-miner to a root-feeder. That such is not the case has been conclusively proved by experiment. A larva, being reared in a vial and having exhausted the leaves, bored through a stalk and finally formed a mine under the skin on one side, living quite as well in this manner as otherwise. It would be an easy transition for a leaf-mining larva of this genus to follow down a stem to the roots in such low-growing plants as *Lepidium*.

6. *Phyllotreta utana* Chttn. (Pl. II, Fig. 6)

Phyllotreta utana Chittenden, Jour. Wash. Ac. Sci., v. 10, 1920, pp. 389, 390, fig. 1.

Elongate oval, moderately convex, shining black with more or less distinct metallic luster; prothorax and elytra variably black or aeneous; elytral vittae narrow, feebly sinuous, pale yellowish. Antennae less than half as long as the body, joints 2 to 5 usually honey yellow, 1 and 6 either partly black or pale, remainder piceous. Head finely, densely punctate. Prothorax about one-third wider than long, wider than the head at the apex, sides strongly irregularly arcuate; surface distinctly, rather closely punctate. Elytra wider at base than prothorax, humeri abruptly, narrowly rounded, umbone moderate, sides somewhat feebly arcuate. Vittae narrow, rather feebly recurved toward suture at base, subparallel in middle third, about half as wide in apical fourth, incurved toward, but not reaching the suture, humeral branch distinct and broad, no apical branch; surface scarcely more coarsely punctate than on the thorax with the exception of the base and without tendency to serial arrangement. Ventral segments subopaque black, rather feebly and sparsely punctate, sparsely pilose with short black hairs. Femora piceous, punctulate; tibiae and tarsi yellowish brown.

♂.—Antennal joints 2, 3, 4 subequal in length; 3 wider at apex; 4 much wider, deltoid; 5 still wider, about one-half longer than 4, depressed, inner face longer, straight, outer surface arcuate; 6 nodular; 7–11 a little wider than 3, 11 a little longer. Fifth ventral segment concave at the sides, distinctly concave at the apex with a distinct tubercle each side and a fine median impressed line about the length of the segment.

♀.—Antennae about as in *zimmermanni* and *vittata*. Last ventral segment simple.

Length 2.5–3.0 mm.; width 1.4–1.5 mm.

Logan, Utah (type locality); also Alta, Park City, Utah; Elko, Nev.; Corvallis, Forest Grove, Oreg.; Florence, Mont.

In general appearance and punctation this species is similar to *zimmermanni*. In addition to the distinctive characters of the antennae, joints 2–5 honey yellow and 5 flat, not bowed, and the last ventral segment of the male, the elytral vittae are quite different from other species, approaching *zimmermanni*, but are not so distinctly sinuate or so distinctly yellow as in that species. It is larger than the latter, which measures only 1.8–2.4 mm.

Has been observed attacking sugar beet and was abundant in a beet field overgrown with hedge mustard, on which it was also taken.

7. *Phyllotreta vittata* (Fab.) (Pl. I, Fig. 1)

Crioceris vittata Fabricius, Syst. Eleuth., v. I, 1801, p. 469.

Haltica striolata Fabricius, *in* Illiger, Mag. f. Inseckten-Kunde, v. VI, 1807, p. 148.

Orchestris vittata Fabricius, Crotch, Proc. Ac. Sci. Phil., 1873, p. 66.

Phyllotreta sinuata Redtb. *et auct.* (cf. Heikertinger).

Phyllotreta vittata Fabricius, Horn, Trans. Am. Ent. Soc., 1889, p. 296; Heikertinger, Die Käfer des deutschen Reiches, v. 16, 1913, p. 174, 175, fig. 20; Chittenden, l. c., p. 133, fig. 1.

Elongate oval, moderately convex, shining black, surface with slight aeneous luster, elytra with a yellow vitta incurved at base, thickened and slightly incurved at apex. Antennae half as long as the body, piceous, the basal two or three joints testaceous. Head sparsely, finely punctate with a frontal longitudinal impressed line. Prothorax about one-third wider than long, narrowed in front, sides moderately arcuate, convex; surface minutely alutaceous, punctures moderately coarse and close, denser at the sides. Elytra a little wider at base than the prothorax with humeri obliquely rounded, convex, punctures scarcely coarser than those of the prothorax, moderately closely placed, finer near the apex and with a strong tendency to a serial arrangement in the yellow vitta. Vitta usually strongly constricted at middle, incurved at base and with a broad, short, post-humeral branch, apical third abruptly broader, incurved apically toward, but not attaining the suture, on the apex. Ventral segments subopaque black, faintly alutaceous, punctures numerous, but not coarse. Legs piceous, tibiae and tarsi brown.

♂.—Antennal joints 2, 3, 4 subequal in length; 4 wider, 5 a little wider than 4, nearly equal in length to 3 and 4 together or 6 and 7 combined; 6 short; 7–10 subequal; 11 longer. Fifth ventral segment concave at apex, concavity small, moderately deep and more or less circular in outline.

♀.—Antennal joints 2, 3, 4 and 7–11 as in male; 5 scarcely shorter but narrower than in male. Fifth ventral segment simple, but in some specimens there is a faint impression at the apex.

Length 1.6–1.8 mm.; width 0.8–0.9 mm.

This species, the well-known striped cabbage flea-beetle, also inhabits Europe and northern Asia and evidently is an introduction from the Old World. In America it occurs from New England westward to Wisconsin, Kansas, and neighboring western States, southward to the Gulf States, as also in California. It occurs commonly in southern Canada, also in Nova Scotia, Manitoba and British Columbia. So far as known, it has not yet reached the strip of States from Montana to New Mexico.

The food plants known to the writer include cabbage, cauliflower, turnip, radish, mustard (*Brassica nigra* and *arvensis*), horseradish, watercress, peppergrass (*Lepidium*), charlock (*Sinapis*), shepherd's purse (*Bursa*), stock (*Matthiola incana* et al.), Virginia stock (*Cakile maritima*), rocket (*Hesperis matronalis*), hoary alyssum (*Berteroa incana*), sweet alyssum (*Alyssum maritimus* et al.), wallflower (*Chieranthus cheiri*), candytuft (*Iberis*), yellow cress (*Radicula silvestris*), sea lavender (*Statice sinuata*), *Erysimum* spp., and the beetle probably attacks all other Cruciferae and Capparidaceae. The larva is restricted to these two families, but the beetles when in unusual numbers have been reported to attack plants of other botanical families, such as peas, beets, celery, tomato, and strawberry. Reports of injury to such plants are apt to be erroneous, the insect in reality living on cruciferous weeds growing in truck patches between rows.

In 1885 Riley[7] gave an account of *vittata* and its habits as known at that time with special reference to injuries to cabbage and turnips, the account including a detailed description of the larva.

Five color varieties or forms exist, two of which have been described.

7*a*. *Phyllotreta vittata monticola* Weise

> *Phyllotreta vittata monticola* Weise, Naturg. Ins. Deutsch., pt. I, vol. 6, 1893, pp. 873, 874.

> Elytra each with the yellow vitta covering a great part of the elytron, leaving a small marginal border scarcely or very feebly constricted at the middle and evenly arcuate in outline.
>
> Length 1.8 mm.; width 0.9 mm.

Specimens from Marburg, Styria, Austria, have been received from Franz Heikertinger, which are typical. In a lot of hundreds of specimens examined it is represented from Huntington Beach, Calif.; Edmonton, Alberta, Canada, and the District of Columbia. This variant is comparatively rare on this Continent.

[7] Rept. Comm. Agr. 1884 (1885), pp. 301–304.

7*b*. *Phyllotreta vittata discedens* Weise (Pl. I, fig. 2)

Phyllotreta vittata discedens Weise, l. c., pp. 873, 874.

Elytra each with two large irregular, wide yellow spots; humero-basal spot not extending to lateral margin or reaching the base, incurving basally toward the elytral suture; subapical spot narrower, widely subreniform, incurved apically toward the suture.

Length 2.0 mm.; width 0.8 mm.

This variant occurs more commonly in the South, in the Gulf States practically taking the place of normal *vittata*. Numerous specimens from San Antonio, Cuero, Tex.; Baton Rouge, La.; Crystal Springs, Miss., and Orlando, Fla.; occasionally seen from St. Louis, Mo. Once taken at Plummer's Island, Md., about five miles from the District of Columbia, by W. L. McAtee.

It is smaller than *bipustulata*, with which it has been generally confused and which it closely resembles in coloration and punctation, distinctly differing in the antennal structure of the male and the incurved subapical vitta. There is a tendency in this species to lighter coloration in the paler portions. One fully developed specimen has the first four antennal joints, tibiae and tarsi pale yellow.

7*c*. *Phyllotreta vittata* **lineolata** n. var.

Elytra each with a very narrow incurved dark red or bright yellow subhumeral spot, and a longer and narrow incurved subapical spot, the latter either widely separated from the humeral one or exceptionally connected by a faint red or yellow line.

Length 1.8 mm.; width 0.9 mm.

Corvallis, Oreg., July 2, 1918; Ft. Collins, Colo.; Washington; Waupaca, Wis.; Knox, Ind.; Ithaca, N. Y.; Birmingham, Ala.; Muscatine, Iowa; Rampart, Alaska.

Type ♂.—Cat. No. 28,805, U. S. National Museum.

The type of this variant, although related to *vittata discedens*, resembles also *decipiens ordinata*, which latter has either one or two spots on each elytron.

7*d*. *Phyllotreta vittata* **vernicosa** n. var.

Surface brightly shining black. Antennae scarcely half as long as the body, first and second joints reddish, remainder piceous. Prothorax very large and wide with two depressions each side; surface not deeply punctate. Elytra so highly glittering like varnish as to partially obscure the punctation, which is not at all serial in character. Femora pale at apex, tibiae yellow at each end, tarsi dark brown.

♀.—Antennal joint 5 not wider than adjacent joints, or about as in the female of typical *vittata*. Fifth ventral segment distinctly longitudinally impressed for more than half its length, not circular in outline.

Length 2.5 mm.; width 1.2 mm.

Fieldbrook, Calif., May 30 (H. S. Barber).

Type ♀.—Cat. No. 28,809, U. S. National Museum. One specimen.

The type is much larger than normal. The antennal structure indicates that it is a female, but the median impression of the fifth ventral segment is masculine. A similar case is cited in the discussion of *zimmermanni*.

7e. *Phyllotreta vittata* **artivitta** n. var.

Shorter and more robust than normal *vittata*, brightly shining black without color luster. Antennal joints 1, 2, 3 piceous, remainder black, otherwise about as in *vittata*. Prothorax strongly convex, highly polished. Elytral vittae deep ocherous, incurved at base, but not reaching basal margin, without definite branch; remainder extending in a nearly straight and narrower line, not attaining the apex. Surface of elytra without distinct tendency to serial arrangement of punctures. Legs black.

Length 1.5 mm.; width 0.9 mm.

Muscatine, Iowa (F. M. Wadley).

Type ♂.—No. 28,803, U. S. National Museum. One male.

The vittae are quite unlike those of normal *vittata*, more nearly resembling *zimmermanni*, but the antennae are practically the same. This aberration is described from a somewhat imperfect, poorly mounted male.

The study of the five variations of this common species interests the writer and probably many others, and it is furthermore believed that all data that have a bearing on the taxonomy of a genus or other group should be recorded. Such study may also have a bearing on the status of species or so-called species in related groups. Form *monticola* may intergrade slowly with normal *vittata*, but specimens have not been seen which confirm this supposition. Form *discedens* intergrades frequently, especially in the Gulf region, both forms being found in the same localities, and the same is true of *lineolata* in more northern regions. Forms *vernicosa* and *artivitta* are unique; hence nothing more can be said of them further than to state that well-marked individuals of each variant present the aspect of new species.

The width of the antennal joints, especially of 4 and 5, is quite variable in *vittata*.

8. *Phyllotreta liebecki* Schf. (Pl. I, fig. 4)

Phyllotreta liebecki Schaeffer, Jour. N. Y. Ent. Soc., vol. XXVII, 1919, p. 439.

Similar in form and color to *vittata*, surface smoother, more shining and aeneous; elytra each with a moderately broad yellow vitta widely placed, extending to the extreme base, incurved at scutellum, dilated below humerus, moderately constricted near middle, strongly dilated near apex, apical part incurved to the suture. Antennae scarcely half as long as the body, moderately slender, joints 1–4 yellow. Head alutaceous, distinctly punctate. Prothorax about twice wider than long, sides arcuate, slightly narrowed in front; surface alutaceous, punctures moderately coarse and close. Elytra slightly wider at base than the prothorax, humeri obliquely rounded; surface moderately coarsely punctate, punctures much finer towards apex. Ventral surface piceous, abdominal segments rather sparsely punctate. Femora black with a feeble metallic lustre, yellow at apex, tibiae and tarsi yellow.

♂.—Antennal joints 2 and 3 subequal; 4 distinctly shorter than the preceding; 5 a little stouter than in *vittata;* 6 short, oval; 7–10 subequal and less elongate than in *vittata*, 11 slightly longer than the preceding. Last ventral segment impressed at sides, with a small moderately transverse impression at apex.

♀.—Third and fourth antennal joints nearly equal; fifth longer than either the fourth or sixth, the latter elongate but shorter and more slender than the seventh, seventh to tenth equal, eleventh a little longer.

Length 1.75 mm.; width 0.85 mm.

Enterprise, Florida (type); also seen by the writer from Jacksonville, Fla.; Baton Rouge, Hammond, Ponchatoula, La.; Columbus, Tex., and Plummer's Island, Md., five miles north of the District of Columbia (W. L. McAtee).

This species is distinguishable from *vittata*, which it resembles in outline and in punctation, by the male antennae, particularly the much shorter fourth and wider fifth joint, by the elytral vitta incurving to the suture, as also by the paler legs and more metallic surface.

At Baton Rouge, La., on mustard, radish and Chinese cabbage or pe-tsai, the larva reared from mines in the leaves of *Lepidium virginicum, Radicula walteri* and *obtusa* and *Arabis virginica*.

9. **Phyllotreta alberta** n. sp.

Elongate oval, slightly more than twice as long as wide, moderately convex, shining black on dorsal surface; elytral vittae ocher yellow, sinuous, nearly uniformly wide, with wide humeral and postapical branches. Antennae half as long as the body, black. Head irregularly, somewhat finely sparsely punctate, with a distinct frontal impression. Prothorax nearly twice as wide as long, moderately convex, moderately shining, with aeneous luster, somewhat strongly and sparsely punctate. Elytra elongate oval, much wider at base than prothorax, rather feebly arcuate at sides; surface strongly, rather densely punctate, with no tendency to strial arrangement on the disc, but a distinct tendency at the sides on the vittae. Each yellow vitta (without the branches) of nearly uniform width throughout, distinctly sinuous, moderately incurving toward suture at base, forming a long humeral branch, enclosing the humerus, strongly constricted at the middle toward the suture, followed by a distinct subapical branch, recurved toward apex, nearly attaining the suture. Ventral surface feebly, sparsely punctate. Tibiae and tarsi a little paler than femora.

♂.—Antennal joint 1 very thick; 2, 3, 4 short, slender, subequal; 5 as long as 3 and 4 together but shorter than 6 and 7 combined; 7 equal to 4 in length, deltoid; 7–11 nearly twice as wide as 4; 11 a little longer. Fifth ventral segment deeply transversely concave at sides, vaguely if at all impressed at extreme apex.

♀.—Antennal joints nearly as in the male. Fifth ventral segment not concave or impressed at sides or at apex.

Length 2.3–2.4 mm.; width 1.0–1.1 mm.

Edmonton, Alberta, Canada (F. S. Carr), May 1, 1918.

Collected by Mr. Carr on *Lepidium virginicum.*

Type ♂.—Cat. No. 28,791, U. S. National Museum. Paratypes in the Canadian National collection and that of F. S. Carr.

No variation worthy of mention rather than sexual is observable in the material examined. The resemblance of the females to *zimmermanni* is strong. The elytral vittae of *alberta* are wider and more abruptly constricted near the middle toward the suture than in *zimmermanni,* though not so strongly as is usual in *vittata,* and the humeral and apical branches are wider than in *zimmermanni.* The appendages are nearly black throughout, and the ventral surface is not so distinctly punctate.

10. **Phyllotreta perspicua** n. sp.

Elongate oval, twice as long as wide, moderately convex, black, elytral vitta buff yellow, very narrow, sinuous, with narrow humeral and apical branches. Antennae half as long as the body, five basal joints dull reddish yellow, first black above, apical joints black. Head nearly uniformly and densely, distinctly, but finely punctate. Prothorax nearly twice as wide as long, convex, distinctly wider at apex than the head; surface finely, distinctly and densely punctate, slightly aeneous and moderately shining. Elytra wider at base than prothorax, convex, strongly arcuate at sides; disc a little more coarsely and sparsely punctate, punctures less distinct at sides, nearly as strong at apex, with some tendency to serial arrangement. Vittae each proceeding from base, where it is incurved somewhat feebly toward the suture, humeral branch very short, extending distally from the prominent humerus a little farther than the length of the humerus, apical branch beginning about one-fifth from the apex, the vitta extending nearly to the apex but still nearer to the suture. Ventral segments distinctly, finely and densely punctate, feebly pilose at the sides with gray hairs, distinctly at the apex with fine black hairs. Posterior femora nearly smooth, black, brown at apex; tibiae and tarsi mostly reddish brown.

♂.—Antennae as in *alberta.* Fifth ventral segment scarcely impressed at sides, concave in apical half, with distinct but not deeply impressed median line half the same length of the segment and widely concave at the extreme apex.

♀.—Has not been seen.

Length 2.6 mm.; width 1.3 mm.

Klamath Lake, Oreg., 1917 (Dr. Conger, coll. Ralph Hopping).

Type ♂.—Cat. No. 28,812, U. S. National Museum. Unique.

The male has the antennae and general appearance of a female *utana.* Of the unusual fifth ventral in the male it may be added that it is subdeltoid, about one-half wider than long at the base and obtusely rounded at the apex; the surface is densely, distinctly, and finely punctate throughout and the apex is so densely pilose as to appear pubescent beyond the segment. The distinguishing features include the distinct and dense punctation of the head, prothorax and ventral segments, the finely distinctly punctate surface of the prothorax and the widely concave apex of the fifth ventral segment of the male.

11. **Phyllotreta obtusa** n. sp.

Oblong oval, robust, distinctly less than twice as long as wide, somewhat strongly convex, subopaque black; elytra each with a dull ocherous, very narrow sinuous vitta. Antennae moderately thick, a little more than half as long as the body, black, second and third joints dark brown. Head wide, surface irregular, finely punctulate. Eyes not prominent, widely separated. Prothorax large, less than twice as wide as long at base, strongly, regularly arcuate at sides, much wider at apex than head; surface somewhat uneven, sparsely subaciculately punctate. Elytra comparatively short, at base much wider than prothorax, basal three-fifths subparallel at sides, apical two-fifths suddenly but rather feebly arcuate, humeri rounded, umbone small; vitta very narrow, attaining the base where it is incurved toward the suture, and with a short humeral branch, only apical third outcurved, then incurved and narrowed, not reaching the suture; surface a little more coarsely punctate on the disc, finer at sides and apex, with moderate tendency to serial arrangement. Ventral segments shining black, very feebly punctulate. Femora black, tibiae brown, tarsi pale yellowish brown.

♂.—Antennal joints 2 and 3 subequal in length and width; 4 not wider, shorter than 2 and 3 combined; 5 slightly wider at apex than 4, fully as long as 2 and 3 together; 6 as long as 4; 7–11 wider. Fifth ventral segment strongly concave each side, apex obconical.

♀.—Unknown.

Length 1.6 mm.; width 1.0 mm.

Breckenridge, Colo., July 15, 1896, elevation 9,000–10,000 feet (H. F. Wickham).

Type ♂.—Cat. No. 28,793, U. S. National Museum. One specimen.

This species differs from any other with vittate elytra by its shorter and more robust form. The vittae resemble somewhat those of *zimmermanni* but they are distinctly incurved at the base and do not even approach the suture at the apex; they are narrower and darker in color. The head is without a depressed median line and on the prothorax there is tendency to a transverse depression near the base.

12. **Phyllotreta oblonga** n. sp. (Pl. II, fig. 5)

Moderately elongate oval, twice as long as wide, moderately convex; highly polished black on dorsum, shining black on ventral surface; elytral vittae ocher yellow, wide at the ends. Head irregularly, coarsely and sparsely punctate. Antennae distinctly less than half as long as the entire body; first three joints pale reddish. Prothorax about one-half wider than long, strongly convex, very highly polished, without aeneous luster; surface finely, feebly and sparsely punctate. Elytra rather short oval, strongly arcuate at the sides, feebly and sparsely punctate, without distinct tendency to serial arrangement. Each yellow vitta on margin toward suture extending from base toward apex in a nearly straight line, leaving between them a parallel-sided or oblong median area more than 3 times as long as wide; anterior lateral branch with its lateral margin parallel with the corresponding margin of the prominent humerus; at middle strongly arcuately narrowed but comparatively wide; posterior branch a little wider than anterior, slightly recurving at the extreme apex toward the suture. Ventral surface densely punctate. Tibiae and tarsi pale yellowish brown.

♂.—Antennal joints 2, 3, 4, 6 subequal, 5 a very little longer, 2–6 only a little narrower at the base than at the apex, 7–10 less than twice as wide, elongate deltoid, 11 a little longer. Fifth ventral segment somewhat feebly concave at sides, otherwise simple.

♀.—Antennae as in male. Fifth ventral segment simple.

Length 2.4 mm.; width 1.2 mm.

Edmonton, Alberta, Canada (F. S. Carr), June 1, 1919, on *Lepidium virginicum*.

Type ♂.—Cat. No. 28,840, U. S. National Museum. Paratype in the collection of Mr. Carr.

In some specimens only the first two antennal joints are paler than the remainder, and in some the extreme base of the elytral vitta shows a slight tendency to curve toward the suture.

This species appears to have no counterpart in our fauna, the nearly straight subsutural line of the elytral vitta distinguishing it from all other species. In others having elytral vittae strongly sinuous on the lateral margin, the base of each vitta is more or less distinctly incurved toward the suture. A similar straight inner line is present in certain European vittate species, notably *vittula*

Redtb., *nemorum* L. and *undulata* Kutsch., the last doubtfully established in the United States. Even with the rather small series available for study, one specimen indicates a tendency to the extreme color variations displayed by *vittata*. This shows only a thin subsutural line connecting the anterior and the posterior branches of the elytral vitta. The size of this species is about one-fourth longer than *vittata* and the width is considerably greater. The male sexual characters, strongly arcuate sides of the elytra and the still stronger recurvature of the lateral margin of the elytral vittae at the middle and the finer and lighter punctation are also noticeable characteristics.

13. **Phyllotreta ramosa** (Crotch) (Fig. 2)

Orchestris ramosa Crotch, Trans. Am. Ent. Soc., 1874, p. 80.

Phyllotreta ramosa Crotch, Horn, Trans. Am. Ent. Soc., 1889, p. 299; Essig, Ins. Cal., 1915, p. 282, fig. 275, 276; Insects of Western North America, 1926, p. 480, 481.

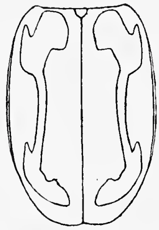


Fig. 2.—*Phyllotreta ramosa* in outline, highly magnified.

Elongate oval, more than twice as long as wide, moderately convex, black, with very faint aeneous luster, each elytron with a narrow sinuous yellow-white vitta with a humeral and lateral branch. Antennae scarcely half as long as the body, piceous, second and third joints and underside of first pale. Head with very few punctures between the eyes. Prothorax one-half wider than long, narrower in front, sides arcuate, disc convex, punctures moderately coarse and rather closely placed. Elytra a little wider at base than the prothorax, humeri rounded, disc convex, punctures coarser than those of the thorax, but not so closely placed; each elytron with a slender sinuous vitta, incurved at base and with a post-humeral branch; near the apex the vitta joins a narrow crescentic spot, one end of which points anteriorly, the other is incurved toward the suture, forming an apical branch. Ventral segments shining black, punctulate. Posterior femora black, distinctly but feebly punctulate; tibiae and tarsi largely piceous or rufopiceous.

Length 1.8–2.1 mm.; width 0.7–0.9 mm.

♂.—Antennae as in *bipustulata*. Last ventral very feebly sinuate on each side, a short, rather feeble impression at apex.

♀.—Antennae as in the male. Fifth ventral segment flat and simple.

Lakeport, Calif. (type locality); Los Angeles, Chino, Guadeloupe, Crystal Springs, Alameda, San Jose, San Mateo, Los Amitos, Guerville, Gilroy, Davis, Calif.; Elko, Nev. (Wickham); Rochester, N. Y. (Dr. D. E. Fink).

This species resembles *vittata* in color and punctation, but may be recognized by the form of the apical portion of the vitta and the undilated fifth joint of the male antenna, which will distinguish it from that species.

Essig (l. c., p. 480) reports this flea-beetle often very abundant and destructive to cabbage, cauliflower, Brussels sprouts, radish, rape, mustard, stocks, turnip, wallflower, watercress and other cruciferous plants in California.

14. **Phyllotreta bipustulata** (Fab.) (Pl. II, fig. 7)

Crioceris bipustulata Fabricius, Syst. El., vol. I, 1801, p. 464.

Orchestris bipustulata Fab., Crotch, Proc. Acad. Nat. Sci., Phila., 1873, p. 66.

Phyllotreta bipustulata Fab., Horn, l. c., p. 300; Chittenden, Bul. 33, n. s., Div. Ent., U. S. Department of Agriculture, 1902, pp. 77, 78, fig. 18; Proc. Ent. Soc. Wash., vol. 25, 1923, pp. 133, 134.

Oblong oval, moderately robust, black, shining without metallic luster; each elytron with two large, irregularly oval, yellow spots, one humeral, the other subapical. Antennae half as long as the body, distinctly thicker externally, black, the five basal joints paler. Head sparsely, finely punctate, not alutaceous. Prothorax one-third wider than long, narrowed apically, sides feebly arcuate, disc convex, punctures aciculate, not closely placed, surface very indistinctly alutaceous. Elytra distinctly wider at base than the prothorax, humeri obtusely rounded, punctures coarser than those of the thorax, but gradually finer toward the apex, and with a faint tendency to a serial arrangement at middle, humeral spot oval, touching the base, not including the umbone, subapical spot elongate oval, narrower, not incurving toward the suture. Ventral segments black, sparsely punctate. Posterior femora darker beneath, tibiae and tarsi rufotestaceous.

♂.—Antennae with fifth joint very slightly longer than 4 or 6, but not wider. Fifth ventral segment sinuate at sides, deeply concave at middle, concavity circular in outline.

♀.—Antennae with fifth joint scarcely shorter than in male. Fifth ventral feebly impressed at apex.

Length 1.6–2.1 mm.; width 0.8–1.1 mm.

Exact localities have been indicated by the writer (l. c., 1902) in the States of New York, New Jersey, Maryland, Virginia, Indiana, Iowa, Illinois and Wisconsin. Specimens also have been seen from Grand Ledge, Highland Park, Mich.; Marietta, Ohio; Berkeley Springs, W. Va.; Heyworth, Ill.; St. Louis, Mo., and Baxter Springs, Riley and Douglass Counties, Kans.

This species does occasional damage to cabbage, mustard, radish, turnip and horse-radish and occurs commonly on these plants. It also attacks wild Cruciferae, such as *Lepidium virginicum, Barbarea barbarea, Radicula palustris, Sysimbrium officinale* and *Bursa bursapastoris*. The larva is with little doubt a root-feeder.

14*a*. *Phyllotreta bipustulata conjuncta* Gentn.

Phyllotreta conjuncta Gentner, L. G., Entom. News, vol. XXXV, 1924, p. 168.

A male of this form from Riley Co., Kans., collected by F. Marlatt, and another from a lot of *Phyllotreta* collected by Mr. Gentner before he had specialized on the *Halticini* have been studied. The latter is labeled Madison, Wis., May 29, 1919, on radish. The type is from East Lansing, Mich. In the Wisconsin and Kansas specimens the two dark yellow elytral vittae are nearly separated at the middle by an extremely thin darker area. Gentner's surmise that this form "may at some time be shown to bear closer than specific relation to" *bipustulata* meets with the writer's agreement. The material now available, together with intergradational forms, in the writer's opinion, establishes positively the zoological status of this form as a variant. Thus far this variant has not been seen among Eastern material. It occupies much the same relationship toward normal *bipustulata* as *discedens* toward *vittata*.

The fifth abdominal segment in the male terminates in a subtriangular concavity, deeply impressed at the middle, the impression extending to the base of the segment.

15. *Phyllotreta denticornis* Horn

Phyllotreta denticornis Horn, Trans. Am. Ent. Soc., 1889, pp. 297, 298, Pl. VI, fig. 19.

Elongate oval, rather feebly convex, black, shining, surface with very slight aeneous luster. Antennae half as long as the body, black, second and third and a portion of the fourth joints paler. Head alutaceous, rather closely punctate. Prothorax nearly twice as wide as long, slightly narrowed in front, sides somewhat feebly arcuate, disc convex, alutaceous, moderately coarsely and closely punctate. Elytra distinctly wider at base than the prothorax, humeri rounded, umbone prominent, surface shining, not alutaceous, the punctures finer than on the prothorax, equally dense, but less impressed, smoother near the apex. Ventral segments sparsely punctulate, clothed with gray pile. Femora piceous, tibiae and tarsi brownish.

♂.—Antennal joints 2, 3 subequal in length; 2 nearly twice as long as wide, very narrow; 3 triangular, much wider than 2; 4 still wider, also longer, subdeltoid, with its inner angle produced in a subacute process; 5 longer and a little wider than 4, of elongate oval form, bowed; 6 very short, with its lower angle produced into an acute process; joints 7–10 subequal in length and width, serrate on inner surface; 11 longer. Fifth ventral segment feebly sinuate each side, strongly concave at middle.

♀.—Antennal joints shorter, 2, 3, 4 subequal; 5 fully one-half longer than preceding; 6 of same length as 2, a little wider; 7–11 slightly wider. Fifth ventral segment strongly concave each side, otherwise simple.

Length 2.4–2.6 mm.; length 1.3 mm.

Described from the male "California; region unknown." The female was also hitherto unknown. Represented by a good series from Hood River and Dalles, Oregon (Hubbard and Schwarz).

Of this species Horn remarked that while "it has the dilated antennal joints of the vittate species, the form of body and uniform color approach it to *albionica*." The females are, indeed, much alike in the two species. In the male the antennal joints are noticeably longer.

16. **Phyllotreta amplicornis** n. sp.

Elliptical oval, nearly three times as long as wide, moderately convex, shining black without metallic or other luster. Antennae barely half as long as the body, entirely black, all except second joint very thick. Head wide with distinct minute interocular fovea, feebly sparsely punctulate. Eyes of moderate size, rather widely separated, not prominent. Prothorax about one-third wider than long, moderately convex, sides moderately arcuate, at apex wider than the eyes, narrowed at base; surface rather coarsely densely punctate. Elytra suboblong, distinctly wider at apex than prothorax, humeri very broadly rounded, umbone prominent, somewhat sharply defined, sides subparallel; surface rather uneven, disc a little more coarsely and densely punctate, more feebly at sides, with a slightly elevated nearly smooth longitudinal line midway between the umbone and the suture. Ventral segments shining black, tibiae and tarsi piceous.

♂.—Antennal joint 2 one-third longer than wide; 3 much wider, triangular; 4 still wider, subquadrate; 5 slightly wider than 4, suboval; 6 suboblong, narrower than 4; remaining joints about as wide as 6. Fifth ventral segment feebly punctulate, sinuate at sides and with a large deep oval concavity at apex.

♀.—Not seen.

Length 2.2 mm.; width 0.8 mm.

Type ♂.—Cat. No. 28,802, U. S. National Museum. One specimen.

This species has more strongly developed male antennal joints than in any other concolorous species in our fauna, except *denticornis*, to which it is closely related. It is, moreover, more slender and more oblong in form and the color, especially of the antennae, is nearly uniform shining black throughout.

17. *Phyllotreta ulkei* Horn

Phyllotreta ulkei Horn, Trans. Am. Ent. Soc., 1889, p. 298.

Oblong oval, moderately convex, piceous black, shining, without metallic luster; legs, excepting the posterior femora, reddish brown. Antennae half as long as the body, piceous, three basal joints pale. Head not punctate. Thorax one-third wider than long, very little narrowed in front, sides arcuate, disc convex, sparsely regularly punctate, surface alutaceous. Elytra scarcely wider than the thorax, humeri obliquely rounded, a distinct depression within the umbone, disc convex, more coarsely, closely and deeply punctate than the thorax, a little smoother near the apex, surface shining. Body beneath piceous, abdomen sparsely punctate. Legs reddish brown, posterior femora piceous. Length 0.10 inch; 2.5 mm.

♂.—Last ventral segment distinctly sinuate each side, middle lobe moderately prominent, a deep triangularly oval impression extending more than half the length of the segment. Antennae with joints 2, 3, 4 gradually shorter and broader, fifth as long as the preceding two and more than twice as broad, sixth equal to fourth, 7–10 longer and equal, eleventh longer (Horn).

Ohio.

In commenting on this species, Horn states that it is rather more robust than any other known to him, recalling some *Chaetocnema.* Among species without elytral vittae, the male is distinguished by the broad fifth antennal joint and the simple form of the sixth, as long as the fourth.

18. *Phyllotreta decipiens* Horn

Phyllotreta decipiens Horn, l. c., p. 298.

Oval, rather strongly convex, shining black without metallic luster; elytra without an apical red spot. Antennae fully half as long as the body, first three joints black, although sometimes paler. Head obsoletely finely punctulate. Prothorax short, one-half wider than long, slightly narrowed anteriorly, scarcely wider than the head, feebly arcuate at the sides; disc convex, deeply, rather coarsely and sparsely punctate. Elytra distinctly wider at base and much wider at middle than the prothorax, humeri obtusely rounded, umbone prominent, sides somewhat strongly arcuate; disc a little more coarsely punctate than prothorax, punctures without, or with faint tendency to serial arrangement, punctation a little finer at apex. Ventral surface finely and sparsely punctulate, with short gray pile at extreme sides, darker at middle. Femora black, shining, with punctules bearing short gray pile; tibiae and tarsi piceous brown.

♂.—Antennal joints 2, 3, 4 subequal in length, 3 narrowest, 4 widest; 5 nearly as long as 3 and 4 combined, scarcely wider at apex than 4; 6 equal to 2; 7–11 about one-half wider than 4 and 5, 11 a little longer. Fifth ventral segment short, with a moderately deep, elongate deltoid depression at the middle and a small subtransverse tubercle each side at apex.

♀.—Antennal joints nearly as in *vittata.* Fifth ventral segment simple.

Length 1.8–2.0 mm.; width .9–1.0 mm.

Described from Oregon and Washington. Specimens studied from Portland, Oreg.; Auburn, Tenino, Wash.; Victoria, Vancouver Id., B. C.; Lo Lo, Mont., June 8, 1912.

In collections this species has been confused with *albionica* and *pusilla,* from both of which it may be distinguished by the male characters and by the more robust oval form and coarser punctation, especially of the elytra. It is black with only faint metallic luster, and aside from color, it is more closely related to *vittata* than to *albionica*. E. T. Cresson, Jr., kindly informs the writer, what had been concluded from Horn's description, that the type is unmarked and that the specimens described as *decipiens ordinata* do not represent what is considered typical *decipiens*.

This species is reported attacking radish, turnip, sugar beet and potato.

18*a*. *Phyllotreta decipiens* **ordinata** n. var.

Of the same form and color as normal *decipiens*. The elytra bear each a very small, often indistinct dark red subapical spot and the disc is distinctly seriately punctate. The latter is moderately convex with the punctures scarcely deeper or coarser but much more closely placed than on the prothorax and in quite regular rows or striae, feeble and less distinct at the sides and apex. Nearer the sides than the suture is the very small incurved red spot mentioned, sometimes indistinctly indicated. Ventral segments and femora about as in normal *decipiens*; tibiae reddish at the articulations, tarsi yellowish. Antennal joints about as in *decipiens*. Fifth ventral segment longer in ♂, with faint impression at apex.

Length 1.8 mm.; width 0.8 mm.

Type ♂.—Cat. No. 28,814, U. S. National Museum. Paratypes in the Canadian National Collection.

Elko, Nev. (Wickham); Bozeman, Lo Lo, Mont., June 8, 1912, June 27, 1906; Washington; Pocatello, Idaho; Portland, Oreg. (E. A. Schwarz).

Apparently different from others of this group by the more distinctly serial arrangement of the discal elytral punctures. The minute red subapical elytral spot is quite probably invisible in some individuals. In one, a female, there is also a subhumeral spot and in still another, a male, these two somewhat indistinct, though perfectly visible, spots show a decided inclination to become united. It is not impossible that perfectly vittate forms exist, that the species was originally definitely vittate and that such vittae have become obsolete or nearly so through melanism. In certain other characters this form appears different from the melanistic one, but these characters are of doubtful constancy.

19. *Phyllotreta albionica* (Lec.)

Haltica albionica Leconte, Pacific R. R. Rept., 1857, p. 68.
Phyllotreta albionica Lec., Horn, Trans. Am. Ent. Soc., 1889, p. 299, pl. VI, fig. 22.

Elongate oval, moderately convex, shining black with metallic luster, more or less aeneous. Antennae half as long as the body, slender, second, third and apical portion of the first antennal joints dark red, remainder black and densely gray pilose. Head feebly punctulate. Prothorax short and narrow, especially at apex, scarcely one-fourth wider than long, sides moderately arcuate, feebly narrowed at base; disc moderately convex, punctation relatively coarse and dense, but not deep. Elytra moderately narrow, suboblong, distinctly wider at base than the prothorax, humeri obtusely rounded; disc a little more coarsely and densely punctate than on prothorax, partially subrugose, less distinct at sides and apex. Ventral segments shining black, finely, distinctly punctate, punctures piliferous with very fine and rather long gray hairs widely separated in longitudinal and parallel rows. Femora black, finely punctulate, punctules piliferous gray; tibiae brown at the ends, also with piliferous gray punctules, tarsi yellow brown.

♂.—Antennal joints 2, 3, 4 subequal in length; 4 one-fourth wider, deltoid; 5 nearly one-third longer to twice as long as 4, less than one-third wider at apex, suboblong, less than one-third longer than wide; 6 subequal to 4; 7 a little wider and one-half longer than 6; 8–11 wider, about twice as wide as 3. Fifth ventral not sinuate, somewhat flattened at apex, each side of which is a small rounded tubercle. Pygidium visible, forming with the apex a poorly defined, rather shallow semicircle.

♀.—Antennal joint 6 much shorter than 3 and 4 combined. Fifth ventral simple without tubercles; gray pilosity of all segments more distinct than in ♂.

Length 1.5–1.9 mm.; width 0.7–0.9 mm.

Described from San Jose and San Diego, Calif., and recorded from Gallinos, Canyon, Cloudcroft and Highrolls, N. Mex. Represented in specimens examined by the writer from localities in California, including Amedee, Altadena, Oxnard, Huntington, Squaw Valley, Los Angeles, Riverside, and Salinas; and in Montana, at Selway, Alzada, Glasgow, Assiniboine, Billings, Bear Paw Mt., Bozeman, Paw Paw Mts., Huntley and Blaine Counties. The following is added: The Dalles, Huntington, Oreg.; Govan, Auburn, Ritzville, Lind, Sprague, Wawawai, Wash.; Colorado Springs, Delta, Fowler, Dolores, Paonia, Canon City, Custer County, Ft. Collins, Colo.; Sierra Ancha Mts., Ariz.; Argus Mountains, Nev.; Logan, Nephi, Promontory, Wellsville and Salt Lake City, Utah; Douglas and National Park, Wyo.; Blackfoot, Lethbridge, Idaho; Onefour, Medicine Hat, Alberta, Can., Vernon, B. C.

There are both published and unpublished records of injuries by this species to turnip, radish, cabbage, cauliflower, rutabaga, alfalfa and sugar beet. It feeds also on *Cleome integrifolia.* Early records of injury attributed to *Ph. albionica* are largely due to *Ph. pusilla,* since the latter was not described until 1899, while the former was known much earlier.

This species represents a well-defined group, the component parts of which are closely affiliated. These related forms, not hitherto described, have been confused in collections, even with species so diverse as *decipiens, pusilla* and others. The principal character that will separate the female *albionica* from most others with which it might be confused consists of the unusually heavy covering of fine gray pile proceeding from the punctures of the ventral segments.

The length and width of the male antennal joints, especially of 4 and 5, are subject to extreme variation. A series from Montana exhibits this strikingly. In these the fifth joint is quite strongly dilated, while in specimens from Washington State this joint is much smaller and narrower, scarcely more than half as wide in some examples. The fact that gradations occur, in a large series, makes it undesirable to assign a varietal name for a Montana form with the more strongly dilated fifth antennal joint.

19*a*. *Phyllotreta albionica* **corusca** n. var.

Elongate oblong-oval, more than twice as long as wide, moderately convex; elytra brightly shining metallic, faintly greenish-black, prothorax with more distinct greenish luster. Antennae fully half as long as the body, basal joints slender, apical joints more than twice as wide. Head distinctly, rather densely punctulate. Prothorax moderately convex, about one-fourth wider than long, much wider at the apex than the head, strongly unevenly arcuate at the sides, narrowed at the base; surface finely, not deeply, somewhat densely punctate. Elytra distinctly wider at base than the prothorax, rounded at humeri, umbone nearly invisible, sides parallel; surface more coarsely, irregularly and more densely punctate than the prothorax, nearly as coarsely at the sides, faintly at apex. Ventral segments moderately shining black;

finely, distinctly, rather densely punctate. Legs black.

♀.—Antennal joints 2, 3, 4 subequal in length and width; 5 longer than 3 and 4 combined, but not wider; 6 much shorter, but longer than 4; 7–11 fully twice as wide as 4. Fifth ventral segment moderately conical, slightly flattened near apex.

Length 1.6 mm.; width 0.7 mm.

Nicola Lake, B. C., August 13, 1920 (R. Hopping).

Type ♀.—Cat. No. 28,814, U. S. National Museum. One specimen.

The long fifth antennal joint indicates relationship to *albionica*, and the discovery of the male may determine the degree of this relationship.

20. **Phyllotreta herbacea** n. sp.

Elongate oval, moderately depressed, slender, a little more than twice as long as wide, dorsum metallic dark grass-green. Antennae half as long as the body, slender, first four and apical half of the fifth joint light red or yellow, apical joints dark fuscous. Head finely, regularly and densely punctulate. Prothorax about one-fourth wider than long, sides strongly arcuate, suddenly narrowed at base; disc moderately convex, punctures considerably coarser than on head, rather closely placed. Elytra moderately narrow, suboblong oval, distinctly wider at base than the prothorax, humeri subacutely rounded; disc subdepressed, more coarsely and densely punctate than the prothorax. Ventral segments shining black, distinctly punctate, the fifth more irregularly; surface scarcely pilose. Femora black, posteriorly finely punctulate, tibiae and tarsi fuscous.

♂.—Antennal joint 2 short; 3 slightly longer; 4 about one-fourth wider than 3, subovate; 5 elongate oval, still wider, fully one-half longer than wide, length equal to 3 and 4 together; 6 distinctly longer than 3, one-fourth shorter than 7, one-third longer than wide; 7–11 subequal in width, not forming a club. Fifth ventral segment not impressed at the sides, flattened with a large transverse tubercle each side; pygidium inflexed, forming a semicircular cavity.

♀.—Antennal joints 2, 3, 4 subequal; 5 a little shorter than 2 and 3 together and not wider; 6 long, but distinctly shorter than 7. Fifth ventral segment flattened, slightly acute at apex without tubercles.

Length 1.8 mm.; width 0.9 mm.

Dolores, July 20, 1906 (H. O. Marsh), Canon City, April 4 (H. Soltau), "Colorado" (Chittenden).

Observed by Marsh with *Ph. aeneicollis* feeding on turnip.

Type ♂.—Cat. No. 28,820, U. S. National Museum. Paratype in the Canadian National Collection and that of Mr. Carr.

Separable from *albionica* by the distinctly green dorsum and red or yellow basal antennal joints, the strongly arcuate and suddenly narrowed prothorax, with correspondingly wider base of the elytra, and the male antennal and ventral characters. Probably common locally and liable to be injurious; in which case it might in time extend its range in Colorado and to adjoining States.

21. **Phyllotreta prasina** n. sp.

> Elongate oblong-oval, more than twice as long as wide, somewhat strongly depressed, elytra shining dark metallic green. Antennae fully half as long as the entire body, joints 2 and 3 and a portion of 1 ferruginous. Head somewhat finely, distinctly and densely punctate. Eyes moderate in size, prominent. Prothorax very narrow, nearly as long as wide, subparallel at sides, narrower at the apex than the eyes, much narrower at the base than the elytra; surface sparsely and a little more coarsely punctate than the head. Elytra narrow, subparallel at the sides, obtusely rounded at the humeri, umbone rather large, prominent; surface somewhat uneven, scarcely more coarsely punctate than the prothorax. Ventral segments shining black, moderately punctulate, sparsely but distinctly pilose with gray hairs.
>
> ♂.—Antennal joints 2, 3 subequal; 4 a little longer and very slightly wider at apex; 5 fully one-third longer and a little wider than 4; 6 subequal to 4; 7–11 not wider than 5. Fifth ventral depressed at sides, concave at extreme apex with a rather large prominent transverse tubercle each side.
>
> ♀.—Antennal joints 4 and 5 subequal in length and width; 7–11 wider and longer. Fifth ventral segment conical, without tubercles, but with strong setiform hairs at apex.
>
> Length 1.2–2.1 mm.; width 0.7–0.9 mm.

Riverside, Calif., June 10, 1919 (C. F. Stahl); Los Angeles County (E. A. Schwarz), Kern County, Mojave, Calif. (A. Wetmore); Globe (D. K. Duncan), Argus Mts., May, 1891 (A. Koebele), Nogales, Ariz.; Brownsville, Benson, Cohise County (F. Knab), Tex.

Type ♂.—Cat. No. 28,797, U. S. National Museum. Paratypes in the Museum of Comparative Zoology, and the Canadian National Collection, and that of D. K. Duncan.

The form is quite similar to that of *pusilla,* but in the male antennae closer relationship is shown to *albionica.* The prothorax usually has a cupreous luster, and the elytra are generally bright metallic green, although exceptionally black. The fourth and fifth antennal joints in the male are smaller than in the latter, and the fifth is comparatively shorter and distinctly narrower.

This species is not rare and may at some future time prove injurious. Its food habits are unknown.

22. *Phyllotreta chalybeipennis* (Crotch)

Orchestris chalybeipennis Crotch, Proc. Ac. Nat. Sci. Phila., 1873, p. 67.

Phyllotreta chalybeipennis Crotch, Horn, Trans. Am. Ent. Soc., 1889, pp. 300, 301.

Elongate oval, moderately convex, bright blue, green or purple on dorsum, black on venter. Antennae longer than half the body, basal five joints yellow or rufotestaceous, apical joints mostly dark brown. Head sparsely, but very distinctly punctate. Prothorax about one-third wider than long, narrowed at apex, sides rather strongly irregularly arcuate; disc convex, alutaceous, moderately closely, but not coarsely punctate. Elytra scarcely wider at base than the prothorax, humeri obliquely rounded, punctation similar to that of the thorax and equally close, interspersed with much larger punctures, forming quite distinct striae near the base, five being very evident; surface irregular, not alutaceous. Ventral segments black, distinctly, sparsely punctate, sparsely pilose, hairs gray. Anterior and middle femora brown, posterior piceous with bluish green luster, punctulate apically, tibiae and tarsi pale brown, posterior tibiae more dilated than usual at apex.

♂.—Antennal joints 2 and 3 equal; 4 a little longer; 5 a little longer and wider than 4; 6 a little shorter than 5; 7–11 very little wider; 11 a little longer. Fifth ventral segment distinctly concave at the sides, truncate at apex, a distinctly impressed line extending from the base but not attaining the apex, a small transverse tubercular process each side at extreme apex. Pygidium inflexed at apex.

♀.—Antennae as in the male. Fifth ventral segment concave at sides, simple or feebly longitudinally impressed at apex, without tubercles.

Length 2.3–2.8 mm.; width 1.2–1.4 mm.

Described from New Jersey. Occurs commonly along the Atlantic seacoast from "Massachusetts to Florida," also in Bermuda.

A maritime form living on *Cakile edentula,* or sea-rocket, the leaves of which the larvae mine. The largest and most robust of all the species with simple antennae and unicolorous elytra. A beautiful and well-defined species, apparently limited to a single food plant.

23. *Phyllotreta aeneicollis* (Crotch)

Orchestris aeneicollis Crotch, Proc. Acad. Nat. Sci. Phil., 1873, p. 67.

Phyllotreta aeneicollis Crotch, Horn, l. c., p. 301.

Phyllotreta aeneicollis Crotch, Chittenden, Proc. Ent. Soc. Wash., v. 25, 1923, p. 136.

Elongate oval, moderately convex with shining metallic luster, with the appearance of slenderness and rather strong convexity; elytra variable from aeneous brown to blue, green, purple and cupreous to nearly black. Antennae moderately slender, half as long as the body, piceous, joints 2–5 and underside of first rufotestaceous, apical ones piceous. Head sparsely, indistinctly punctulate. Prothorax one-fourth wider than long, convex, narrowed in front, sides irregularly arcuate; punctation distinct, fine and dense, surface alutaceous. Elytra distinctly wider at base than the prothorax, humeri obtuse, disc rather strongly convex, the punctation coarser than that of the prothorax, punctures less closely placed but irregular, sometimes coalescing, becoming finer near the apex; near the base there are conspicuously larger punctures tending to form striae. Ventral segments black, sparsely punctate, subglabrous. Femora black, tibiae and tarsi brownish testaceous.

♂.—Antennae with joint 5 just perceptibly longer but not wider than 4 and 6; 7–11 subequally a little wider. Fifth ventral segment strongly concave at sides, feebly impressed at apex, usually without tubercles, when present minute and rounded, situated closely together inside the impression. Pygidium strongly inflated and plainly visible beyond the last segment.

♀.—Antennae as in the male. Fifth ventral segment simple.

Length 1.2–2.0 mm.; width 0.6–0.9 mm.

The sexes may be separated easily by the presence or absence of the concavity on each side of the fifth ventral. In the male the apical impression, as well as the tubercles, are not constant.

Described from Texas. This species has a range from Rocky Ford, Ft. Collins, Dolores, Colo., and Elk Point, S. Dak.—the most northern locality—southward to Baton Rouge and Berwick, La. It occurs south to Brownsville, Tex., and is fairly common in the States mentioned; also recorded from Cloudcroft, N. Mex. (Cockerell and Fall).

Most specimens from Texas and Louisiana are brown aeneous, although green individuals are not uncommon. Colorado specimens are occasionally green but most have a distinctly blue luster and less seldom purplish.

Three color varieties may be indicated, as follows:

Head and prothorax bright cupreous or aeneous; elytra blue, seldom green or black; Kans., Colo., S. Dak. .... *a* typical *aeneicollis*

Dorsum unicolorous, metallic aeneous brown, dark green, black or purple with aeneous luster; La., Tex. .... *b* variation

Head and prothorax metallic green or purple, elytra blue, seldom green, without aeneous luster; Colo. .... *c* variation

Reported on turnip, radish and cabbage in Colorado and injurious to the foliage of mustard and turnip in gardens in Louisiana. The larva is a leaf-miner on *Lepidium virginicum* and *Coronopus didymus.* According to H. O. Marsh, this species also occurs on *Cleome.*

24. *Phyllotreta lewisii* (Crotch)

Orchestris lewisii Crotch, l. c., p. 66.

Phyllotreta lewisii Crotch, Horn, l. c., p. 301, 302.

Elongate oblong-oval, moderately depressed, dorsal and ventral surface dark blue, exceptionally blue black or black. Antennae slender, distinctly more than half as long as the body, dull piceous, joints 2–5 and apex of 1 pale. Head feebly, sparsely and irregularly punctate. Eyes moderately prominent. Prothorax about one-third wider than long, slightly narrowed at apex, sides moderately arcuate, disc convex, punctures rather deep, moderate in size, somewhat sparsely placed, surface not alutaceous. Elytra scarcely wider at base than the prothorax, basal three-fourths subparallel, humeri broadly rounded, disc convex, the punctures a little coarser than those of the thorax, and more closely placed, finer toward the apex. Ventral segments feebly shining to subopaque, very finely and sparsely punctate, distinctly pilose, hairs black and short. Femora black, tibiae and tarsi piceous or brown.

♂.—Antennal joints as in *aeneicollis,* apical ones fully twice as wide as 2 or 3. Fifth ventral segment distinctly sinuate each side, rather deeply and widely concave at apex with a small depressed tubercle widely separated at each side.

♀.—Antennal joints as in the male. Fifth ventral segment with or without a faint impression at apex, without tubercles.

Length 1.9–2.7 mm.; width 0.8–1.1 mm.

Described from Colorado and Illinois; Horn added Texas, Nevada and California. Specimens have been seen from Rocky Ford, Fort Collins, Greeley, Longmont, Pleasant Valley, Cadoa, Colorado Springs, Debeque, Denver, Colo.; Williams, Flagstaff, Winslow, Santa Rita Mts., Ariz.; Gallup, N. Mex.; Monroe, Salt Lake City, Utah; Dallas, Ontario, Oreg.; Wawawai, Wash.; Cheyenne, Wyo.; Morton Co., Decatur Co., Kans.; Lafayette, Ind.; Moscow, Iowa City, Iowa; Cypress Mills, Tex.; Bladensubrg, Md. The last locality may be accidental or erroneous.

Specimens of this common species were collected by Titus on sugar beet, alfalfa, Cleome and "skunkweed" in different regions of Colorado and Utah. At Rocky Ford, Colo., Marsh collected beetles on *Cleome serrulata* and obtained the larva on the roots of this weed. It does not appear to be recorded on any of the Cruciferae, but undoubtedly attacks them.

25. **Phyllotreta columbiana** n. sp.

Elongate oval, fully twice as long as wide, moderately convex; prothorax with distinct green luster; elytra shining, very dark blue. Antennae slender, fully half as long as the body, black, basal joints 2, 3, 4 and part of 1 paler. Head moderately wide, eyes prominent; surface distinctly sparsely punctate. Prothorax small, one-third wider than long, strongly narrowed at apex, wide at base, producing with the front of the head a triangular appearance, feebly arcuate at the sides; disc convex, surface distinctly, somewhat regularly, finely and distinctly punctate with punctures closely placed. Elytra scarcely wider at base than prothorax; sides subparallel in basal three-fourths; humeri inconspicuous; umbone small, not prominent; disc convex, punctures a little coarser than on prothorax with tendency to serial arrangement near base, scarcely finer toward apex. Ventral segments very feebly and sparsely punctate and pilose, hairs black. Femora shining black, feebly and sparsely punctulate, tibiae and tarsi opaque black.

♂.—Antennal joints 2–6 subequal in length and width, 7 a little wider, 8–10 about twice as wide as 3; 11 longer. Fifth ventral segment slightly transversely concave at sides, thickened each side at apex, flattened but scarcely concave at extreme apex with a minute tubercle each side.

♀.—Antennae as in the male. Last ventral simple, usually without tubercles.

Length 1.8–2.3 mm.; width 0.8–1.1 mm.

Agassiz, British Columbia, Canada, June 27–July 3, 1923 (R. Glendenning, Canadian National collection).

Type ♀.—Cat. No. 28,795, U. S. National Museum. Paratypes in the Canadian National collection.

Separable from *lewisii* by the characters tabulated, also by the narrower head and prothorax, more prominent eyes and shorter antennae. The male secondary sexual characters are less distinct, the last abdominal segment is scarcely or feebly impressed at the apex and the tubercles are less constant. It is related to the European *nigripes* and *atra*, agreeing with the latter in the sublinear arrangement of the elytral punctation. In *atra* the dorsum is entirely black, the fifth ventral segment ♂ bears at the apex a distinct, more or less prominent tubercle each side, while the apex ♀ is more or less strongly produced and without tubercles.

26. **Phyllotreta subnitida** n. sp.

Elongate oval, a little more than twice as wide as long, moderately convex, rather dull polished black without metallic luster. Antennae very slender, scarcely half as long as the body, basal joints 2 and 3 and portions of 1 and 4 dull reddish. Head short, narrow, surface indistinctly and sparsely punctulate, smooth on vertex; eyes small, not prominent. Prothorax short, moderately convex, nearly one-third wider than long, narrowed and scarcely wider at the apex than the head, moderately irregularly arcuate at the sides, widest at the basal third, somewhat feebly narrowed at the base; surface finely, not deeply, rather irregularly punctate, punctures moderately closely placed. Elytra long, narrow, very little wider at the base than the prothorax, humeri obtusely rounded, umbone not prominent, sides rather feebly and evenly arcuate, punctation coarser than on the prothorax, lighter and sparser at the side margins and apex. Ventral segments shining black, finely, feebly punctulate, punctules bearing sparse, short black hairs at middle and gray at sides. Femora black, rather sparsely gray pilose, tibiae piceous, tarsi pale fuscous.

♂.—Antennal joints 2, 3, 4 subequal in length; 2 wider than three or four; 3 slightly longer; 5 about one-fourth longer than 4 or 6; 7 scarcely wider; 8–11 a little wider than preceding, subequal in length, 11 a little longer. Fifth ventral segment subtruncate and flattened or slightly concave at apex, with or without transverse tubercles.

♀.—Antennae as in the male. Fifth ventral segment feebly concave at the sides, apex conical without tubercles.

Length 1.8 mm.; width 0.8 mm.

Pasadena, Calif. (A. Fenyes); Torrance Co., N. Mex. (J. R. Douglas); Esmeralda Co., Nev. (F. W. Nunenmacher).

Type ♂.—Cat. No. 28,818, U. S. National Museum.

Somewhat similar in general appearance to *pusilla*, agreeing rather closely in size, antennal structure, and in the prothoracic and elytral punctation. The prothorax, however, is larger and wider than in the latter, and the color is uniformly rather dull polished black without distinct metallic luster, whereas *pusilla* is usually distinctly shining cupreous or aeneous. It is of rather remarkable dimensions with its short prothorax and long narrow elytra.

27. *Phyllotreta aerea* Allard

Phyllotreta aerea Allard, Bull. Soc. Ent. France, 1859, p. C; Heikertinger, Halticinae, Käfer d. Deutsch. Reiches, IV, 1913, p. 177; Chittenden, Proc. Ent. Soc. Wash., 1926, pp. 139–142.

Phyllotreta punctulata Foudras, Ann. Soc. Linn. Lyon, ser. 2, 1859–1860, pp. 255, 257.

Elongate oval, not more than twice as wide as long, moderately convex, moderately polished black, with rather faint metallic, more or less aeneous luster. Antennae very slender, slightly more than half as long as the body, first three basal joints as viewed from lower surface light yellowish red. Head narrow; surface distinctly, very finely and somewhat densely punctulate; eyes rather large but not prominent. Prothorax moderately convex, long, nearly one-third wider than long, feebly narrowed, a little wider at the apex than the head, moderately arcuate at the sides, widest near the middle, feebly narrowed at the base; surface finely, regularly and sparsely punctate. Elytra wide, distinctly wider at the base than the prothorax, humeri abruptly rounded, umbone not prominent, sides moderately and evenly arcuate, punctation about as on the prothorax, finer at the apex. Ventral segments shining black, finely, rather densely punctulate, punctules with very fine, sparse gray hairs only. Femora black, faintly pilose with gray; tibiae piceous, brown at articulations; tarsi pale fuscous.

♂.—Antennal joints 2, 3, 4 subequal in length; 2 slightly wider than 3; 3 slightly shorter; 5 about one-fourth longer than 4 or 6; 7 scarcely wider; 8–11 a little wider than preceding, scarcely more than twice as wide as 2, 3, 4, subequal in length, 11 a little longer. Fifth ventral segment subtruncate, transversely concave across the middle, not flat but with a ridge at the apex, tubercles wanting or rather indefinitely indicated.

♀.—Antennae about as in the male. Fifth ventral segment feebly concave at sides, apex conical without tubercles.

Length 1.4–2.2 mm.; width 0.7–1.1 mm.

Rochester, N. Y. (R. L. Michaud, D. E. Fink); southern and southcentral Europe.

This species is related to *subnitida* with which it agrees in certain structural features. It is, however, more perfectly oval, with a larger prothorax and proportionately shorter elytra, the eyes are larger and more prominent, the humeri abruptly rounded, and the elytral punctation is finer. The ventral punctules bear fine gray, instead of black, hairs and the last segment is distinctly different in the male.

Introduced from Europe and reported from 1919 to 1921 destroying seedling radish, turnip and cabbage in the vicinity of Rochester, N. Y. The species is capable of breeding on probably most other Cruciferae since it has been recorded as feeding in Europe on *Sisymbrium, Sinapis, Armoracia, Reseda* and *Bunias*.

28. **Phyllotreta inconspicua** n. sp.

Elongate oblong-oval, twice as long as wide, convex, shining black on dorsal and ventral surfaces, with nearly uniformly faint greenish luster, form convex. Antennae slender, less than half as long as the body, opaque piceous black, joints 2, 3, 4 paler. Head narrow; surface finely and very sparsely punctulate. Eyes large, widely separated and prominent. Prothorax short, nearly as long as wide, moderately convex and moderately arcuate at the sides, wider at the apex than the head; surface finely, not deeply, irregularly and sparsely punctulate. Elytra not much wider at base than prothorax, basal three-fourths or more subparallel; umbone small, not prominent; surface a little coarser and less sparsely punctate than on prothorax, without tendency to serial arrangement. Ventral surface black, finely and very sparsely punctulate, subglabrous. Femora shining black, tibiae and tarsi opaque black.

♂.—Antennal joints 2, 3, 4 subequal in length; 3, 4 very slender; 5 slightly longer than 4 or 6; 7–11 three times as wide as 2 or 3. Fifth ventral segment rather widely flattened, scarcely concave at apex, with a minute tubercle each side.

♀.—Antennae as in the male. Fifth ventral segment not flattened, with obsolete tubercle at apex.

Length 1.3–1.5 mm.; width 0.7–0.8 mm.

Medicine Hat, Alberta, Canada, March 29, August 6, 1913 (F. S. Carr); Saskatoon, Saskatchewan (Kenneth M. King); Aweme, Manitoba, June 19, 1917 (N. Criddle); Wawawai, Wash. (M. C. Lane).

Type ♀.—Cat. No. 28,801, U. S. National Museum. Paratypes in the Canadian National collection and in that of F. S. Carr.

This species is smaller than the two to which it is most nearly affiliated, *lewisii* and *columbiana*, from which it may be distinguished by the characters in the table. One example is blue and one is much slenderer than the type but does not differ otherwise. This is an inconspicuous form, variable in outline and proportions.

29. **Phyllotreta fulgida** n. sp.

Elongate oval, about twice as long as wide, convex, brightly shining black with metallic luster; form convex. Antennae slender, a little more than half as long as the body, first four basal joints, as viewed from below, pale red, apical joints piceous. Head wide, feebly and sparsely punctulate. Eyes rather large, prominent, widely separated. Prothorax large, distinctly convex, scarcely one-fourth wider than long, not much wider at the apex than the eyes, somewhat strongly arcuate at the sides, a little narrower at the base than near the middle; surface distinctly and somewhat coarsely punctate. Elytra scarcely wider at base than the prothorax, humeri and umbone not prominent, sides moderately arcuate; punctation slightly coarser than on the prothorax, finer at the sides and fainter at the apex. Ventral segments moderately shining black, finely punctulate, feebly pilose, hairs recumbent, long and gray at the sides. Femora black with gray piliferous punctules; tibiae and tarsi testaceous.

♂.—Antennal joints 2, 3, 4 subequal in length; 5 and 6 subequal, one-fourth longer; 7–11 about twice as wide as the basal joints. Fifth ventral segment impressed at the sides, apex flattened, scarcely concave with a distinct transverse tubercle each side. Pygidium inflexed.

♀.—Fifth ventral segment simple without tubercles.
Length 1.6–2.1 mm.; width 0.75–1.0 mm.

Type ♂.—Cat. No. 28,811, U. S. National Museum. Paratypes in the Canadian National collection.

Canon City, Colo. (Wickham); Bright Angel Camp, Ariz., 6,900 ft. elevation, July, 1915 (Wickham); Hilton Creek, Sierra Nevada Mts., Calif., June 17, 1922; California (Chittenden); "N. M" (Canadian National collection).

A moderately distinct species of variable shades of color and of outline, confused in collections with *pusilla*. The larger and more convex prothorax with its more arcuate sides readily separate it from that species. Furthermore, there are no tubercles at the apex of the last ventral segment in the female. Some specimens have a faint greenish luster and one is faintly aeneous.

30. **Phyllotreta transversovalis** n. sp.

Robust oval, less than twice as long as wide, convex, elytra shining blue black with faint metallic luster, lower surface dark brown. Antennae very slender, fully half as long as the body, second, third and fourth basal joints and apical half of first pale yellow brown, remainder opaque piceous. Head rather wide, impunctate. Eyes of moderate size, not prominent. Prothorax large, about one-third wider than long, at apex narrowed and scarcely wider than the head, strongly arcuate at the sides, wide at base; surface finely and sparsely punctate. Elytra short, at base scarcely wider than prothorax, moderately arcuate at sides, umbone small; surface scarcely more coarsely or densely punctate than on the prothorax, punctures much finer and sparse on the sides and at apex. Ventral segments finely punctate, fifth more coarsely, glabrous. Femora, tibiae and tarsi pale brown.

♂.—Antennal joints as in *aeneicollis*. Fifth ventral segment somewhat faintly and narrowly impressed each side, at middle more deeply impressed, forming a large transverse oval concavity extending nearly to the base of the segment, bearing tubercles each side at apex.

♀.—Not seen.

Length 1.3 mm.; width 0.8 mm.

Milford, Utah, July 17 (Wickham).

Type ♂.—Cat. No. 28,804, U. S. National Museum. Unique.

The short oval form, convex transversely oval prothorax and large transversely oval fifth segment of the male distinguish this species from others in this group. The unique male is evidently slightly immature, but is otherwise perfect.

31. **Phyllotreta brevipennis** n. sp.

Oval, less than twice as long as wide, depressed, dorsum rather feebly shining; prothorax dark aeneous green; elytra black without color luster. Antennae half as long as the body, joints very thick, second and third and apex of first red. Head wide, nearly impunctate; eyes small, prominent, widely separated. Prothorax large, more than one-third as long as the elytra, one-fourth wider than the length, feebly convex, narrower at base than the head, strongly irregularly arcuate at sides; surface finely, distinctly and densely punctate. Elytra scarcely wider at the base than the prothorax at its widest part, humeri and umbone inconspicuous, the latter hardly visible, sides feebly arcuate; surface a little more coarsely, much more sparsely punctate, punctures finer and sparser at sides and apex, without tendency to serial arrangement. Ventral segments feebly shining black, minutely punctulate, distinctly, sparsely pilose with white hairs at the sides. Femora black, tibiae reddish brown at ends, tarsi pale brown.

♂.—Antennal joints 2, 3, 4 subequal; 5 distinctly, but not much longer than preceding; 6 a little shorter, scarcely longer than 4, 7–11 slightly wider. Fifth ventral segment concave at sides, flattened at apex with a long transverse tubercular process each side.

♀.—Not seen.

Length 1.7 mm.; width 0.75 mm.

Aweme, Manitoba, Canada, October 11, 1916 (N. Criddle).

Type ♂.—Cat. No. 28,816, U. S. National Museum. Paratype in the Canadian National collection. Two specimens.

Remarkable for the short oval body; finely, distinctly and densely punctate pronotum; very thick, nearly uniformly wide antennal joints and the transverse tubercular processes at the apex of the last ventral segment in the male.

32. *Phyllotreta pusilla* Horn (Pl. II, fig. 8)

Phyllotreta pusilla Horn, Trans. Am. Ent. Soc. 1889, p. 302; Chittenden and Marsh, Bul. 902, U. S. Dept. Agr., 1920, pp. 1–21; Chittenden, Proc. Ent. Soc. Wash., v. 25, 1923, pp. 138, 139.

Elongate ovate, strongly depressed, dorsum distinctly cupreous or aeneous, exceptionally black or nearly so. Antennae slender, half as long as the body, piceous, joints 2 and 3 paler. Head scarcely visibly punctate. Prothorax very narrow, less than twice as wide as long, widest at middle, sides arcuate, apex slightly narrower than base; disc moderately convex, punctures fine and closely placed. Elytra wider than the prothorax, humeri obtuse, punctation a little coarser than that of the prothorax, closely placed, very little finer near the apex, but less dense. Pygidium inflexed and visible from ventral surface. Ventral segments black with cupreous or aeneous luster, sparsely punctate, not pilose. Femora black with aeneous luster, tibiae and tarsi dark brown.

♂.—Antennal joints 2, 3, 4 subequal in length; 5 and 6 slightly longer, but not much wider; 7–11, each about twice as wide as 2, forming a 5-jointed club. Fifth ventral segment impressed at the sides, more or less concave at the middle, distinctly linearly impressed at the apex, the impression either very short and narrow or longer and narrowly subdeltoid, with a small rounded, or, exceptionally, a transverse tubercle each side, usually somewhat closely placed together.

♀.—Antennal joints about as in the male. Fifth ventral segment impressed at the sides, feebly concave, not linearly impressed at the middle and with a minute tubercle each side, more closely placed together.

Length 1.2–1.7 mm.; width 0.6–0.8 mm.

The sexual characters of this species are even more flexible than indicated in the foregoing description. When the pygidium is strongly inflexed, this gives to the extreme apex of the fifth ventral segment the appearance of an oval concavity. The apical tubercles are sometimes transverse in both sexes. Since the females of this species and of *albionica* are so similar, both being injurious with a similar although not identical distribution, it may be stated that in the latter the fifth antennal joint is as long as the third and fourth together, the ventral segments are more distinctly pilose and the fifth ventral is without tubercles. In *pusilla,* on the contrary, the fifth antennal joint is shorter than the third and fourth together, the ventral segments are glabrous, and the fifth ventral segment is usually distinctly tuberculate in both sexes. A series of this species collected in Torrance Co., New Mexico, September, 1926, by J. R. Douglass, is worthy of mention. Some of the males have no tubercles whatever on the fifth ventral segment, and the apex only is finely, linearly impressed; some of these also have no lateral impressions.

Phyllotreta pusilla is known as the western cabbage flea-beetle and is the most injurious species of the genus. It is widely distributed in the Rocky Mountain region, especially abundant in Colorado and New Mexico, and occurs eastward and westward in Arizona, California, Washington, Montana, Wyoming, Idaho, Nebraska, Oklahoma, Kansas, and ranges southward through Brownsville, Tex., into Mexico. It frequently occurs at high altitudes and is a permanent inhabitant of lower areas. It is evidently a Sonoran form.

The western cabbage flea-beetle, although principally an enemy of cruciferous plants, has often been observed and recorded as injuring sugar beets and other vegetable crops. Turnips, mustard and radish are decidedly the favorite food plants. In the Arkansas Valley of Colorado, and elsewhere, the beetles attack these and frequently injure all of the Cruciferae, including cabbage, cauliflower, watercress, Chinese cabbage or pe-tsai, horse-radish, rape, nasturtium, beeplant (*Cleome serrulata*), sweet alyssum, candytuft, peppergrass (*Lepidium* spp.), hedge mustard (*Sisymbrium* spp.), wild watercress (*Radicula* spp.), and tansy mustard (*Sophia pinnata*), all normal food plants. When the beetles occur in great abundance they attack and injure also lettuce, beans, peas, carrot, tomato, potato, corn, table beet and mangel-wurzel.

Injury is due to the beetles eating pit-like holes in the leaves of young plants, usually selecting the lower surface. Radish is so seriously attacked practically everywhere within the destructive range of this pest that, at times, it is almost impossible in such regions to grow this vegetable unless strenuous efforts are made to prevent inroads.

33. **Phyllotreta laticornis** n. sp.

Elongate oval, more than twice as long as wide, little narrower anteriorly, moderately convex, shining dark aeneous. Antennae half as long as the body, black, second and third joints paler and very slender, apical joints much thicker. Head distinctly, rather densely and finely punctate. Eyes not prominent. Prothorax strongly convex, one-third wider than long, narrowed at apex, where it is slightly wider than the head, sides arcuate in apical half, subparallel in basal portion; surface densely and finely aciculately punctate. Elytra narrow suboblong, nearly twice as long as wide, at base scarcely wider than prothorax, humeri rounded, not prominent, umbone subobsolete, sides feebly arcuate, surface moderately uneven, slightly more coarsely punctate than on prothorax, less distinctly and less densely at apex. Ventral segments feebly shining cupreous, distinctly subseriately punctate, strongly coated with fine widely-separated recumbent white pile. Femora black, tibiae piceous and brown, tarsi brown.

♂.—Antennal joints 2, 3, 4 subequal in length; 5 and 6 a little longer, subequal; 7–11 about three times as wide as 3; 11 longer. Fifth ventral segment narrowly and transversely concave, concavity shallow, bearing a small transverse tubercle each side. Pygidium visible.

♀.—Antennae as in male. Fifth ventral segment flat at apex with a smaller tubercle each side.

Length 1.5–2.1 mm.; width 0.7–0.9 mm.

Sierra Anca Mts., Ariz., July (D. K. Duncan).

Type ♂.—Cat. No. 28,807, U. S. National Museum. Paratype in the collection of D. K. Duncan.

This species is quite distinct, differing markedly from all others in structure. It is not even distantly related to *pusilla* but is merely placed near it for tabulation. The color is the same but it is larger, more convex, with wider prothorax and the apical antennal joints are especially thicker. The very distinct punctation of the dorsum and of the ventral segments together with the pilosity of the latter are worthy of note. The sexual differences are not especially strong or entirely constant.

34. **Phyllotreta viridicyanea** n. sp.

Elongate oblong-oval, a little more than twice as long as wide, strongly depressed, elytra moderately shining dark metallic blue-green. Antennae half as long as the body, basal joints very slender, the first four and part of fifth joint bright yellow. Head purple aeneous, very feebly punctulate; eyes rather small, not prominent. Prothorax aeneous green, scarcely wider than long, slightly wider at apex than head, arcuate at the sides; feebly convex, finely, rather densely punctulate. Elytra oblong, wider at base than prothorax, humeri rounded, umbone rather large but not prominent, sides subparallel; surface even, punctation nearly as on prothorax but a little coarser. Ventral segments subopaque black, without metallic luster, nearly smooth, feebly pilose with white hair. Posterior femora black, tibiae and tarsi yellow brown.

♂.—Antennal joints 2, 3, 4 subequal; 5 about one-half longer than 4, not wider; 6 a little shorter, 7–11 about one-half wider than preceding and twice as wide as the basal joints; 11 a little longer. Fifth ventral segment impressed in apical half, impression distinct but moderately narrow and rather shallow, without tubercles.

♀.—Antennae as in the male, except joint 5, which is a little shorter. Fifth ventral segment flattened at extreme apex, without tubercles.

Length 1.9 mm.; width 0.8 mm.

Kaweah, Tulare Co., Calif., 1,000 ft. elevation (R. Hopping); Amadee, Calif., July 21, 1882, 4,200 ft. elevation (Wickham).

Type ♀.—Cat. No. 28,813, U. S. National Museum.

Except for the antennal characters of the male, this species resembles *prasina*, especially in its bright green luster. The allotype is less brightly colored than the female. A female from California agrees with the description, except that the dorsum is aeneous. The basal antennal joints vary from bright yellow to red. An attractively colored species.

35. **Phyllotreta polita** n. sp.

Elongate oval, twice as long as wide, moderately convex; elytra polished jet black with greenish, aeneous or darker metallic luster; prothorax shining black. Antennae slender, half as long as the entire body, joints 1–6 flavotestaceous, apical ones piceous. Head sparsely punctulate, interocular fovea on vertex minute; eyes large, prominent. Prothorax strongly convex, about one-fourth wider than long, moderately regularly arcuate at sides, much narrowed apically; surface finely sparsely punctate, not alutaceous. Elytra distinctly wider at base than prothorax, humeri very broadly rounded, umbone not prominent; surface more coarsely and densely punctate than on the prothorax, punctures regularly, nearly uniformly placed on disc, less regularly on sides and more faintly at apex. Ventral segments shining black, finely sparsely punctulate, glabrous. Femora pale yellow-brown at extreme apex, tibiae and tarsi pale fuscous.

♂.—Antennal joints 2, 3, 4 subequal; 2 scarcely longer than wide; 5 about one-third longer than 4 or 6; 7–11 subequal, about one-third wider than preceding but much wider than basal joints; 11 a little longer. Last ventral segment with a large deep subdeltoid concavity at apex, without distinct tubercles. Pygidium not strongly inflexed, scarcely visible from ventral surface.

♀.—Antennae about as in male. Last ventral segment conical, simple, without trace of tubercles.

Length 1.8–2.1 mm.; width 0.8–1.1 mm.

Corvallis, Oreg. (G. F. Moznette); Leeds, Utah (Wickham).

Type ♂.—Cat. No. 28,796, U. S. National Museum. One male and one female.

The distinguishing features are the highly polished black color of the dorsum, on which an equally distinct color luster may be seen in a good light, doubtless due to the rather deep and regular punctation of the same, and the large and deep deltoid concavity at the apex of the last ventral segment in the male.

36. **Phyllotreta inordinata** n. sp.

Oval, a little less than twice as long as wide, varnished black, prothorax brightly shining with bluish or other luster. Antennae nearly half as long as the body, basal joints slender, mostly moderately bright yellow, apical joints darker, successively wider. Head and eyes prominent, head nearly smooth, very feebly punctulate. Prothorax long, about one-fourth wider than long, a little wider at apex than the head, strongly, irregularly arcuate at the sides; surface finely and sparsely punctulate. Elytra wider at base than prothorax, humeri subacutely rounded, umbone nearly obsolete, basal three-fourths of sides subparallel, apex subtruncate; surface finely, but a little more coarsely and more densely punctulate than the prothorax, not much finer at sides, but finer at apex. Ventral segments feebly and sparsely punctate, moderately shining and subglabrous. Femora feebly shining black, tibiae and tarsi dull yellow.

♂.—Antennal joint 2 short; 3 and 4 longer; 5 still a little longer; 6 about one-third shorter than 5; 7–11 about twice as wide as joints 2, 3, 4; 11 a little longer than preceding. Fifth ventral segment feebly concave at sides and at extreme apex, latter concavity small and circular in outline, without tubercles.

♀.—Antennal joints similar to ♂. Fifth ventral segment conical at apex, sparsely finely pilose, hairs black.

Length 1.7 mm.; width 0.9 mm.

San Antonio, Tex., June 22, 1895 (H. Soltau); Brownsville, Tex., April 30, 1904 (H. S. Barber); Texas (Belfrage); Globe, Ariz. (D. K. Duncan).

Type ♀.—Cat. No. 28,811, U. S. National Museum. Paratype in the Canadian National collection.

This species is rather notable for its lack of conspicuous features; summarized, the most noticeable are: Its varnished, rather than highly polished, black color, evidently due to the feeble punctation, its large prothorax, and feebly developed secondary sexual characters, especially notable in the fifth ventral segment of the male.

Addendum

Phyllotreta undulata Kutsch is of doubtful occurrence in this country and *Ph. lindahli* Dury is not believed to be a real *Phyllotreta.* The types of this latter have not been seen, and Mr. Dury is not certain of the genus. Brief descriptions of these species, however, are furnished in this addendum.

Phyllotreta undulata Kutsch

Haltica undulata Kutsch, Wien. Entom. Monatschrift, 1860, p. 301.

Phyllotreta undulata Kutsch, Chittenden, Proc. Ent. Soc. Wash., 1923, p. 134.

Elongate oval, moderately convex, moderately shining black, feebly aeneous; elytral vitta broad, yellow, slightly incurved at base, subparallel on sutural margin to near apex, thence recurved toward but not reaching the suture, antennae about half as long as body, opaque black, 2 or 3 basal joints wholly or in part testaceous. Head punctate about as in *vittata.* Elytra distinctly wider at base than prothorax, humeri not prominent, punctures of disc as in *vittata* but with somewhat less tendency to strial arrangement; vitta slightly wider in basal fifth without subhumeral branch, narrower and subparallel in middle three-fifths, wider in apical fifth. Ventral surface including femora black, tibiae and tarsi more or less testaceous.

♀.—Fifth joint of antennae very little longer than fourth or sixth, sixth shorter than seventh. Last ventral simple.

Length 1.8 mm.; width 0.8 mm.

This species has been mentioned by the writer (l. c.) as having been taken at Bladensburg, Md. Two specimens are at hand so labeled, but it is doubtful if the species has been established in this country.

Phyllotreta lindahli Dury

Phyllotreta lindahli Dury, Jour. Cinn. Soc. Nat. Hist., 1906, p. 254.

Elongate oval, convex, black, shining. Thorax wider than long, minutely alutaceous. Punctures fine, becoming coarser towards base. Elytra wider at base than thorax, with humeri rounded. Disk coarsely punctured, with a faint strial arrangement. Tibiae, tarsi and antennae (except the last four joints of antennae, which are piceous) pale.

♂.—Last ventral segment rounded at tip with a deep rounded depression, which extends forward in triangular shape through the entire length of the penultimate segment. In bottom of the depression is a groove extending its length. There are two minute tubercles at bottom of depression near apex of last segment.

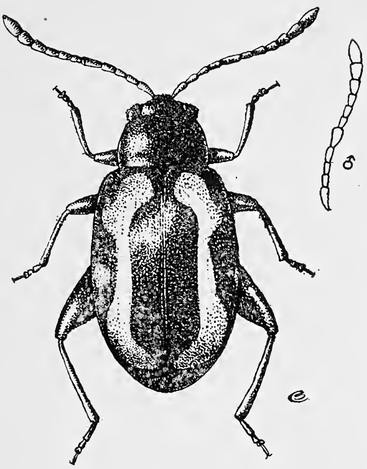
♀.—Last ventral segment with a shallow fovea near tip. Obliterated in one specimen. This species comes nearest *lewisii*.

Four specimens 2.5 mm.; Cincinnati, Ohio, May 30 (Dury).

The generic status of *Ph. picta* = *Trachymetopa picta* Say is given by Heikertinger, "Die Halticinengenera der Palaearktis und Nearktis, Bestimmungstabellen, 1925," p. 58. Possibly *Ph. lindahli* may belong to *Tanygaster* Blatch (Heik., p. 59). Dury (in lit.) had previously expressed this opinion.

PLATE I

Pl. I, fig. 1—*Phyllotreta vittata*
2—*Phyllotreta (vittata) discedens*
3—*Phyllotreta zimmermanni*
4—*Phyllotreta liebeccki*



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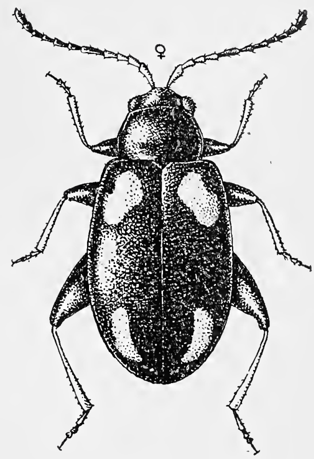

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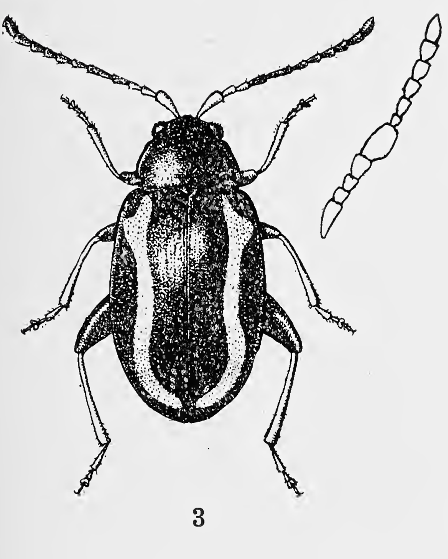

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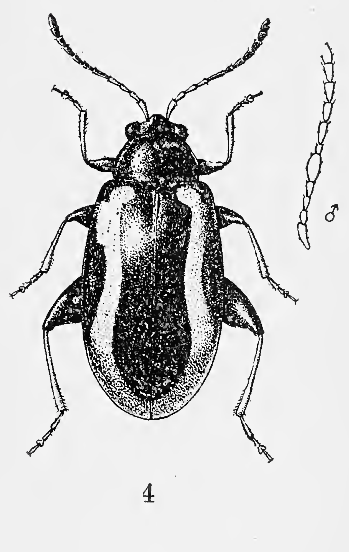

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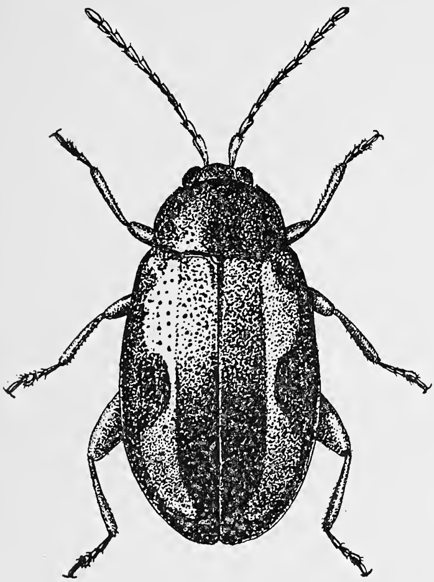
PLATE II

Pl. II, fig. 5—*Phyllotreta oblonga*
6—*Phyllotreta oblonga*
7—*Phyllotreta bipustulata*
8—*Phyllotreta pusilla*



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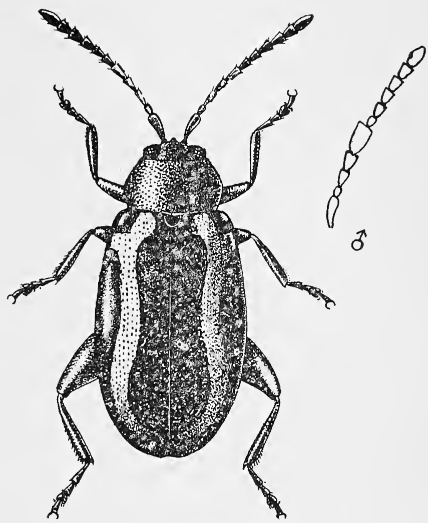

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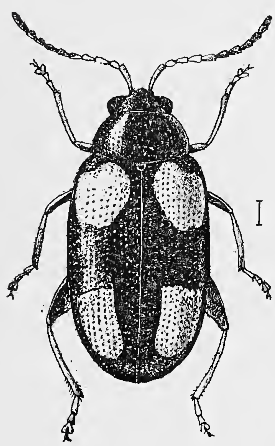

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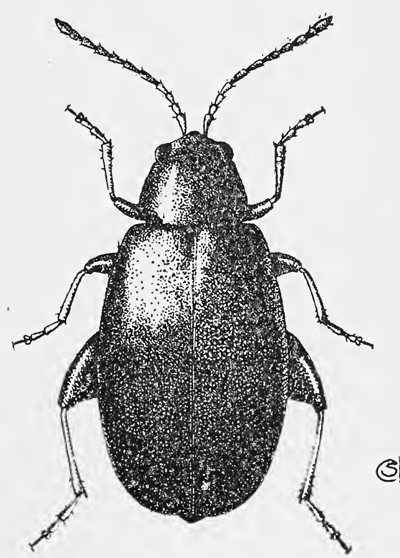

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ENTOMOLOGICA AMERICANA

After a lapse of 36 years, this veteran journal of American entomology emerges from its hibernaculum to take its place once more as a vehicle for the progress of our branch of science. Thanks to the generosity of a friend the Brooklyn Entomological Society is enabled to revive this journal to render, we hope, as good service and fill as worthy a place as its predecessor of long ago.

The Society has long felt that a medium was needed for the appearance of those longer papers—monographs, synopses of smaller groups, biological studies, morphology, embryology, revisions, and the many excellent technical productions too long and too special, perhaps, for our regular journals yet too short for a book—emanating from many workers not connected with institutions which publish the results of the research of their staffs. The opportunity has at length presented itself; and the Society has taken the positive step.

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The publication will be issued in four numbers a year, and will average approximately 50 to 60 pages to the number, or a total of 200 to 240 pages per volume. Each number will carry *one* paper; or possibly two, but not more, in view of its purpose. The annual subscription price is set at $4.00 a volume. Single numbers will sell on an approximate basis of $1.50 for 50 pages; subscriptions will be received per volume—*not* for four consecutive numbers—payable strictly in advance. The edition for the first of the new volumes will be limited to 200 copies; and those intending to subscribe, particularly institutions and libraries, should do so promptly to ensure possession of complete sets.

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A REVIEW OF THE NORTH AMERICAN SPECIES OF PODABRUS

By H. C. Fall

TYNGSBORO, MASS.

The soft-bodied beetles of the families Lampyridae, Cantharidae and others, have never been favorites of coleopterists, which probably, in part at least, accounts for their general neglect by both collectors and taxonomists. Not since Le Conte's *Synopsis of the Lampyridae of the United States,* in 1881, has the genus *Podabrus* received any attention at the hands of our systematists, nor in the forty-six years since then has a single new species of this genus been described from our fauna.

The scheme adopted by Le Conte of dividing the genus into groups based on the form of the tarsal claws is a good one, but his failure to observe that in many species there exists a sexual difference in the claws, makes it necessary to add new groups and to make some changes in his arrangement of species.

While the present review has been based almost entirely upon a study of the material in my own collection, combined with a careful examination of the Le Conte types, yet I have received aid in the way of specimens from a number of correspondents, notably my Canadian friends Mr. J. B. Wallis and Mr. F. S. Carr; also from Mr. K. F. Chamberlain, then of Cornwall Bridge, Conn., who kindly collected for me a local series of both *Podabrus* and *Cantharis* (*Telephorus*); Mr. A. W. Andrews, of Detroit; Mr. Chas. Liebeck, of Philadelphia, and Mr. H. S. Barber, of the National Museum, who sent me certain species from their collections.

For a cabinet arrangement, the order of species in the text should be followed rather than that in the tables.

The types of all new species are in the writer's collection.

Table of Groups and Species

1. Tarsal claws in both sexes armed with a long acute tooth, causing them to appear broadly cleft....2

Tarsal claws in both sexes armed with a broad basal tooth or appendix, the free angle of which may be rectangular or more or less acute....33

Tarsal claws on all feet in the male finely cleft, all broadly toothed at base in the female....45

Tarsal claws of male finely cleft on the front and middle feet, toothed at base on the hind feet; in the female all broadly toothed at base....46

Tarsal claws of front feet of male finely cleft, of middle and hind feet with a broad basal tooth, which on the middle pair may have the free angle a little more acute; all claws in the female with broad basal tooth....52

Tarsal claws of male finely cleft on the front feet, on the middle feet outer claw toothed inner cleft, on the hind feet both claws toothed; in the female all claws toothed....55

Outer claw of hind tarsi of male toothed, all others cleft; all claws in the female toothed. Body yellow above, head blackish posteriorly, elytra often more or less dusky toward the apex....56

2. Eyes rather small, not prominent; last joint of maxillary palpi less obliquely truncate than usual, though somewhat variable individually. Californian species....3

Eyes larger and more prominent, especially in the male....4

3. Above black with sides of thorax yellow; more rarely yellow, the thorax with a discal black spot. Thorax transverse, sides rounded; front tibiae of male dilated inwardly into a thin plate....*latimanus*

Above yellow, thorax with black spot of variable size, elytra varying to fuscous. Thorax transversely quadrate, sides nearly straight and parallel; protibiae of male only slightly curved and dilated....*ambiguus*

4. Front tibiae of male more or less curved and apically dilated; hind coxae in the male with an apical process or tuft of hair (except *tomentosus*) 5
   Front tibiae of male only slightly curved and not distinctly dilated apically 13

5. Prothorax strongly narrowed in front of middle, black, sides yellow; elytra entirely black, elevated lines strongly marked; 2^d joint of antennae not much shorter than the 3^d; length 7–8 mm. .... *rugulosus*
   Prothorax less narrowed in front, elevated lines of elytra feebly marked as a rule (more evident in *frater*) 6

6. Prothorax with sides yellow, disk more or less blackish or infuscate; head and legs never entirely pale. (Eastern U. S.) 7
   Prothorax entirely yellow 9

7. Size larger (12 mm.), hind coxae of male with strong apical process; thorax distinctly closely punctured except at sides, yellow with reddish brown discal spot having a black center; elytra dull yellow or fuscous, with obscure paler vittae in the darker forms .... *appendiculatus*
   Size smaller (about 9–10 mm.), hind coxae of male with apical tuft of hairs; front tibiae angularly dilated inward before the apex; thorax much less transverse, finely sparsely punctate or nearly smooth 8

8. Thorax yellow with two brown discal spots, sometimes confluent, elytra with pale margins .... *knobeli*
   Thorax black with sides yellow, elytra not margined .... *frater*

9. Legs black 10
   Legs entirely or in great part yellow 11

10. Prothorax a little more rounded on the sides, entirely yellow, an eroded line between the convexities; protibiae of the female showing feebly the curvature and apical thickening of the male .... *comes*
    Prothorax a little more transverse and with sides less rounded, apical margin with a black spot, no eroded line between the convexities; protibiae of female not at all modified in the manner of the male .... *conspiratus*

11. Head black posteriorly. (California.) .... *illex*
    Head entirely yellow 12

12. Hind coxae modified in the male. (Pacific Coast Species.)
Size somewhat larger and broader, prothorax a little more transverse, median line excavated; head, thorax, antennae and legs typically entirely pale. (San Francisco to British Columbia, including the variety.) .... *pruinosus*
Antennae except basal joint, and tarsi black or fuscous .... var. *diversipes*
Size a little smaller, form narrower, thorax less transverse, median line not excavated; head, thorax and legs entirely pale yellow, elytra black with side margins narrowly pale; protibiae of male less dilated apically. (Eastern California.) .... *limatus*
Hind coxae unmodified in the male. (Eastern U. S.) ... *tomentosus*

13. Prothorax very strongly transverse, twice as wide as long, evidently narrowed in front 14
Prothorax much less strongly transverse, never as much as twice as wide as long 15

14. Elytra entirely black, strongly tricostate, distinctly dilated at sides; 2^d^ antennal joint plainly shorter than the 3^d^ .... *tricostatus*
Elytra with pale margins, sides less evidently dilated, discal costae much less distinct, 2^d^ antennal joint but little shorter than the 3^d^ .... *brevicollis*

15. Species of the Eastern U. S. and Mississippi Valley 16
Species of the Rocky Mts. and Pacific Coast 24

16. Head less produced and more rapidly narrowed behind the eyes, prothorax more strongly transverse 17
Head longer and more gradually narrowed behind the eyes; prothorax less transverse, in males of *brunnicollis* almost as long as wide; male hind coxae simple; protibiae slightly modified in males of *protensus* 23

17. Elytra with lateral and sutural margins pale, head densely punctate 18
Elytra entirely black, head sparsely punctate and opaque, legs entirely black .... *diadema*

18. Entire disk of thorax punctate; legs piceous, femora usually paler at base 19
Disk of thorax polished and nearly smooth, very finely and sparsely punctate; legs typically entirely yellow, varying to dusky or fuscous, the thighs only diffusely paler basally .... *modestus*

Disk of thorax sparsely punctate and shining, sides straighter and more parallel; antennae longer, nearly as long as the entire body in the male, 2d joint much shorter, scarcely more than half the length of the 3d .... *longicornis*

19. Prothorax with large brownish red discal area which is very densely punctured and opaque, sides more parallel basally and a little more oblique in front; front tibiae and hind coxae of male simple........ *fissus*

Prothorax with blackish discal area which is much less densely punctate and either dull or somewhat shining, sides more noticeably rounded 20

Prothorax wholly yellow; hind coxae of male entirely devoid of sexual modification 22

20. Head narrower than the thorax in both sexes, conspicuously small in the female; legs entirely black, front tibiae and hind coxae of male simple........ *nothoides*

Head larger, as wide as or wider than the thorax in the male; legs piceous or piceo-testaceous with base of femora pale 21

21. Antennae somewhat more elongate, intermediate joints in the male rather more than three times as long as wide, 2d joint nearly equal the 3d; hind coxae of male with apical spot of fuscous hairs .... *basilaris*

Antennae a little shorter, intermediate joints rather less than three times as long as wide, 2d joint distinctly shorter than the 3d; hind coxae of male without spot of fuscous hairs .... *punctulatus*

22. Sides of prothorax rounded........ *flavicollis*

Sides of prothorax straight and parallel, rounded only at the apical angles .... *quadratus*

23. Head and thorax pale, the former sparsely punctured behind, the latter feebly sparsely punctate; elytra blackish, sometimes diffusely paler basally with margins pale as far as the middle .... *protensus*

Head in front and prothorax yellow, elytra blackish with external and sutural margins pale; head and thorax more strongly punctate .... *brunnicollis*

Thorax with a discal black spot or stripe........ var. *poricollis*

24. Prothorax yellow with two discal black spots occupying the convexities; entire upper surface yellow, or with the elytra gradually dusky toward the apex; hind coxae of male with conspicuous process .... *binotatus*

Prothorax entirely yellow or reddish yellow without spots (except *modulatus*) 25

25. Head entirely yellow or rufous 26

Head usually wholly or in great part black behind the antennae 27

26. Elytra brownish testaceous to pale piceous, legs varying from yellow to blackish; prothorax widest at about the middle, the sides more arcuate .... *confraternus*

Elytra entirely black, legs yellow; prothorax widest just behind the obliquely truncate front angles, the sides thence converging and nearly straight to base .... *viduus*

27. Eyes smaller and less prominent than in the allied species, elytra and legs black .... *muliebris*

Eyes normally larger and prominent in the male 28

28. Hind coxae posteriorly more or less prominent or with a tuft of hair in the male; size larger 29

Hind coxae and front tibiae of male unmodified; size much smaller 31

29. Elytra entirely yellow, legs black .... *fulvus*

Elytra black, legs rufotestaceous .... *sierrae*

Elytra black, legs black 30

30. Front angles of prothorax obliquely truncate, surface smooth and nearly impunctate except along the basal and toward the apical margins; no median eroded line .... *tenuis*

Front angles of prothorax not distinctly truncate, surface more or less punctate throughout, median impressed line eroded .... *mexicanus*

31. Head and prothorax bright yellow, the former with a blackish occipital fascia; elytra, legs and antennae (except at base) black .... *occipitalis*

Upper surface almost wholly yellow, the head blackish behind, the apex of the elytra often somewhat dusky 32

32. Prothorax wider than long in both sexes, entirely yellow, median line as a rule unimpressed; legs mostly yellow, the base of the middle and hind thighs, and the hind tibiae and tarsi, blackish .... *mellitus*

Prothorax as long as wide in the male, a little transverse in the female, discal excavation with a black stripe or spot of variable size, rarely entirely lacking, median line sharply impressed and nearly entire; legs mostly black .... *modulatus*

33. Prevailing color above yellow; posterior part of the head and a spot in the discal excavation of the thorax, black; elytra often more or less dusky especially toward the apex 34
Prevailing color above black 35

34. Third antennal joint nearly or quite twice as long as the second; head and prothorax more distinctly and a little more coarsely punctate; legs more black than yellow .... *extricatus*
Third antennal joint about one-fourth longer than the second; head rather more finely and sparsely punctate, the thorax very obsoletely so; legs more yellow than black .... *tejonicus*

35. Prothorax opaque and densely punctate 36
Prothorax small, surface dull or opaque, evidently but quite finely and not densely punctulate 40
Prothorax more or less shining, usually finely and sparsely punctate or even quite smooth, at least on the disk 41

36. Dorsal line of prothorax feeble, convexities slight, size larger (11 mm.) 37
Dorsal line of thorax deeper, convenities more prominent, size smaller (6–9 mm.) 38

37. Black, prothorax with lateral red spot (Oregon; Vancouver) .... *scaber*
Piceous, anterior half of head and margins of elytra pale; prothorax ferruginous, varying to blackish with sides reddish .... *cinctipennis*

38. Prothorax entirely red .... *punctatus*
Prothorax black, sides yellow 39

39. Elytra entirely black (B. C.; Mont.) .... *excursus*
Elytra black with pale margins (N. H.) .... *limbellus*

40. Prothorax black with sides fulvous (typical), varying to entirely fulvous (California) .... *macer*
Prothorax and entire upper surface black (Alaska and Oregon to New England) .... *piniphilus*

41. Elytra black or piceous margined with testaceous 42
Elytra black throughout 43

42. Prothorax with sides narrowly yellow .... *puncticollis*
Prothorax entirely black .... *extremus*

43. Elytra (♀) much shorter than the abdomen and less than twice as long as wide .... *brevipennis*
Elytra (♀) covering the abdomen and relatively much longer 44

44. Prothorax more evidently transverse, typically yellow with basal and apical margins blackish at middle, varying with sides alone yellow .... *xanthoderus*

Prothorax smaller, almost as long as wide, black with sides yellow; antennae less stout .... *bolteri*

45. Form narrow, prothorax small; entire upper surface black in the female, muzzle testaceous in the male, in which sex there is also a small obscure rufous spot at the anterior thoracic angles (British Columbia; Alaska) .... *fissilis*

46. Claws of hind tarsi of male and all claws of female with a broad basal tooth, the free angle of which may be somewhat less than rectangular but is not acutely produced 47

Claws of hind tarsi of male and on all feet of female with a short basal acute tooth 50

47. Species of the Rocky Mts. and farther east 48

Species of the Californian Sierras 49

48. Thorax black, sides yellow.

Elytra black, margins not appreciably paler (Colorado; New Mexico) .... *lateralis*

Elytra black with paler side margins, disk with an obscure subsutural paler vitta (Alberta) .... *obscurevittata*

Thorax typically black with a small pale spot at the front angles, but varying to more largely rufous; elytra entirely black .... *puberulus*

Thorax entirely yellow, punctate, head yellow in front, elytra entirely black .... *simplex*

Thorax yellow, apical and basal margins typically narrowly black, its surface shining and nearly impunctate; elytra and legs black .... *pattoni*

49. Head behind the antennae, and elytra, black, side margins of latter narrowly paler; thorax bright yellow with elongate black spot occupying the discal concavity, sometimes extending to the front margin .... *gracilis*

Head black behind the antennae, upper surface otherwise entirely dull yellow, or with the elytra gradually dusky posteriorly; varies to entirely pale piceous above........ *instabilis*

50. Upper surface entirely black, head in male not wider than the thorax, 2^{d} antennal joint much shorter than the 3^{d}; size small (6–6½ mm.) (California) .... *moestus*

Sides of prothorax yellow, elytra black, size somewhat larger 51

51. Head in male not wider than the thorax, epistoma black; length 8–10 mm. (Alaska) .... *tetragonoderus*

Head distinctly wider than the thorax in the male, epistoma pale; length 7–8 mm. (California) .... *altus*

52. Color above pale yellow, head behind the antennae black .... *citrinus*

Prevailing color black 53

53. Head opaque, but with very few fine punctures; thorax quite smooth and impunctate .... *laevicollis*

Head and thorax distinctly punctate, surface more or less rugose 54

54. Prothorax black with a small marginal rufous spot just behind the front angles, disk without eroded line (California) .... *fenestratus*

Prothorax entirely black, disk with distinct eroded line between the convexities (New Hampshire) .... *probus*

55. Head in the male scarcely wider than the thorax; antennae short and rather stout, intermediate joints not more than 2½ times as long as wide .... *heteronychus*

Head in the male distinctly wider than the thorax; antennae slender and elongate, intermediate joints about 3½ times as long as wide .... *furtivus*

56. Head more finely less closely punctate, 2d and 3d antennal joints equal .... *cavicollis*

Head more distinctly punctate, 2d joint of antennae very evidently shorter than the 3d, especially in the male........ *corneus*

Podabrus latimanus Motschulsky

P. mellifluus LeConte

This very distinct and apparently somewhat scarce or perhaps local species is notable for its modification of the male protibia, which structure also exists in an incipient form in the female. It is not represented in my collection, specimens previously so labeled belonging really to the next species. It is known to me only from Middle California.

Podabrus ambiguus n. sp.

Size of *latimanus,* to which it seems closely allied. Type—dull yellow, the disk of thorax, occiput, labrum, antennae except the under side of the basal two joints, and legs, black.

The discal pronotal spot varies much in size; the elytra may become entirely blackish, and the body beneath and legs may be in part testaceous. The maxillary palpi are as in *latimanus,* the apical joint, however, rather more obliquely truncate than LeConte's remarks would indicate. Eyes not very prominent, the head scarcely as wide as the thorax in either sex; occiput and neck coarsely densely punctate. Prothorax transversely quadrate, the front angles rounded, hind angles minutely prominent, surface closely punctate, a median eroded line which reaches neither base nor apex. Elytra finely rugose, with faint traces of discal costae. Front tibiae of male feebly sinuate and slightly thickened apically, but without hint of the thin plate peculiar to the male of *latimanus.* Claws all cleft as in Group A of LeConte. Length 6 to 9 mm.

Described from a series of specimens collected by Nunenmacher in Yuba and Tehama Counties, California. A specimen in the LeConte collection is wrongly placed with *latimanus.*

As in *latimanus* the head is small with non-prominent eyes, but the last joint of the maxillary palpi is moderately oblique at apex and cannot fairly be called "nearly transversely truncate" as does LeConte in defining *latimanus.* The thorax in *latimanus* is also more rounded on the sides and more narrowed anteriorly.

Podabrus rugulosus LeConte

This well known species occurs throughout the Northern States from Maine to Kansas. It is our most abundant New England species, and is given in the Washington, Cincinnati and Schwarz' Florida lists; I have a single example from Southwestern Arkansas.

Podabrus appendiculatus n. sp.

This species is very similar to *basilaris* and is sure to be found mixed with it in collections. Males are easily separated from *basilaris* by the distinctly curved and apically thickened protibiae, and by the hind coxae being apically broadly and strongly appendiculate, the downward projecting process being clothed with short dense fuscous hairs at tip.

Head not wider than the thorax, varying but little in the sexes, black, shining, coarsely and densely punctate, clypeus smooth. Antennae as long as half the body in the female, a little longer in the male; black, first joint pale in basal half; joints 2 and 3 nearly equal in the female, 3 slightly longer than 2 in the male. Prothorax ½ wider than long, sides broadly rounded, front angles indistinct, feebly subsinuate before the basal angles, which are minutely prominent; color testaceous, having a broad reddish brown discal area with a black central spot; punctuation distinct and rather close on the disk, feeble in the pale margins except in front, an eroded median line through the black spot. Elytra entirely dull testaceous with broad fuscous vittae separated by narrow paler lines on the disk; the suture narrowly, the sides more widely pale; surface moderately rugose, dull or but feebly shining. Metasternum and abdomen blackish; thighs pale except at tip, knees, tibiae and tarsi blackish. Length 10–11 mm.

Three specimens only of this species are now before me; a male (type) from Cornwall, Connecticut, collected by Mr. K. F. Chamberlain June 18, 1921, and 2 females taken by myself, one at Tyngsboro, Mass., the other labeled simply "Mass." I have seen Pennsylvania specimens taken by Mr. Liebeck.

Podabrus knobeli n. sp.

Very similar in size and form to *frater* Lec., to which it is otherwise closely related. Head black, sides in front pale beneath the antennae; thorax yellow, discal convexities each with a reddish brown spot, these sometimes confluent; elytra black, side margins and suture narrowly testaceous. Head as wide as or slightly wider than the thorax in the male, not quite as wide as the thorax in the female; clypeus smooth, front loosely, occiput and neck densely punctate, surface polished. Antennae black throughout, not very slender, half the length of the body (♂) or a little shorter (♀); joint 2 from 3/5 to 3/4 as long as joint 3. Prothorax 2/5 wider than long, moderately arcuately narrowed in front, feebly narrowed and slightly sinuate before the hind angles, which are minutely prominent; surface polished, the convexities and the area in front of them moderately punctate, sides nearly smooth, a short eroded line between the convexities. Elytra rugose, thinly pale pubescent, discal costae feeble but traceable. Body beneath and legs black, the prothorax and lateral margins of the ventral segments narrowly pale. Protibiae of male curved basally, and with an angular dilatation on the inner side at about the apical fourth. Length 9–10½ mm.

Described from 4 ♂, 4 ♀, all collected at Hope, Arkansas (Apr. 24–May 17) by Miss Louise Knobel, to whom the species is dedicated with appreciation of her industry and success in collecting the insects of her local fauna. So far as known to me, this species and *frater* alone possess the distinct angulation of the subapical inner margin of the male protibiae. The color differences distinguish the two species very readily.

Podabrus frater Lec.

In addition to the color characters given in the table, this species differs from the preceding by the thorax being nearly impunctate except antero-medially. LeConte gives the range of this species from Virginia to Florida, but it is evident from my series that it is not rare from New Hampshire to Pennsylvania.

Podabrus comes Lec.

This moderately large species is widely dispersed on the Pacific Coast and in the Rocky Mountain region, occurring from Oregon to Southern California, and also according to LeConte in Montana. Specimens from Jemez Springs, New Mexico, in my collection do not seem to be separable from the California ones. LeConte says the occiput is sometimes dark, but I have not as yet seen such specimens. The pale head and thorax, dark antennae and legs, and distinctly curved and apically dilated front tibiae in the male will separate it from nearly all its nearer allies. *Mexicanus* is extremely similar but has the protibiae of the male scarcely modified.

Podabrus conspiratus Fall

This form, recently described by me from Alaska (Pan Pac. Ent. II, No. 3, p. 152) as a possible variety of *comes,* I now am inclined to consider distinct. In addition to the differences named in the description, I might add that in *comes* the front tibiae of the female exhibit feebly but unmistakably the curvature and apical thickening which is much more conspicuous in the male, while in the present species there is no indication of such modification. It may be that when the male of *conspiratus* is found the protibiae will prove to be unmodified, in which case the species should be associated with *Mexicanus* and *tenuis* rather than with *comes* and allies.

Podabrus illex n. sp.

Similar in size and form to *comes.* Head yellow in front, black behind the antennae; muzzle smooth; front sparsely, occiput and neck densely punctate; surface shining, not alutaceous. Antennae black, basal joint yellow, joints 2 and 3 pale beneath. Prothorax moderately transverse, entirely yellow, polished and nearly impunctate, or with a few fine punctures near the front margin, more evident in the female; sides parallel, broadly arcuate, front angles rounded, hind angles sharp but scarcely at all prominent, the sides before them not or barely perceptibly sinuate; median line finely impressed between the convexities. Elytra entirely black, feebly pruinose with short ashy pubescence; surface rugose, the discal costae fine but traceable. Legs yellow, the tarsi dusky. In the male the head is as wide as the thorax, the antennae a little longer than half the body, protibiae rather weakly curved and dilated, hind coxae appendiculate at apex, venter black with the last segment entirely yellow, the two preceding pale except at sides. In the female the head is narrower than the thorax, antennae half the length of the body, protibiae straight and not dilated at apex, venter black, the terminal segment alone in part yellow. Length 11–12½ mm.

Six examples (3 ♂, 3 ♀) are before me, all collected by Mr. Ralph Hopping at Fallen Leaf Lake and Angora Lake, Middle Sierras, California. The type is a male from the first named locality and bears date vii–8–1915.

Should the color characters of this species not prove definitive, it may I think be separated with certainty from *comes* and *pruinosus* by the obviously less strongly modified protibiae of the male, and there is a corresponding difference detectable in the female. Should the present species be referred by the student to the *binotatus-mexicanus* group because of the comparatively feebly modified male protibiae, it would by the table run to *sierrae,* which species differs notably in its more quadrate thorax with sides more nearly straight and convergent posteriorly from a point in advance of the middle, the front angles more or less distinctly obliquely truncate.

Podabrus pruinosus Lec.

This species was united with *tomentosus* by LeConte in his latest paper on the Lampyridae (1881). *Tomentosus* does not, so far as I know, occur on the Pacific Coast, and the error could not have occurred had LeConte been aware of the secondary sexual character of the hind coxae, well marked in *pruinosus,* but entirely lacking in *tomentosus. Tomentosus* differs further from *pruinosus* in its much less prominent eyes and consequently narrower head in the male. *Pruinosus* is very closely allied to *comes,* and were it not for the entirely black legs of the latter it would be difficult to name good characters for their distinction. In *pruinosus* the legs are typically entirely yellow, but in numerous specimens ranging from Northern California to British Columbia, and not otherwise satisfactorily separable, the tarsi or tibiae and tarsi are blackish, which suggests the possibility that the femora may vary in color in these two supposed species. For this supposed variety of *pruinosus* the name *diversipes* is proposed.

LeConte gives Oregon as the type locality of *pruinosus* in his original description.

Podabrus limatus n. sp.

> Head, thorax, antennae and legs rufotestaceous; elytra black, side margins narrowly pale, the suture also extremely narrowly so toward the base; metasternum and abdomen black, segments 6–8 of the latter rufous. Second joint of antennae a little shorter than the third. Front moderately closely punctate, occiput and neck densely so. Prothorax slightly narrower in front, sides arcuate, front angles obtuse, hind angles minutely prominent; surface almost smooth, median line not eroded. Protibiae of male somewhat feebly dilated apically; claws rather narrowly cleft. Length 8 mm.

Inyo Co., California; 2 ♂'s collected by O. C. Poling. Smaller and narrower than *viduus,* to which it is closely similar; the head, however, is much more punctate, the thorax of different form (being more like that in *tomentosus*) and the elytra margined with testaceous. As compared with *tomentosus* the form is narrower, the median line of the thorax not eroded and the front tibiae of the male less dilated.

Podabrus tomentosus Say

This species occurs from New Jersey to Kansas. It is also recorded from Colorado and California. The California specimens are certainly something else (*pruinosus* et al.) and the Colorado ones need verifying.

There are no eastern species with which *tomentosus* is likely to be confused, and the simple hind coxae in the male (without apical process or tuft of hair) will separate it at once from the Pacific Coast forms which resemble it. The elytra are typically entirely black, but may have the margins narrowly pale; in these latter the tibiae are usually pale, while in the typical form they are dusky.

Podabrus tricostatus Say

This large species with its strongly transverse thorax with broadly explanate sides and its dilated and costate elytra is so well known as to need no special comment. It occurs from New England and Canada to Michigan, Southern Ohio and the District of Columbia.

Podabrus brevicollis n. sp.

> Of large size and robust form for the genus. Color piceous brown or blackish; head in front of a line joining the middle of the eyes pale testaceous, the anterior margin of the epistoma blackish; prothorax testaceous, disk with blackish median spot occupying about the middle half (in a transverse sense), narrowed in front, not or scarcely attaining the apex; elytral suture and margins narrowly pale; body beneath piceous brown, the head and thorax pale. Antennae scarcely differing in the sexes, piceous, basal joint more or less pale beneath, second joint only just perceptibly shorter than the third. Head smooth in front, becoming abruptly coarsely densely punctate in the dark area. Prothorax varying from slightly less than, to a little more than twice as wide as long, a little narrowed in front, sides arcuate throughout, the base angles minutely prominent, front angles rounded; blackish discal area distinctly punctate, pale margins smooth, deeply concave within the base angles. Elytra densely scabrous punctate, each with three fine discal costae, the outer one usually obsolete. Tarsal claws all cleft or acutely toothed. Length 10.5 to 12.5 mm.

New York (Peekskill); Pennsylvania (Inglenook); Rhode Island.

The type is a male from the first named locality and bears date "5-21-90."

This species is generally confused with *basilaris,* with which it stands in the LeConte collection. It is at once distinguishable from the latter by its much more transverse prothorax, which is more narrowed in front, and in form resembles rather that of *tricostatus.* The latter has the elytra more broadly dilated and more strongly costate, and entirely black; and the second antennal joint is conspicuously shorter than the third.

Podabrus fissus Lec.

This species is thus far one of the rarest of the genus and is known to me only by the unique male type. If the type is a normal specimen the species may be distinguished from all others by the reddish brown densely punctured and opaque discal area of the thorax. Described from Florida.

Podabrus nothoides Lec.

> Size moderate (8–9 mm.), dull black, sides of front below the antennae, and sides of thorax, yellow; the elytral margin narrowly paler, at least basally. Head unusually small and antennae only half the length of the body in the female; in the male the head is subequal in width to the thorax, the antennae longer, thicker, and with the joints more parallel; antennae and legs entirely black.

Occurs from the New England states to Manitoba; apparently not abundant.

Podabrus nothoides Lec.

> Size large, usually 12 to 13 mm. Head black except the posterior part of the clypeus and beneath the antennae. Thorax in the male pale yellow with a median fuscous stripe, sometimes not reaching the apical margin; in the female with disk broadly blackish, at times with the angles alone paler. Elytra black with suture and lateral margins pale. Beneath fuscous, the abdominal apex paler or not in the male; femora pale except near the knees, tibiae and tarsi dark. Antennae blackish, the basal one or two joints in part pale; joints 2 and 3 nearly equal in both sexes. Clypeus smooth, head otherwise densely rather coarsely punctate. Prothorax 1/2 to 1/3 (♂) or 3/4 (♀) wider than long, transversely subquadrate, the sides broadly arcuate, a little narrower and more rounded at the front angles; surface moderately shining and not densely punctate, median line finely eroded, not entire. Elytra thinly pubescent and rather finely rugose.

Northeastern Atlantic region, precise limits of distribution uncertain.

The *basilaris* of LeConte's *Revision* and of collections generally is a composite species, including the forms *brevicollis* and *appendiculatus* herein described as new, and the *punctulatus* and *flavicollis* of LeConte, which I believe to be good species. It can never be entirely certain just what Say had in hand when he described *basilaris*; he specifically states, however, that the thighs are pale, which I take it definitely excludes *brevicollis* in which the legs are

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Correction to a Revision of Podabrus.—On page 80, Vol. VIII, No. 2, of Entomologica Americana, two species are described under the title *Podabrus nothoides* Lec. The second title should read *Podabrus basilaris* Say.—H. C. FALL.

entirely dark in all specimens seen. Both the present form and *appendiculatus* have pale thighs, and as Say was not aware of the differences in the male hind coxae, he may have had either or both of these before him. The type of *discoideus* Lec. is a female and appears to be identical with the present species.

Podabrus punctulatus Lec.

A species of the *basilaris* type but smaller (8–9½mm.), clypeus wholly pale, femora pale only in basal half or less; 2^{d} joint of antennae a little shorter than the 3^{d} in both sexes, hind coxae of male unmodified.

Described from Kansas and known to me also from Illinois, Indiana and Wisconsin. A male from Smugglers Notch, Vermont (Emerton), and two females from Cornwall, Connecticut (Chamberlain), in my collection appear to be identical with western specimens.

Podabrus flavicollis Lec.

Closely allied to the two preceding species, but seemingly always separable by the immaculate yellow thorax. The size (10–12 mm.) is more nearly as in *basilaris,* the clypeus broadly infuscate except at base, also as in *basilaris,* the femora pale in basal third or fourth; joints 2 and 3 of antennae equal in the male, joint 2 a trifle shorter in the female; protibiae and hind coxae unmodified in the male.

In his original description LeConte says "Middle and Southern States." I have taken the species in Rhode Island and have it also from Arkansas. A Lake Superior specimen in the LeConte collection seems to be identical. The type is a male from the Southern States region.

I do not know on whose authority *flavicollis* is placed as a synonym of *modestus* in the Leng List. The two are really quite distinct, the punctate wholly yellow thorax of *flavicollis,* and the relatively smooth thorax with more or less developed discal cloud in *modestus* being probably sufficient for their separation in all cases.

Podabrus quadratus Lec.

This is one of the rare species and is known to me only by the two original female specimens from Texas in the LeConte cabinet. The thorax is transversely subquadrate, sides straight and parallel in basal two-thirds, rounded a little in front, quite coarsely uniformly punctate, median impressed line not excavated; joints 2 and 3 of antennae equal; front of head except clypeus at middle, thorax and elytral margins, pale; extreme base of femora paler.

Evidently closely related to *flavicollis*, and possibly only a variety thereof, but more material is needed to establish the relationship.

Podabrus modestus Say

A common species of the Northeastern U. S., ranging from Quebec to west of the Mississippi River, Say's type being from "Missouri" (probably now Iowa or Nebraska). The southern limits are uncertain. It appears in the Southwestern Pennsylvania and New Jersey Lists, but not in the Washington or Cincinnati ones. LeConte, however, gives Georgia among his localities.

The species is of moderate size (9–11 mm.), and as typically colored is black with the base of the antennae, front of head, sides of thorax, elytral margins and suture, and legs, pale. The legs vary from entirely pale to piceous, the femora in the latter case diffusely pale only at the extreme base. The disk of the prothorax is broadly blackish or fuscous from base to apex, the pale side margins rather narrow, especially posteriorly.

Modestus is most readily separated from all its near allies by the comparatively smooth prothorax, the discal convexities being broadly almost impunctate. There is a fine median impressed pronotal line, which, however, is not eroded or excavated in the great majority of specimens at least.

Podabrus longicornis n. sp.

Pale piceous, including antennae and legs; sides of thorax narrowly, and lateral and sutural edges of elytra, rather obscurely paler. Head (♂) distinctly wider than the prothorax, blackish, clypeus paler, strongly and closely punctate behind the clypeus. Antennae nearly as long as the entire body, basal two joints pale beneath, 2^d joint much shorter than the 3^d, intermediate and outer joints filiform, four to five times as long as wide. Prothorax transversely quadrate, 2/5 wider than long, sides parallel, a little arcuate medially, front angles rounded, hind angles prominent; surface sparsely punctate and shining, median line finely acutely impressed. Elytra rather finely and smoothly scabrous, moderately shining. Venter fuscous throughout. Length (head deflexed) 7 mm.

A single male specimen from New Hampshire without precise locality.

It is possible that the rather dilute color may be due in some degree to immaturity, and that in fully colored examples the pale margins of the thorax and elytra will be more distinct. The protibiae and metacoxae are not sexually modified.

PODABRUS DIADEMA Fab.

> Length 9–11 mm. Black, clypeus and sides of thorax yellow, elytra without pale margins or suture, head rather sparsely punctured and opaque.

The range of this species is almost identically the same as for *modestus*; Northern U. S. and Canada from New England to Minnesota and Iowa. It occurs in New Jersey and Pennsylvania but is absent from the Washington and Cincinnati lists.

PODABRUS PROTENSUS Lec.

The tabular characters should suffice for the easy recognition of this peculiar species. The rather small head with long tapering neck, and the entirely yellow head and thorax, both of which are finely remotely punctate, are quite distinctive. Although here included among the species having the protibiae of the male straight and without appreciable apical dilatation, there is really an observable modification of the typical sort, so that the species might with almost equal propriety have been tabulated in the other group.

Protensus occurs from Southern New England to Indiana, and as a rule seems not to be very common.

PODABRUS BRUNNICOLLIS Fab.

Similar by its long tapering neck to *protensus,* but considerably smaller (7–10 mm.), with narrow thorax, and differently colored and punctured as indicated in the table. This species with its variety *poricollis* ranges from New Jersey to Iowa and south to Georgia and Texas.

PODABRUS BINOTATUS Lec.

A moderately large species (10–11½ mm.), at once recognizable by the generally yellow upper surface and bimaculate thorax. It is known to me by very few specimens, all from the vicinity of San Francisco.

Podabrus confraternus n. sp.

Rufotestaceous, the antennae (except basal joint) and elytra brownish testaceous in the type; the antennae, elytra, legs and lower surface varying to piceous. Head moderately closely punctate behind. Prothorax with sides moderately arcuate, somewhat narrower at the rounded apical angles, base angles minutely prominent; surface smooth except anteriorly, median impressed line feebly eroded. Elytra parallel, finely scabrous. Front tibiae of male feebly curved, not appreciably dilated apically; claws all cleft, the inner tooth or division shorter. Length (head deflexed) 9.5 to 11 mm.; width 2.9 to 3.2 mm.

The type is a male taken by the writer at Pomona, California, June 4, '92. A female with darker elytra, legs and under body, from same locality June 28, '92, is unquestionably identical. A third example (♀) from the San Bernardino Mts. appears to be the same.

This species is of the size and form of *comes,* with which it has been associated in my cabinet. The latter species has the elytra truly black, and the front tibiae of the male conspicuously dilated apically.

Podabrus sierrae n. sp.

Black; head in front, prothorax, base of antennae and legs throughout, bright rufotestaceous. Antennae in the male two-thirds, in the female scarcely half the length of the body; second joint nearly as long as the third. Neck and back of head coarsely closely punctate, front sparsely punctate, epistoma smooth. Prothorax nearly as long as wide, subquadrate in the male, sides nearly parallel, either nearly straight or slightly angulate at the middle, the basal and apical angles narrowly obliquely truncate; surface polished and varying from finely punctate to nearly smooth, the median impressed line vague and scarcely eroded. Elytra parallel, finely scabrous, with faint discal costae, pubescence fine and inconspicuous. Claws acutely toothed. Length 11 to 14.5 mm.

Described from three examples. The type is a male from Tallac (Lake Tahoe) collected by Dr. Fenyes; a female example, same locality as type, and a second male from Glen Alpine (Lake Tahoe) also collected by Fenyes. A ♀ from Fallen Leaf Lake has been recently received from Mr. Hopping; in it the feeble truncature of the hind angles of the thorax is not obvious.

Podabrus viduus n. sp.

Closely allied to *sierrae* and differing as follows. The head is entirely rufotestaceous, the front almost smooth; the prothorax is widest and rather distinctly angulate at the anterior fourth or fifth, the sides thence convergent and straight or but feebly curved to both apex and base, the hind angles sharply defined and slightly prominent, rather than obliquely subtruncate as in *sierrae*. Length 12 to 15 mm.

California. Inyo Co., 4,500 ft., July, '22, type: Inyo Co., Sebastian Lake, 8,900 ft.; Kings River Cañon (Daggett): Mohawk (Fenyes). All specimens are females. A pair (♂ ♀) from Fallen Leaf Lake has more recently been received from Mr. Hopping. The male is slightly smaller and more slender than any of the females, the antennae appreciably longer with the joints more parallel, the protibiae not appreciably modified, the hind coxae with an apical tuft of darker hairs

Podabrus fulvus n. sp.

Rather narrow, parallel, size large. Head in front, base of antennae, thorax, elytra and legs, yellow; the base of the hind thighs, body beneath, antennae except basal two joints, and head posteriorly, black. Antennae (♂) attaining the middle of the elytra, slender, joints parallel sided, the second slightly shorter than the third. Front sparsely punctate, occiput and neck coarsely closely so. Prothorax transversely nearly square, sides parallel, anterior angles rounded or subtruncate, hind angles distinct, subrectangular; surface finely punctate to nearly smooth, median impressed line evident. Elytra finely scabrous punctate, discal costae feeble. Legs slender, protibiae of male not appreciably dilated apically. Claws all acutely toothed or cleft within. Length 12 to 14 mm.

Kaweah, California, 6,000 ft. (type ♂); Atwell's Mills, Tulare Co., 6,600 ft. (G. R. Pilate).

This, like all the preceding species, is a member of LeConte's Group A, and except for color is extremely close to the preceding species.

Podabrus tenuis n. sp.

Similar to the several preceding species in general characters but more slender in all its parts; the legs entirely black, the mouth, base of antennae, and prothorax, rufotestaceous. The prothorax is highly polished and virtually impunctate, the median impressed line very vague and not at all eroded; it is nearly as long as wide, the sides nearly straight except for a slight excurvature at the middle, and evidently convergent to base, the base angles sharply defined and just less than right. Length 11.5 mm.

California: Mt. Whitney, 11,000 ft., 7–24–99. A single male example collected and given me by Mr. F. S. Daggett.

PODABRUS MEXICANUS Gorham

Similar in size and color to *comes*, the head, however, usually more or less blackish posteriorly though sometimes entirely pale; legs and antennae entirely black, the first joint of the latter somewhat paler beneath. The front tibiae of the male are not appreciably dilated apically (very distinctly so in *comes*), the hind coxae with an apical process (smaller than in *comes*) tipped with longer hairs. Length 10½–12 mm.

This species occurs in our territory in Southern Arizona, the specimens before me being from the Chiricahua Mts.

Podabrus muliebris n. sp.

Similar to *comes* and *mexicanus* but a little smaller. Black, prothorax and front of head rufotestaceous; antennae and legs entirely piceous, margins of the last two or three ventral segments tinged more or less with testaceous. Head (♂) barely or scarcely as wide as the prothorax, the eyes less prominent than usual in this sex; clypeus smooth, rest of head and neck closely coarsely punctate. Antennae (♂) more than 2/3 as long as the body, 2^{d} joint shorter than the 3^{d}, 4th to 8th about three times as long as wide. Prothorax moderately transverse, widest near the middle, sides flatly arcuate, surface sparsely finely punctate, more closely and strongly so in front; median line finely eroded between the discal convexities. Elytra finely scabrous, costae feebly indicated. Protibiae of male only slightly widened apically, hind coxae nearly simple. Length (♂) 9–11 mm.

Cloudcraft, New Mexico; 4 examples, all males.

The less prominent eyes and virtual lack of tibial and coxal sexual modifications distinguish this species from *comes* and *mexicanus*, the only similar species inhabiting the same general region.

Podabrus occipitalis n. sp.

Prothorax, neck and head, except for a transverse arcuate blackish occipital fascia from side to side between the eyes, bright yellow; elytra black with conspicuous cinereous pubescence; body beneath, legs and antennae except at base, black or piceous, the front legs sometimes in part paler. Head much wider (♂) or slightly wider (♀) than the thorax; surface moderately shining, very sparsely punctate except at base. Prothorax nearly as long as wide, sides feebly arcuate, a little sinuate posteriorly before the somewhat prominent hind angles; disk with prominent longitudinal convexities which make the median portion appear deeply excavate in posterior half; surface subimpunctate, median impressed line very fine, not eroded. Elytra finely scabrous, the discal costae feeble but evident. Protibiae of male entirely unmodified; claws (♂) finely cleft, the inner part approximate to and but little shorter than the outer; in the female the inner part is shorter and less close to the outer. Length 7 to 8.5 mm.

California: Pasadena (type ♂); Pomona; collected by the writer.

Podabrus mellitus Lec.

This species is closely similar in size, form and color to *corneus* and *cavicollis,* together with which it constituted Group C of Le Conte's 1881 Revision. The group characters as given by Le Conte are sufficiently accurate as far as they go, except that the prothorax may be as wide as or wider than long, but there are two errors in the table which follows, both pertaining to *mellitus.* In Group B certain species are said to have the fourth tarsal joint deeply bilobed, while in others it is slightly emarginate; and here again in Group C, *mellitus* is separated from *corneus* and *cavicollis* by the same character. There is in reality no such distinction, all our species of *Podabrus* having the fourth joint bilobed, though at times the contiguity or overlapping of the inner margins of the lobes causes the joint to appear merely emarginate at apex.

In the brief diagnosis of *mellitus* the outer claw of the hind tarsus is said to be toothed, all the others cleft. This is the case in males of *corneus* and *cavicollis,* but an examination of the type shows it is not true of *mellitus,* in which the outer metatarsal claw is cleft like all the others and is the same in both sexes. For this reason *mellitus* is here removed from association with *corneus* and *cavicollis* and placed after *occipitalis,* to which indeed it is nearly related, although less so in general aspect.

The moderate size—about 8 or 9 mm.—slender form, yellow color, small thorax, and lack of sexual modification of the front tibiae and hind coxae of the male distinguish this and the following species (*modulatus*) among the large group (Le Conte's Group A) having all the tarsal claws in both sexes cleft or with a long internal tooth. The type of *mellitus* is a male from Geysers, Sonoma Co., California. Le Conte also gives "Nevada (Horn)"; probably the extreme western part of the state in the Lake Tahoe region. My specimens are from "Sylvania," Sonoma Co. (Ricksecker), and Lake Tahoe.

Podabrus modulatus n. sp.

> The tabular characters constitute, I think, a sufficient description of this species. It is very close indeed to *mellitus* and may prove to be no more than a variant of that species. As in *mellitus* the head is evidently wider than the thorax in the male, subequal to the thoracic width in the female; head polished and with only a few sparse punctures in the black area, except at the extreme rear; yellow area of the front and clypeus impunctate; joints 2 and 3 of antennae equal. Prothorax widest at or near the middle, in *mellitus* usually well in advance of the middle; in both becoming rather suddenly oblique and straight at the anterior angles; surface shining and sparsely punctate; dorsal excavation deep, usually with a dark spot or stripe. Length 6.7 to 8 mm.

Described from 12 examples from Sonoma, Marin, Alameda, San Mateo and Santa Clara Counties, California

The type is a male from Cypress Ridge, Marin Co., and bears date "4–11–20."

Podabrus extricatus n. sp.

> Front of head, prothorax and elytra, yellow, the excavation of the prothorax blackish: antennae except at base, body beneath, and legs in great part, black; the front femora and tibiae, and the middle knees, dull testaceous. Head (♂) moderately closely punctate, alutaceous; second joint of the antennae one-half as long as the third. Prothorax finely sparsely punctate, feebly alutaceous, median concavity deep, without or with only faint trace of eroded line at bottom.

Elytra finely scabrous, apex more or less dusky. Claws all with a broad basal tooth. Length 6 to 7 mm.

California: Placer Co. (type ♂); Sierra Co., Plumas Co. 3 ♀'s, provisionally attached.

This is one of a group of superficially very similar Californian species, of which Le Conte described five. Two of these—*lutosus* and *tejonicus*—were included in his Group B because of the broad basal tooth of the tarsal claws; while *cavicollis, mellitus* and *corneus* were placed apart, constituting his Group C, characterized by having the claws narrowly cleft. Le Conte did not discover the fact that in certain species the claws are differently formed in the sexes, so that his groups as defined are not tenable. It so happens that both *lutosus* and *tejonicus* were described from females, and my own study leads me to believe that the former is the female of the previously described *cavicollis.* So far as I know, males of *tejonicus* have not been recognized. The present species, because of the form of the male claws can be compared with no described species unless *tejonicus,* the unique type of which is rather larger and stouter and differs otherwise by the more finely and sparsely punctate head.

Podabrus tejonicus Lec.

This species is certainly known only by the unique female type, 7.5 mm. long, from Tejon, California. The male being unknown, the true position of the species in the scheme here adopted remains doubtful. Because of the marked similarity of the type to females of *extricatus* it is here tentatively associated with that species. It agrees with *extricatus* in color and in the alutaceous finely punctate head, the punctures however being still finer in that species. The prothoracic punctation while fine and sparse in *extricatus,* is in *tejonicus* virtually obsolete except on the outer flanks and summits of the prominences, and is there indistinct; the third antennal joint is hardly more than one-fourth longer than the second in *tejonicus,* relatively longer compared with the second in *extricatus;* prothorax more evidently narrowed behind in *extricatus,* barely visibly so in *tejonicus.* These differences are, however, all small, and it may well develop eventually that they are one and the same species, but until more material including males from the type region becomes available it is not safe to assume this.

A single female specimen in my collection from Mt. Tom, Fresno Co., California, collected by Hopping, agrees very nearly with the type of *tejonicus,* and I am so labeling it provisionally.

PODABRUS SCABER Lec.

Of this species I have seen only very few specimens. The Le Conte collection contains only the Oregon type and a second example from Vancouver, both females. Wickham records taking a specimen on the Stikine River in British Columbia, and I have a single male example from Glacier Park, Montana (Miss Edith Mank, collector).

The insect is black, sides of front below the antennae and sides of thorax reddish yellow. Head and thorax densely rugosely punctate, dorsal line of the latter present but fine in the type, absent in the second specimen. Length 11 mm.

PODABRUS CINCTIPENNIS Lec.

This is one of the rarest or perhaps most local of the eastern species of the genus. It is still represented in the Le Conte collection by only the unique female type from Pennsylvania. Mr. Liebeck has recently sent me two females taken by him at South Camden, New Jersey, the only ones secured by him in his many years' collecting. He had not identified the species, which is not given in Smith's New Jersey List. It is recorded as common in Hamilton's Western Pennsylvania List, but does not appear in either the Washington of Cincinnati lists.

Cinctipennis should be easily identified, its size (11 mm.) being greater than any other eastern species with broadly appendiculate claws.

PODABRUS LIMBELLUS Lec.

This species is nearly allied to *cinctipennis* and is similarly colored, but is appreciably smaller (9 mm.) and of generally more northern range. Le Conte's type is from New Hampshire, taken by Austin, probably in the White Mts. My own specimen and others in the Blanchard collection are from Mt. Washington. Hamilton records the species from Western Pennsylvania, but I do not find it on any other lists which I have consulted.

PODABRUS PUNCTATUS Lec.

Easily known by the dull, densely punctated head and thorax, the latter entirely clear red or reddish yellow, the elytra black without pale margins; length 6–8 mm.

Occurs from New Brunswick and Pennsylvania to Lake Superior. It is generally dispersed though not abundant in the New

England States, and I have a specimen from Newfoundland, New Jersey (Bischoff coll.), although the species does not appear in the New Jersey List.

Podabrus excursus n. sp.

> Black, sides of epistoma and basal two joints of antennae beneath pale; prothorax sometimes entirely black, sometimes with the sides either obscurely or distinctly reddish yellow. Antennae half as long as the body in the male, the 2d joint scarcely as long as the 3d, intermediate joints parallel sided and about four times as long as wide; in the female nearly as long, 2d and 3d joints equal, following joints gradually slightly narrowed basally. Head (♂) distinctly wider than the prothorax, moderately coarsely closely punctate, epistoma smooth. Prothorax transversely quadrate, about two-fifths wider than long, sides nearly straight and parallel or feebly convergent toward the base, hind angles rectangular, front angles rounded or obliquely subtruncate; discal convexities moderate, an impressed median line between them; surface rather shining, not or scarcely perceptibly alutaceous, punctuation fine and sparse. Elytra one-half wider than the thorax, parallel, finely rugose, distinctly cinereo-pubescent. Legs entirely black, protibiae and metacoxae not sexually modified. Length 8 to 10 mm.

British Columbia: Vernon, June 5, 1921, one pair (type ♂); Otter Creek, June 14, 1920, 2 ♀'s; Midday Valley, June 5, 1921, 1 ♂; all collected by Mr. Hopping. With these I place a series of specimens collected in Glacier Park, Montana, by Miss Edith Mank, of Lawrence, Mass. These are unfortunately all females, but I am quite satisfied of their identity with the B. C. series.

This species is quite unstable in the color of the prothorax. In the type and in some other examples, while the thorax at first sight seems quite black, closer inspection shows it to be faintly rufescent at sides toward the front angles. In three females the sides are sharply rufotestaceous throughout the length; in others the condition is intermediate. The epistoma also varies to entirely pale except for a dusky spot at the middle of the front margin. The tarsal claws are not fairly typical of this group, the inner tooth being more acutely angulate than usual, and in the front feet of the male is so long and acute that the claw might reasonably be called cleft and the species placed with *laevicollis* and allies.

PODABRUS MACER Lec.

> A very slender species, $7\frac{1}{2}$ to 8 mm. long. Head and thorax dull, the former densely punctate, the latter more sparsely so. Thorax very little (about one-tenth) wider than long, sides nearly straight and converging backward from the obliquely truncate front angles. The thorax is typically black with sides fulvous, but in my three examples is entirely fulvous or with only a blackish shade at the middle of the front margin. Elytra normally black, varying to dull testaceous; legs black. In the male the second joint of the antennae is not much more than half the length of the third.

This species occurs in the Middle California Coast region; type locality San Mateo. My specimens are from "Sylvania," near Santa Rosa.

PODABRUS PINIPHILUS Esch.

> A smallish species ($5\frac{1}{2}$ to $7\frac{1}{2}$ mm.). Entirely black except for a small spot at the sides of the front beneath the antennae, and the underside of the first two or three antennal joints. Prothorax small, and with the head distinctly alutaceous and dull.

An abundant and widely dispersed northern species ranging from Maine to Alaska, and south in the mountains to New Mexico and Central California.

PODABRUS PUNCTICOLLIS Kby.

> Le Conte's brief diagnosis of this species is as follows: "Piceous, base of antennae, sides of mouth, sides of prothorax and margins of elytra testaceous; head sparsely punctured behind; prothorax deeply concave at the middle, dorsal line fine, surface shining, sparsely punctulate; length 8 mm."

Kirby's type was taken in British America, "lat. 54°." It was known to Le Conte from Lake Superior and Mt. Washington, N. H. My specimens are from Mt. Washington; Farmington, N. H., and the summit of Mt. Wachusett, in Massachusetts.

PODABRUS EXTREMUS Lec.

Of this northern species, at present rare in collections, I have seen only three specimens, all females; viz.—the unique Hudson Bay type in the Le Conte collection, and single examples taken by myself at Banff, Alberta, and Skagway, Alaska. These all agree in coloration; black, the head in front of the antennae and narrow side margins of elytra testaceous, the base of the antennae and the tibiae, more especially of the front legs, also tinged with testaceous. The head is narrower than the thorax (in the female at least), strongly alutaceous and dull; thorax transversely quadrate, sides nearly straight and just perceptibly convergent from the obliquely truncate front angles, surface polished and sparsely very finely punctate except near the side margins, where the punctures are closer and the surface narrowly subalutaceous. Length 6.5 to 7.5 mm.

In addition to the localities mentioned above, *extremus* is also reported from Labrador (Sherman) and Mt. Washington, N. H. (Mrs. Slosson).

Podabrus brevipennis Lec.

If the type (a female) is a normal specimen, this species is a most remarkable one and quite unique in our fauna, in that the elytra in this sex are very short, less than twice as long as wide, and lack much of covering the abdomen, of which the last three segments are exposed. The form is robust, the prothorax nearly as wide as the elytra at base, the sides subparallel almost to the front angles, black with rufous spots at front and hind angles, disk shining, sparsely finely punctate, more coarsely punctured in front and along the hind margin; antennae short and stout, tapering to tip, joint 2 slightly shorter than 3, each nearly as wide as long; eyes small, not prominent, sides of head feebly convergent behind. Length 8.7 mm.

Type locality—Argentine Pass, Colorado, 13,000 ft. Several specimens from various localities were subsequently placed with the type by Le Conte, but the reasons for the association are by no means obvious and I should be unwilling to admit the identity. It it of course quite possible that the male when found will prove to have normally developed elytra.

Podabrus xanthoderus Lec.

Length 7.5 to 8 mm. Head, elytra and legs entirely black; pubescence of elytra short, semierect and black or nearly so. Thorax yellow with front and rear margins narrowly black at middle in the type. The head is finely scabrous and opaque; thorax finely punctate, surface finely alutaceous except the summits of the convexities, which are nearly smooth and more shining. In one of three specimens from Placer Co., California, in my collection, the thorax shows a narrow median dark stripe. The black suberect pubescence of the elytra is a very exceptional character in *Podabrus,* the elytral hairs being cinereous, or in the yellow species yellowish, and more recumbent in the vast majority of species. *Rugulosus, frater* and *pattoni* are the only other species that I notice having the elytral pubescence wholly or predominantly black. In certain examples of *rugulosus* in my series the pubescence inclines to grayish, especially toward the margins, showing that here the character is not entirely constant; moreover I have a number of specimens from the Californian Sierras, from Shasta to Southern California, which seem to agree with *xanthoderus* in every other character of weight, except that the pubescence is grayish. It is at present impossible to say whether these constitute a distinct species or not. *Xanthoderus* was described from Lake Tahoe.

Podabrus bolteri Lec.

A slender smallish species (6.5 mm.) inhabiting the Sierras of middle California, and represented in the Le Conte collection by the unique male type from Lake Tahoe. Black, mandibles and sides of thorax reddish yellow, legs entirely black. Second joint of antennae distinctly shorter than the third. Head sparsely finely punctate throughout and somewhat shining. Prothorax not quite as long as wide, sides visibly convergent from near the front angles, polished, very sparsely finely punctate, deeply concave posteriorly, no median eroded line. Le Conte is in error in saying that the thorax is longer than wide and the sides parallel.

Podabrus fissilis Fall.

This species is similar in form and appearance to *piniphilis, puberulus* and *simplex,* but differs from them and all other known species of our fauna by the narrowly cleft claws on all the tarsi of the male. For detailed statements of characters the student is referred to the recently published description (Pan Pacific Entomologist, Vol. II, p. 153). Length 6–7 mm.

Emerald Lake, British Columbia (type); Skagway, Alaska.

Podabrus lateralis Lec.

Black, conspicuously ashy pubescent; front of head and sides of thorax yellow. The yellow thoracic margin is often quite narrow and almost interrupted opposite the discal convexities. Head and thorax alutaceous and not or scarcely shining, rather closely finely punctate; elytra black without pale margins. Length about 7 mm.

Rocky Mts. of Colorado and New Mexico up to 13,000 ft. Le Conte records a variety with thorax entirely yellow. This is represented in his collection by a single female example from Veta Pass, Colorado. When the male turns up it may prove to be a distinct species.

Podabrus obscurevittatus n. sp.

> Virtually identical in size, form and general aspect with *lateralis*, of which it may be no more than a more northern race. It differs from typical *lateralis* in having the lateral margins of the elytra testaceous, the disk with an indistinct paler subsutural vitta, the front legs in great part testaceous, and the yellow side margins of the thorax continued narrowly along both apical and basal margins though sometimes limited to the reflexed edge, more especially at base. In *lateralis* the broad black median area widely involves both apical and basal margins. In the present form as in *lateralis* the head is slightly wider than the thorax in the male, antennae passing the middle of the elytra, the 2ᵈ joint about 2/3 or 3/4 as long as the 3ᵈ joint. In the female the head is scarcely as wide as the thorax, the antennae somewhat shorter. The thorax is a little wider than long, sides slightly convergent from the obliquely truncate front angles, surface finely alutaceous and moderately closely finely punctate. Elytra finely scabrous and distinctly pale pubescent. Length 6–7 mm.

The type (♂) is one of a series of specimens from Edmonton, Alberta, kindly sent me by Mr. F. S. Carr. Other examples are from Calgary, Banff and Medicine Hat in the same province.

Podabrus puberulus Lec.

Of this little species there are in the Le Conte collection the two Lake Superior types and a Hudson Bay specimen, these typically colored, the prothorax black with a dull rufous spot at the anterior angles, and a fourth specimen with entirely red thorax, from Canada, mentioned by Le Conte as a color variety in his Revision of 1881. This last is strikingly suggestive of *simplex,* a closely allied species with reddish yellow thorax, and may belong there. Both *puberulus* and *simplex* have the front and middle tarsal claws finely cleft in the male, and were therefore wrongly included by Le Conte in his Group B, which was intended to comprise only those species in which the claws are armed with a broad basal tooth in both sexes. In the case of *puberulus* the mistake was natural enough since Le Conte had only females in his series.

In his brief diagnosis (1881), Le Conte says of *puberulus*: "Mouth piceous" and "three joints of antennae testaceous." These color characters are evidently not constant, for in several of the examples before me the epistoma is entirely testaceous, and in no specimen at hand are more than two of the antennal joints entirely pale.

Puberulus is truly a northern species; my own small series contains examples from Lake Superior (Michigan-Mackinac Co.) and Manitoba (Onah and Mile 256 H. B. Railway). A female specimen from Canaan, Conn., seems also to belong here.

PODABRUS SIMPLEX Lec.

A small species (5–5½ mm.) having the front of the head, base of antennae and entire thorax yellow; legs in part testaceous, the front ones more fully so. The head and thorax are visibly alutaceous and finely sparsely punctate. Le Conte gives for localities "Canada and Florida (Bolter)." My own specimens are all from eastern Massachusetts. Inasmuch as the species does not appear on either the New Jersey, District of Columbia or Cincinnati lists, the Florida reference is open to suspicion.

PODABRUS PATTONI Lec.

This apparently scarce little species is represented in the Le Conte collection by the unique female Pennsylvania type, and in my own collection by a single female from Mt. Toby, Massachusetts. Le Conte also gives "Canada." *Pattoni* may easily be known among the Eastern species of the genus by the tabular characters, notably the small very smooth and shining and almost impunctate thorax. It is included by Le Conte in his group with tarsal claws broadly toothed at base, but a male in the Horn Coll., Mr. Liebeck informs me, has the claws of the four anterior feet cleft.

Podabrus gracilis n. sp.

General form in all respects similar to *cavicollis* and allied species, but rather more slender than any of them. Head behind the antennae, and elytra, black, the latter with the side margins narrowly paler. Antennae blackish, paler at base; thorax yellow with the excavation blackish; legs varying from almost entirely dull yellowish to largely piceous. Head (♂) sparsely finely punctate, scarcely perceptibly alutaceous; (♀) alutaceous and more numerously less finely punctate. Antennae filiform, second joint (♂) one-half, (♀) two-thirds as long as the third. Prothorax narrow, almost as long as wide in the male, front angles obliquely subtruncate, sides a little convergent to the base angles, which are slightly prominent; surface finely indistinctly punctate. Elytra moderately shining, finely scabrous. In the male the front and middle claws are cleft, hind claws toothed; in the female all claws toothed at base. Length 4.5 to 6.5 mm.

Described from a series of eight examples taken by the writer in the San Bernardino Mts. (7,500 ft.), Southern California.

In its ungual formula this species agrees with the Eastern *simplex,* and does not look greatly unlike it; the latter however differs in its entirely yellow thorax, shorter antennae with the second joint relatively longer and by the elytra not paler at margins.

Podabrus instabilis n. sp.

Similar in size, form and general features to *gracilis,* with which alone, among Western species, it agrees in ungual formation. The color above as well as the legs varies greatly from a fairly clear though rather dull yellow to a nearly uniformly dilute fuscous, the great majority of specimens being of a dingy yellow, with the elytra gradually more or less dusky posteriorly. The thorax is usually entirely dull yellow, but may be completely or partially suffused with brownish, but seems never to be a clear yellow with sharply defined black central spot as in *gracilis.* Length 5 to 6.75 mm.

California: Lake Tahoe (type ♀, taken by the writer); Tuolumne Meadows, 8,600 ft. (G. R. Pilate); Plumas and Sierra Counties (Nunnenmacher); Inyo Co., Mono Co. (above Lundy, 9–11,000 ft., Wickham).

This species, like the preceding, seems to be confined to the Sierras, but with a more northern range, and both appear to be partial to rather high altitudes.

Podabrus moestus n. sp.

Black, a spot beneath the antennal insertion, mandibles and basal two joints of antennae beneath, pale; anterior tibiae tinged with testaceous. Pubescence fine, short and inconspicuous. Head and thorax alutaceous and scabrous, the former barely as wide as the thorax in the male, slightly narrower in the female. Antennae attaining the middle of the elytra in the male, joints feebly obconic, the 2ᵈ barely half the length of the 3ᵈ. Thorax distinctly transverse, rather large for the size of the insect, front angles truncate, sides just perceptibly convergent posteriorly with a slight prominence at middle; convexities moderate, with only a trace of impressed line between them. Elytra scarcely more than one-third wider at the humeri than the thorax, sculptured as usual. Length 6–6½ mm.

Described from a single pair (type ♂) taken at an elevation of 10,000 ft. on Mt. Silliman, California, by Mr. Hopping.

The claws of the front and middle tarsi of the male are cleft, the inner portion nearly as long as the outer on the front feet, a little shorter on the middle feet, and so much shorter on the hind feet as to best be described as an acute subbasal tooth, which also describes the dentition of all the claws in the female. In the two following species the claws are similarly formed.

Podabrus tetragonoderus Fall.

This species may probably be separated with certainty by the tabular characters from *moestus* and *altus,* with which alone it agrees nearly in ungual formation. It is closely similar to *altus,* but it should be remarked that the head is more coarsely densely punctate and somewhat shining, while in *altus* it is scabrous and dull with the punctures finer and less distinct. *Scaber* also resembles the present species quite strongly, but in it the thorax is still more densely and strongly punctured, and the claws are differently toothed.

Since describing *tetragonoderus* from Alaskan specimens (Pacific Ent., II, p. 152), I have received a specimen from Glacier Park, Montana (Miss Edith Mank, collector), which seems to be identical.

Podabrus altus n. sp.

Black, epistoma and sides of prothorax yellow; basal two joints of antennae yellowish beneath. The yellow area of the epistoma is invaded posteriorly by two short approximate extensions of the black color of the front. Antennae moderate, 2ᵈ joint about 3/5 (♂) or 3/4 (♀) as long as the third, intermediate joints (♂) parallel sided and about 2½ times as long as wide. Head (♂) distinctly wider than the thorax, scarcely as wide as the thorax in the ♀, rather closely scabrous punctate and dull. Prothorax transversely quadrate, front angles obliquely subtruncate, sides slightly convergent backward, nearly straight in the female, a little arcuate becoming sinuate behind in the male, hind angles sharply defined; surface obscurely punctured, dull or feebly shining; longitudinal elevations quite obtuse and entirely within the broad black discal area, which is dilated at the basal third in the male, and in the female extends outward to the side margins. Elytra finely scabrous without discal costae. In the male the claws of the front and middle tarsi are finely cleft, the inner part a little shorter, the hind claws with a shorter acute tooth. In the female all the claws have a rather narrow acute basal tooth. Length 7–8 mm.

Described from a male and two female specimens, the male (type) from Monarch Lake, Tulare Co., California, 11,000 ft., the females from Tuolumne Meadows, 8,600 and 9,240 ft., these latter collected by Mr. G. H. Pilate.

This very distinct species resembles *lateralis* somewhat, but the claws are differently toothed. It is closely related to *tetragonoderus,* but the characters given in the table and under the last-named species should suffice to separate it.

Podabrus laevicollis Kirby

This small species is common and well known to all collectors. It is widely dispersed in northern latitudes, occurring from Labrador and New England to Alaska. Wickham includes it in his Iowa and Colorado lists, but it is not recorded from Cincinnati, Western Pennsylvania or New Jersey. It is instantly recognizable by its perfectly smooth impunctate thorax, which is small as in *simplex* and which varies in color from entirely piceous to largely testaceous. Length about 6 mm.

Podabrus fenestratus n. sp.

Similar in form and appearance to *piniphilus,* but averaging somewhat larger. Black, finely cinereo-pubescent; basal two joints of antennae pale beneath; thorax with a variable but usually small rufous marginal or submarginal spot behind the obliquely truncate front angles. Antennae in the male filiform, passing the middle of the elytra, 2^d joint 2/3 (♂) or 3/4 (♀) as long as the 3^d. Head evidently wider than the thorax in the male, narrower in the female, alutaceous and rather finely scabrous punctate, not shining. Prothorax almost as long as wide (♂), or distinctly wider than long (♀), form as in *piniphilus,* convexities strong, without eroded line between them, surface finely alutaceous and somewhat shining, punctuation a little variable but generally fine and sparse. Elytra entirely black, rather coarsely rugulose; legs entirely black. Length 6.5–8 mm.

Described from five examples (1 ♂, 4 ♀'s) from the Lake Tahoe region in California. The type (♂) bears label, Echo Lake, Tahoe, Cal., July 8, and was collected by Hopping. The four females are from Glen Alpine, July 3–4 (Fenyes); Angora Lake, June 22 (Hopping), and Tahoe, July 7 (Hopping).

This species, as indicated above, resembles *piniphilus* quite markedly, but differs primarily in that the front claws of the male have the free angle of the broad basal tooth so strongly produced and acute as to make them appear cleft, while in *piniphilus* the tooth is much shorter and broader; moreover in *piniphilus* the prothorax never, in my experience, has the rufous spot characteristics of the present one.

Podabrus probus n. sp.

Similar to *piniphilus* but with the head (♂) much wider, the epistoma entirely pale, the front tibiae tinged with testaceous, the protarsal claws cleft. The prothorax is virtually of the same form as in *piniphilus* but a little more elongate, being quite as long as wide, the surface finely rather closely punctate, and there is a well-marked eroded line between the convexities. The 2^d antennal joint is scarcely more than half as long as the 3^d. Length 7 mm.

A single example bearing label, Mt. Washington, N. H., 5–28–18.

Podabrus citrinus n. sp.

Pale yellow, head behind the antennae, and neck, black; scutellum and elytra at apex dusky; antennae blackish, basal two joints yellow, several of the following joints pale beneath; venter fuscous, apex pale; legs yellow, middle and hind femora dusky except toward the apex. Head (♂) distinctly wider than the thorax, front sparsely punctured, occiput and neck closely so. Antennae slender, filiform, 2^d^ joint very nearly as long as the 3^d^. Prothorax nearly square, sides straight and parallel, front angles obliquely subtruncate; hind angles right, their vertices minutely prominent; surface moderately shining and evenly finely but rather feebly punctate, a small prominence but no eroded line between the discal convexities. Elytra finely ruguloso-punctate, discal costae faintly traceable. Claws of front tarsi cleft, of middle and hind tarsi with a broad basal tooth having the free angle moderately acute. Length 7 mm.

Described from a single male specimen taken at Tahoe, California, July 7, 1915, by Mr. Hopping.

This species resembles in a general way several other yellow Californian species of about the same size, but none of them agrees with it in ungual formation.

Podabrus heteronychus n. sp.

Form of *lateralis*. Black, luster dull throughout; head in front of antennae yellow; base of antennae, apex of femora, base of tibiae, and the sixth ventral except at sides, dull yellow. Antennae not very slender, 2^d^ joint 2/3 as long as the 3^d^, the latter obviously shorter than the 4^th^. Head (♂) but slightly wider than the thorax, scabrous punctate. Prothorax transversely quadrate, as in *lateralis*, front angles obliquely truncate, sides a little sinuate before the rectangular hind angles, surface finely punctate, median impression moderate. Elytra finely scabrous, discal costae feebly indicated. Claws of front tarsi finely cleft; of middle tarsi, outer claw toothed at base, inner claw cleft; of hind tarsi both claws with broad somewhat acute basal tooth. Length 5.5 mm.

The male type above described was collected by Mr. J. B. Wallis at Mile 214, Hud. Bay R. R., Manitoba, July 6, 1917. With this I associate with some confidence a female from Homer, Alaska, viii–5–1911 (W. S. McAlpine). This agrees well with the male type in most respects, the legs being, however, less varied with yellow, and the abdomen entirely black. The head is slightly narrower and the antennae shorter, common sexual differences. The claws are all broadly toothed at base. This and the following species are thus far unique in the form of the male claws.

Podabrus furtivus n. sp.

> This species agrees with the preceding in the peculiar ungual formation, but seems definitely separable by its wider head and more slender antennae as indicated in the table. The prothorax is also relatively smaller than in *heteronychus,* being more nearly as in *piniphilus,* and the legs are entirely black. The resemblance to *piniphilus* and *probus* is very marked, more especially the latter, with which it agrees in its wide head (♂), pale epistoma and short second antennal joint, this being only about one-half as long as the third. Length 6¾ mm.

The unique type is a male from Silverton, Colorado, collected by Dr. Fenyes.

Podabrus cavicollis Lec.

This and the following species differ from all others in our fauna by the dissimilarity of the two claws of the hind tarsi in the male, the outer claw being cleft, the inner toothed. Le Conte, in his Revision of, 1881, included *mellitus* with these two species to form his "Group C." The claws in *mellitus* are, however, quite different, being similarly cleft on all feet of both sexes (see remarks under *mellitus*).

The tabular characters should be sufficient for the identification of *cavicollis.* The black spot in the pronotal concavity is typically present but is often wanting; the elytra may be either entirely yellow or more or less dusky at apex; varies in length from 5 to 8 mm., but usually from 6 to 7 mm.

In Le Conte's original description the locality given is San Diego. In his 1881 paper he gives San Francisco and Nevada. It is possible, therefore, that San Diego was cited erroneously. Certainly the species is common across the bay from San Francisco in Alameda Co., and I have as yet seen no specimens from the vicinity of San Diego. I have found the species plentiful about Lake Tahoe, and have examples from Trinity, Plumas, Eldorado, Sonoma, and Tulare Counties; also from Ormsby Co. in Western Nevada.

Podabrus corneus Lec.

Similar to *cavicollis* but a somewhat larger species (7½–9 mm.), the head strongly and closely punctate, thorax very smooth and shining, almost impunctate, and the 2ᵈ antennal joint conspicuously shorter than the 3ᵈ, at least in the male.

Le Conte's type is a male collected by Rathvon, probably somewhere in Middle California.

Corneus is apparently much scarcer than *cavicollis,* and I have in my collection only two examples; a male from Eldorado Co., vi–16–13 (Nunenmacher), and a female from Glen Alpine, vii–3 (Fenyes).

A CORRECTION

Owing to a misunderstanding, the author of "The Species of Phyllotreta North of Mexico" did not receive printer's proof of the explanation of the plates and as a result two errors were made:

Plate I, fig. 4, should read "*Phyllotreta liebecki.*"

Plate II, fig. 6, should read "*Phyllotreta utana.*"

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ENTOMOLOGICA AMERICANA

After a lapse of 36 years, this veteran journal of American entomology emerges from its hibernaculum to take its place once more as a vehicle for the progress of our branch of science. Thanks to the generosity of a friend the Brooklyn Entomological Society is enabled to revive this journal to render, we hope, as good service and fill as worthy a place as its predecessor of long ago.

The Society has long felt that a medium was needed for the appearance of those longer papers—monographs, synopses of smaller groups, biological studies, morphology, embryology, revisions, and the many excellent technical productions too long and too special, perhaps for our regular journals, yet too short for a book—emanating from many workers not connected with institutions which publish the results of the research of their staffs. The opportunity has at length presented itself; and the Society has taken the positive step.

Entomologica Americana once more takes its place among our current journals.

The publication will be issued in four numbers a year, and will average approximately 50 to 60 pages to the number, or a total of 200 to 240 pages per volume. Each number will carry *one* paper; or possibly two, but not more, in view of its purpose. The annual subscription price is set as $4.00 a volume. Single numbers will sell on an approximate basis of $1.50 for 50 pages; subscriptions will be received per volume—*not* for four consecutive numbers—payable strictly in advance. The edition for the first of the new volumes will be limited to 200 copies; and those intending to subscribe, particularly institutions and libraries, should do so promptly to ensure possession of complete sets.

Authors are invited to submit contributions, bearing in mind that such contributions must be of the required length and represent original work advancing our knowledge of the taxonomy, biology, ecology, anatomy or embryology of insects. Arrangements with regard to illustrations will be discussed for each case. Papers should be sent direct to the Editor, Entomologica Americana, 11 North Broadway, White Plains, N. Y.; subscriptions (with check) to Geo. P. Engelhardt, Treasurer, Brooklyn Entomological Society, Brooklyn Museum, Eastern Parkway, Brooklyn.

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BIOLOGICAL STUDIES OF TWO HYMENOPTEROUS PARASITES OF AQUATIC INSECT EGGS

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The material and a part of the data for the following studies were gathered at the Biological Station of the University of Michigan, which is located on Douglas Lake, Michigan. The lake is situated in the upper part of the lower peninsula of Michigan, about fifteen miles south of the Straits of Mackinac. On the older maps of the locality this lake was called Turtle Lake. The region is of recent glacial origin, lying at the southern edge of the Boreal Life Zone. Sandy moraines cover the area which is a cut-over pine district. A few pines still stand, but the aspen association is the prominent one of the uplands. The region abounds with numerous bogs and swamps in various stages of development. The lake itself is said to resemble a fish in outline with the tail toward the southeast. The main axis of the lake is a little over four miles in length and takes nearly the same direction as that of the prevailing winds which are from the northwest nine months of the year. The shores are of fine white sand and with a considerable growth of *Scirpus* along sheltered places. At one point the *Scirpus* extends into the lake, going almost across. At this particular place the water is not over eight feet in depth.

The *Scirpus* offered an excellent place for *Sialis infumata* Newm., *Chrysops striatus* O. S., *Chrysops excitans* Walk., and some *Tabanus* to deposit their eggs. It was the finding of parasites on *Chryosps* egg masses by Dr. H. B. Hungerford that later led the author to work on the life history of this parasite. The work was done under his direction. While working on this life history, eggs of other aquatic insects were also collected, which led to the finding of the gerrid egg parasite, *Tiphodytes gerriphagus* (Marchal). This parasite has been reported only once before in America. Matheson and Crosby[22] found it parasitizing gerrid eggs at Ithaca, New York, in 1912.

Several other such egg parasites should be found in this region. The following are some reported from New York: *Prestwichia aquatica* Lubb., parasitic on the eggs of *Ranatra, Dytiscus, Agabus,* *Notonecta*, dragon-flies and others; *Cataphractus cinctus* Walker, parasitic on the eggs of Notonectidae; *Hydrophylax aquivolans* Matheson and Crosby, parasitic on the eggs of *Ischnura*.

In addition to working on the life histories of the above-mentioned parasites it was possible to obtain some valuable and interesting notes on the egg-laying habits and on the copulation of *Sialis infumata* Newm., which was so common along the shores of the lake at the beginning of the season.

Trichogramma minutum Riley

(Family Chalcididae)

This very common egg parasite, one of the smallest known insects, was figured and described by Riley in the "Third Report on Insects of Missouri." The material that he had emerged from the eggs of *Basilarchia archippus* Cram. that were collected in Missouri. Girault[7] says that the following are synonymic species: *pretiosum, minutissimum, intermedium* and *odontotae*. The types of the species in synonomy were lost or never deposited. *T. odontotae* Howard is a doubtful synonym of *T. minutum* in that this particular form has been reared from only the one host.

The species is recorded from both hemispheres. The following is a list from Girault.[7]

Western Hemisphere

North America: United States, Canada, and West Indies

Eastern Hemisphere

Europe: Germany, Austria
New Zealand: Waikumate and Wellington
Java
Hawaii

As the known distribution is so wide-spread, no doubt further collecting will show that this tiny insect is cosmopolitan in its range. Girault seems to think that "food is a factor of more than usual importance in limiting its range."

Host Records of *Trichogramma minutum* Riley

This egg parasite is known to parasitize well over one hundred and fifty hosts in seven orders; Lepidoptera, Coleoptera, Hymenoptera, Megaloptera, Neuroptera, Diptera, and Hemiptera (?).

Known records indicate that Lepidoptera are the favored hosts. In the partial list gathered from literature at hand these are forty-six species of Lepidoptera recorded as hosts out of the list of sixty-four species.

Girault states that the largest numbers of this parasite's hosts are lepidopterous and later points out that the coleopterous and hymenopterous hosts are closely related to moths and butterflies. In the same paper he makes a statement that all the hosts' larvae "feed upon foliage of various trees and plants—none are wood-boring, carnivorous, or predaceous in the larval stages." In the same paper he then lists *Chauliodes rastricornis* Rambur, a Megalopteran, whose larva *is* predaceous. The author is able to report another Megalopteran that serves as a host, *Sialis infumata* Newm. (Family Sialidae). So far as we are aware, no one has listed this genus as a host. In 1922 Smith[16] reported that it parasitized the eggs of Chrysopidae (Order Neuroptera).

Tabanidae (Order Diptera) were first reported as hosts by Cameron[3] in July, 1926. *Chrysops mitis* O. S., *Chrysops moerens* Walk., *Tabanus phaenops* O. S., *Tabanus punctifer* O. S., were recorded before; *Chrysops excitans* Walk., *Chrysops striatus* O. S., and *Tabanus lasiophthalmus* Macq.

A European writer, Kryger, has reported *Trichogramma evanescens* West. as a parasite on the eggs of *Sialis lutaria* L. (both European species). He also listed tabanid and stratiomyid eggs as serving as hosts for *T. evanescens* West.; so it is very probable that *T. minutum* Ril. will sometime be found parasitizing the eggs of Stratiomyidae in this country.

The Order Hemiptera is listed with a question mark as we have only the information from a correspondent that he has been working with *Trichogramma sp?* that were parasitic on lepidopterous and hemipterous eggs (Mr. C. O. Bare, Tampa, Fla.). Cameron says that Hemiptera eggs are parasitized but does not cite any species or references.

The following is a partial host list made from the literature listed in the bibliography* at the end of this paper.

Host List of **Trichogramma minutum** Riley

* This list is largely from Girault.

ORDER COLEOPTERA

Family Chrysomelidae

Odontota dorsalis Thunberg
Odontota suturalis Thunberg

ORDER LEPIDOPTERA

Family Papilionidae

Papilio glaucus Linn.
Papilio glaucus turnus Linn.

Family Nymphalidae

Polygonia interrogationis Fabr.
Vanessa atalanta Linn.
Agraulis vanillae Linn.
Aglais milberti Godart
Basilarchia archippus Cramer

Family Lymnadidae

Danaus plexippus Linn.

Family Tortricidae

Tortrix fumiferana Clemens
Tortrix citrana Fernald
Platynota rostrana Walk.
Polychrosis botrana Schiff.
Archips rosaceana Harris
Laspeyresia pomonella (Linn.)
Bactra lanceolana Hub.

Family Pyralidae

Phlyctaenia ferrugalis Hub.
Pyrausta nubialis Hub.

Family Pieridae

Eurymus eurytheme Boisd.
Pontia rapae Linn.

Family Agapetidae

Oeneis macounii Edwards

Family Hesperiidae

Calpodes ethlius Cramer
Thanaos lucilius Lintner
Goniurus proteus (L.)

Family Sphingidae

Smerinthus sp.
Phlegethontius sexta Johanssen
Ceratomia catalpae Bois

Family Notodontidae

Datana intergerrima G. & R.
Ianassa lignicolor Walk.

Family Liparidae

Euproctis chrysorrhoea Linn.

Family Noctuidae

Omiodes meyricki
Omiodes blackburnii
Omiodes accepta
Peridroma margaritosa caucia Hub.
Aletia argillacea Hub.
Autographa brassicae (Riley)
Heliothis obsoleta Fabr.
Laphygma frugiperda S. & A.
Mamestra picta Harris
Plathypena scabra Fabr.

Family Arctiidae

Hyphantria cunea Drury
Hyphantria textor Harris
Estigmene acraea Drury

Family Ceratocampidae

Anisota senatoria S. & A.

Family Crambidae

Diatrœa saccharalis Fab.
Diatrœa striatalis

ORDER HYMENOPTERA

Family Selandriidae

Eriocampoides limacina (Retzius)

Family Tenthredinidae

Caliroa obsoleta Norton
Caliroa aethiops Fabr.

Family Nematidae

? *Pachynematus palliventris* Cresson
Pteronus ribesii Scopoli

Family Cimbicidae

Cimbex americana Leach

ORDER MEGALOPTERA

Family Sialidae

Chauliodes rastricornis Rambur
Sialis infumata Newm.

ORDER NEUROPTERA

Family Chrysopidae

Chrysopa spp.

ORDER DIPTERA

Family Tabanidae

Chrysops mitis O. S.
Chrysops moerens Walk.
Chrysops striatus O. S.
Chrysops excitans Walker
Tabanus phaenops O. S.
Tabanus punctifer O. S.
Tabanus lasiophthalmus Macq.

Collecting and Cage Technique

Adults of the parasite were first obtained by placing the egg masses of *Sialis infumata* Newm. in four-ounce homeopathic vials. The mouth of the bottle was covered with a bit of cloth, held in place by a rubber band. Moist sand was kept in the first cages, but this was soon abandoned as fungous growths became quite heavy in some of the cages. The best results were obtained in cages that were dry, the moisture from the eggs and bits of plant stems seeming to be sufficient to keep the eggs in proper condition for the developing parasites and host embryos. Life history cages were also kept dry. Later in the season adults of the parasites were collected in the field while ovipositing in the egg masses of *Chrysops.*

The first emergence was that of a lone, winged female. This individual appeared on the twenty-sixth of June, dying two days later, imprisoned in some of the fungous growth that had started in the cage. No others emerged in this cage until seven days later. The first insects of the other cages were wingless males; an hour or so later winged females appeared. At a later date wingless females were found but no winged males were ever found. An examination of the wingless individuals showed that they possessed tiny, round scales attached to the points on the thorax where the wing bases are attached in winged specimens. These scales, or rudiments of wings, would float at right angles to the thorax when the insect was placed under water.

The males did not always emerge ahead of the females. At times the females were found in the cages an hour or two before the appearance of the males and were observed to oviposit many times before copulating with the late-appearing males. Authors say that the species is parthenogenetic.

Two winged females that have their antennae densely clothed with long hairs were taken from cages. One emerged from material that was collected early in the season and the other emerged from material that was collected late in the season. (See plate III, fig. 3.)

Cage Counts

Cage counts were made so as to determine the percentage of parasitism at different times of the season. While making these counts the number of winged and wingless individuals was kept. No attempt was made to determine the sex because of the large numbers present. In the thirty-six cages of *Sialis* field material there were six cages in which the number of wingless forms exceeded those of the winged. Of the series of eleven life history cages containing *Chrysops* egg masses, there was only one cage that had in it more wingless insects than winged ones. So while winged individuals are usually predominant in the broods, now and then broods appear where the wingless form is predominant. Most of the cages containing a predominance of wingless insects were cages of material collected in the fore part of the season. The average percentage of winged forms in the sixty-six cages was seventy-five per cent.

Habits

In the field and in the cages the parasites continually moved about nervously over the egg masses and up and down the plant stems, walking much and flying little. While on the egg mass the females were constantly searching over it with their antennae; the

Chart Showing the Percentage of Winged and Wingless Individuals

Data from Sialis Field Cages

Cage No.	Date of Emergence	No. of Winged	No. of Wingless	Per Cent Winged	Per Cent Wingless
1	7–2–26	110	68	61.8	38.2
2	6–29–26	32	69	31.7	68.3*
3	6–29–26	141	159	47.0	53.0*
4	7–2–26	14	28	33.4	66.6*
5	6–28–26	91	107	46.4	53.6*
6	6–29–26	210	151	58.1	41.9
7	7–1–26	92	34	72.2	27.8
8	7–4–26	30	5	94.2	5.8
9	6–28–26	307	165	65.0	35.0
10	6–29–26	100	35	74.0	26.0
11	7–1–26	55	60	47.9	52.1*
12	7–3–26	75	25	75.0	25.0
13	7–4–26	25	5	83.4	16.6
14	6–30–26	50	18	64.8	35.2
15	6–28–26	60	24	71.4	28.6
16	6–28–26	105	55	65.7	34.3
17	7–1–26	1320	1200	52.5	47.5
18	6–28–26	125	100	60.0	40.0
19	6–28–26	80	25	76.2	23.8
20	6–28–26	216	144	60.0	40.0
21	7–1–26	225	131	63.3	36.7
22	6–26–26	38	11	77.6	22.4
23	7–2–26	325	245	57.1	42.9
24	6–30–26	226	69	76.6	23.4
25	7–2–26	155	50	75.7	24.3
26	7–2–26	32	22	61.5	48.5
27	7–2–26	700	180	81.7	18.3
28	7–2–26	186	109	60.1	36.9
29	7–1–26	2352	1755	57.2	42.8
30	7–7–26	5	11	31.2	68.8*
31	7–2–26	1417	669	67.5	32.5
32	7–8–26	1595	1092	59.3	40.7
33	7–1–26	20	5	80.0	20.0
34	7–1–26	352	117	75.3	24.7
35	7–2–26	16350	2070	88.8	11.2

The average number of winged specimens in the cages of *Sialis* field material was 75 per cent, of wingless 25 per cent.

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* Marks cages where the number of winged is less than the number of wingless.

Data from Sialis Life History Cages

Cage No.	Date of Emergence	No. of Winged	No. of Wingless	Per Cent Winged	Per Cent Wingless
2–4	7–16–26	121	25	82.9	17.1
2–5	7–14–26	62	76	44.5	55.5*
2–6	7–14–26	153	53	74.3	25.7
2–7	7–14–26	169	21	88.9	11.1
2–9	7–14–26	139	35	79.9	20.1
2–10	7–14–26	116	26	81.7	18.3
2–11	7–14–26	153	50	76.2	23.8
2–12	7–14–26	516	220	70.2	29.8
13–1	7–15–26	233	96	70.9	29.1
27–4	7–15–26	239	55	80.6	19.4

Data from Chrysops Life History Cages

Cage No.	Date of Emergence	No. of Winged	No. of Wingless	Per Cent Winged	Per Cent Wingless
2–4–a	7–28–26	22	18	55.0	45.0
2–6–a	7–27–26	28	28	50.0	50.0
2–7–a	7–27–26	14	16	46.6	53.4*
2–11–a	7–27–26	16	8	75.0	25.0
2–12–a	7–27–26	48	35	57.9	42.1
2–12–b	7–29–26	27	7	79.5	20.5

Data from Chrysops Field Cages

68	7–21–26	314	130	70.8	29.2
69	7–21–26	370	126	74.6	25.4
70	7–21–26	176	45	79.7	20.3
71	7–21–26	83	32	72.3	27.7
72	7–21–26	201	60	77.4	22.6
73	7–21–26	200	62	76.4	23.6
74	7–25–26	75	28	72.9	27.1
75	7–25–26	35	7	83.4	16.6
76	7–25–26	175	31	85.0	15.0
77	7–26–26	30	8	79.0	21.0
83	7–23–26	331	86	79.9	20.1

Total number of winged specimens	31,357
Total number of wingless specimens	10,407
Grand total	41,764
Per cent of winged specimens	76
Per cent of wingless specimens	24

* Marks cages where the number of winged is less than the number of wingless.

males behaved in the same manner. Often the females were observed to stop to clean their wings, stroking them with the hind pair of legs as they pulled them down alongside the abdomen.

Copulation

Most of the copulation took place on the egg mass where the males were always roaming and where the females returned from other parts of the cage. Suddenly a male would dash to a passing female, grasp her wing tips with his front pair of legs, hook his head over the tips, swing up and hold to the wings with the other legs. Thus hanging in an underslung position he would copulate with her, the act lasting usually from four to ten seconds. Then he dropped off and would perhaps go immediately to some other passing female. One male was observed to copulate with three females in rapid succession, going immediately from one to the next. Some females kept moving about while copulation was carried on, as though attempting to shake the male off; others stood quietly. (See plate I, fig. 8.)

Oviposition

The parasite could oviposit in *Sialis* eggs that were in the center of the mass, only around the base of the micropyle. Any spot on the eggs in the outside rows seemed favorable, as was also true with *Chrysops* and *Tabanus* eggs. As Cameron[3] observes, the egg to be oviposited in was apparently picked at random. When a *Sialis* egg was selected, the female walked over it until a position for oviposition was reached. Then the wings were raised and the abdomen lowered between the micropyles until the ovipositor could be inserted in the chorion. With many females there was at first a slight back and forth movement as the ovipositor sawed through the chorion. The female was then quiet until oviposition was complete.

The deposition of an egg inside the host egg seemed to stop all development of the host egg, unless the host embryo had already used much of the yolk. It is not known just how old the host larva must be before it is able to tolerate the parasite and continue to develop. The parasites seemingly do not pay any attention to the age of the host egg. Both in the field and in the laboratory they were observed to oviposit in eggs that were almost ready to hatch.

Inside the laboratory the females oviposited any time of the day but when taken into bright sunlight they refused. All that were found ovipositing in the field were observed always after four o'clock in the afternoon. It is hoped that it will be possible to gather more data next summer on light as a factor in the oviposition behavior of this parasite.

Holloway[11] reports that he was able to induce a female *Trichogramma* to oviposit in the juice globules of okra plants. This fact might lead one to believe that a female will oviposit in any egg but it has been found that there are eggs in which they refuse to oviposit or to which they are not attracted. The writer was unable to get them to oviposit in *Donacia* or gyrinid eggs, possibly because of the nature of the chorion, though Gatenby maintains in his embryological paper on *Trichogramma evanescens* Westw. that they will oviposit in *Donacia* eggs. However, we believe that Mr. Gatenby is in error as to the identity of his eggs. (See plate III, figs. 5, 6 and 7.)

What Gatenby more than likely had were the eggs of *Sialis lutaria* Linn., the most common *Sialis* of Europe. This insect is reported by several European writers as being one of the hosts of *T. evanescens.* His figure 2 (Plate I, fig. 5) is a very excellent outline of a *Sialis* egg that has lost its micropylar projection. All the *Donacia* eggs with which we are familiar, either in nature or in literature, are not set up on end as his fig. 3A (Plate I, fig. 7) shows but are usually glued to the surface on the side. In one species they are laid one against the other at oblique angles. The mass is not symmetrical as shown in Gatenby's figure 8 (Plate I, fig. 6).

In his text Gatenby describes his eggs as being of various shades of brown, depending on the stage of development of the embryo within. Then it is stated that "the egg groups do not adhere very closely to the surface of the reed and they are easily removed by bending the surface on which they are laid," descriptions that fit *Sialis* eggs very nicely. All the *Donacia* eggs with which the writer is acquainted, or can find described, are not of a brownish color but are of an opaque white color. *Sialis* eggs are always of a brownish color. Even when the eggs are freshly laid they are of some shade of brown. *Donacia* eggs are glued firmly to their support and do not come off as easily as *Sialis* eggs do.

Harland[8] found that *T. minutum* refused to oviposit in the eggs of the Cotton Stainer (*Dysdercus delauneyi*) and also that no attention was paid to various spider eggs.

Duration of Oviposition

The following records were made at different times of the day on the duration of oviposition. The last two counts were taken on females that were fairly well spent.

Female No.		Female No.	
1	15 seconds	7	21 seconds
2	20 seconds	8	22 seconds
3	20 seconds	9	25 seconds
4	20 seconds	10	30 seconds
5	20 seconds	11	60 seconds
6	20 seconds	12	60 seconds

Number of Progeny of Each Female

In the life history cages counts were made of the number of females put in and later progeny counts were taken so that in this way it was possible to find the average number of progeny per female.

Average Number of Progeny per Female

Cage No.	Number Females	Number Progeny	Average No. of Progeny
1	4	15	3
2	4	14	3
3	15	138	9
4	15	203	13
5	10	142	14
6	15	250	16
7	16	329	20
8	12	206	17
9	8	174	21
10	8	190	23
11	16	736	46
12	16	736	46
13	6	294	49
14	4	350	87(?)

Dissections of several females were made and the following ova counts obtained:

Female No.		Female No.	
1	30	5	47
2	30	6	48
3	40	7	50
4	47	8	52

Bodkin,[2] in working with a very closely related parasite in British Guiana, gives an idea of the maximum number of progeny that a single female will produce. He had one female make one hundred ovipositions from which eighty adults developed. Our cages at Douglas Lake were probably not observed over as long a period as his. Possibly the average number of progeny of the insects worked with at Douglas Lake was larger than the data given here would indicate. The average number of ova dissected from each female was forty-one, the maximum number fifty-two. The dissections were made in the afternoon on females that had emerged in the morning on the same day. Cage number fourteen, where there was an average of eighty-seven progeny, is to be questioned until further checks can be made. No explanation is offered for the two exceedingly low cages unless these females had already spent themselves before they were put in the life history cage. Possibly some unknown factors entered, such as humidity and toughness of chorion.

Life History Studies

As soon as the parasites began to emerge studies of the egg, larval and pupal stages were begun. Considerable difficulty was encountered in obtaining parasite-free eggs at the times when they were needed. At first attempts to secure them were made by confining a number of *Sialis* adults in cages but few would ever lay while in captivity. At times a sufficient number of eggs were collected by going to the *Scirpus* patches about two o'clock in the afternoon and hunting females that were ready to or just beginning to oviposit. The stem on which the female rested was plucked and either held in the hand or put in a live jar while search was continued for others. On several days a large number of masses was collected in this way. *Chrysops* eggs were collected in the same manner. However the *Chrysops* female was much more wary than the *Sialis* female and would often fly, leaving the mass only partially laid. When kept in a live jar they usually flew off the stem upon which they were ovipositing and would finish on the sides of the jar.

In the laboratory a number of female parasites were released in the cages with the fresh eggs collected. The method of transferring was simple. The mouth of the cage containing the eggs to be parasitized was turned upside down over the mouth of the cage confining the parasite. The females flew up, one and two at a time; others crawled up the sides of the cages. It was not necessary to turn the cages toward the light, as these insects are negatively geotaxic.

The different stages of the parasite were searched for by dissection of the host egg. This was an unsatisfactory method, as the first stages are so nearly the color of the contents of the host egg that it was with considerable difficulty that the parasite could be found. Often a whole morning would be spent without finding any of the early stages. When one was found, the dissected egg was kept on a slide in a moist chamber. The egg of the parasite was always lost when the slide was examined again. Possibly the dissection of the host egg caused it to collapse. Sometimes it was possible to hold a mature larva or pupa a short time, but it was never possible to carry them through to emergence. Enough data were gathered in this way to determine something as to the length of the stages and other facts concerning the biology.

Attempts were made to keep some of the dissected material in a medium consisting of the yolk of hen's egg and also a medium of crushed eggs of the host but they failed rather miserably. To add to the troubles, fungous growths started very easily in spite of attempts to provide clean cultures.

Attempts were also made to watch the parasite through the chorion. This was impractical with *Sialis* eggs, as they are so dark that it is almost impossible to get light through them. With *Chrysops* eggs it was possible to get light through the chorion, but here the same difficulties arose as with dissection. How could one differentiate the parasite egg or larva from the yolk contents of the host egg?

From the results obtained with preserved material it is believed that nearly the whole cycle can be followed by killing the eggs in hot alcohol and later dissecting. In this way the contents of the egg are coagulated and it is quite easy to find the parasite. Some host eggs coagulated more easily than others.

The Egg

The eggs found in the host eggs were almost colorless. In general the shape is elongate-ovoid, being broad at one end and tapering to a point that is about half the width of the widest part. The shape varied for individual eggs. The following measurements were made of ova dissected from the ovaries of female parasites. The measurements were made at the longest and widest part of the ova.

Eggs of this insect found in the host egg measured from .108 mm. to .120 mm. in length and from .032 mm. to .038 mm. in width.

Length of Incubation

The exact length of the time of incubation is not known. From dissections made of preserved material it is known quite definitely that the period is twenty-four hours or less in length.

MEASUREMENTS OF THE OVA OF *Trichogramma minutum* RILEY
(Dissected from ovaries)

Length	Width	Length	Width
.089 mm.	.003 mm.	.112 mm.	.036 mm.
.089	.026	.112	.036
.100	.039	.112	.039
.100	.039	.115	.039
.100	.036	.115	.049
.102	.036	.118	.037
.105	.033	.118	.046
.105	.036	.125	.039
.108	.027	.132	.056
.108	.032	.138	.062
.108	.039	.138	.062
.109	.032	.140	.064
.112	.033	.148	.056

The Larva

The skin of the larva is of a transparent white color, while the contents of the body are usually of a dirty yellowish-white, the same color as the contents of the host egg. The only appendages that the larva possesses are two flattened, cone-shaped, straw-yellow oral hooks. In a larva two days old they are .026 mm. in length and .006 mm. in width near the base. Authors seem to think that the function of the oral hooks is to ''shovel'' food into the mouth opening which lies just above their bases. The writer has slide mounts showing the mouth pressed tightly against the material of the host egg and with the oral hooks on the outside of the material. The oral hooks have never been observed to move in live material but there is no doubt but that their function is to help in getting food into the mouth.

There is no metameric segmentation of the body, though in some specimens several creases and ridges appear, marking the cephalic end of the larva from the rest of the body. The whole organism is sac-like in shape, conforming to the cavity in which it rests. Where it is found at the end of the host egg, the larva is often pressed so tightly between the material of the host egg and the chorion that a finger-like prolongation is found filling the space between the chorion and the rounding of the host egg contents. Gatenby[5] tells us that in *Trichogramma evanescens* the tracheae, ordinary mouth parts, heart, and oesophageal valve are wanting. The same is true for *T. minutum*.

Food Habits and Growth

The larva rapidly swallows the contents of the host egg until all have been crammed into the sac-like body (in the case of *Sialis* and *Chrysops* eggs). The body wall of the larva grows thinner and thinner as more material is taken in, until the parasite fills the *Sialis* egg, and about two-thirds fills the *Chrysops* egg. Apparently not much digestion takes place until all the yolk has been swallowed, so there is no waste material to be defecated in the earlier development. Whether it defecates later is not known for sure, but more than likely it does not.

Gatenby[5] asks how the larva of *Trichogramma evanescens* gets the yolk disclets from the caudal end of its body to the cephalic? From our observations of *Trichogramma minutum* we would say that the material never lies at the caudal end of the body but that the larva keeps pressed against the chorion of the host egg so that as it grows in size it keeps the yolk disclets continually pressed forward. When the last disclets are to be swallowed they are at the cephalic end ready to be swallowed, rather than at the caudal end of the larva.

A larva that is between a day and a half and two days old is .120 mm. in length while the prepupal stage, which is two or three days later, is .130 mm. in length. Thus it is apparent that most of the growth comes about during the first two days of the larval life. The larval and egg stage cover a period from six to seven days. A prepupal stage follows the larval stage but nothing is known as to the length of it.

Number of Larvae in an Egg

In *Sialis* and *Chrysops* eggs it would be a physical impossibility for more than one larva to reach maturity. In all dissections made only one larva was ever found in one of these eggs. Whether the females are instinctively aware of this fact is not known. Gatenby[5] states that he rarely found two eggs or two larvae in the sections of his supposed *Donacia* eggs. *Tabanus* and other large eggs are able to support more than one larva and generally several are found in the larger eggs. In such eggs the parasite lays its eggs in such close proximity that it is a common occurrence to find two larvae lying together in close contact, especially those at the poles of the egg. It is very doubtful if these larvae could injure one another except by causing starvation and this is not likely to happen in a *Tabanus* egg. As many as five larvae have been dissected from a *Tabanus* egg. Usually there are two at each pole and one in the center of the egg. Howard and Fiske[12] report that the largest number of parasites developing from one egg to be 10. These were obtained from one Browntail Moth egg. Kryger obtained 13 adult parasites of *Trichogramma evanescens* from lepidopterous eggs.

The Pupa

The newly formed pupa is of a yellowish-white color. As it grows older it gradually turns darker until two or three days before emergence it is of the same black color as the adult. The measurements for the pupa are almost the same as for the adult. The total length averages .39 mm., the width of the abdomen, .30 mm., and the length of the wing pads .039 mm. When the life history runs fourteen days this stage is seven or eight days long. As is characteristic of this family, no cocoon is spun, the chorion of the host egg being sufficient protection. Sometimes the pupa is found lying upside down in the host egg.

Appearance of the Parasitized Host Egg

As many authors mention, the host egg turns darker after it has been parasitized a few days. When the parasite has pupated, the egg turns black, possessing a peculiar sheen that marks it from non-parasitized eggs of the mass.

Emergence of the Adult

Hungerford[13] has published the following notes on the emergence of this parasite from the eggs of the European Rose Slug, *Caliroa aethiops* Fabr. "From one egg, from one to three wasps issued. . . . From one egg three came forth, one following the other in quick succession. The tiny wasp cuts its way from the egg shell with its mandibles. The time required for the process in one case was thirty-five minutes from the first puncture of the egg, until the wasp emerged. Where there are more than one wasp in the egg the second wasp sometimes enlarges the exit hole of the first before attempting to pass. As soon as the wasp comes forth and while the wings are still pads it can jump an inch with alacrity. They fill out in about four minutes."

Emergence Response to Light

Wolcott[17] in working with this parasite found that they show an emergence response to light. He had trouble with this being strongly positively phototropic, so placed his cages in the dark. When the cages were removed from the dark he found the greater number contained no adults but that in the next hour of exposure to light a large emergence took place. He came to the conclusions that " . . . the normal time of emergence is approximately two hours after sunrise" and that in his cages " . . . six times (6.19) as many adults of *T. minutum* emerged in the first hour after being exposed to daylight, as emerged in the dark per hour of previous daylight in the same day."

Length of Emergence

On a check of some field material it was found that emergence in the same brood continues one and even two days after the first day of emergence. No accurate check was made of other cages, as was done with the above mentioned but it was noticed that in other cages the numbers were sometimes quite noticeably greater on the second and third days. In the same cages checks were also made on the length of the life of the adult in the cage. In all four cages they lived for a period of four days without food.

Length of Life History

The complete life history ran from fourteen to sixteen days in the *Sialis* cycle which occurred during the fore part of the season. The greatest number of parasites emerged on the fourteenth day. The average temperature for this generation was 66.8° F. During the *Chrysops* cycle the period ran from thirteen to sixteen days, as in *Sialis* eggs. The temperature average reached its peak during this generation at 75.4° F. The sixteen day cycle occurred in two cages, a *Sialis* cage and a *Chrysops* cage, that contained host eggs that were laid before the maximum average temperature had been reached. Taking all the cages collectively, the average length of the time in the host egg was fourteen days. After the *Chrysops* cycle, the *Tabanus* cycle began, and probably other hosts also began to lay eggs at this time. At this period the average temperature was beginning to fall. No data were obtained from *Tabanus* eggs in the field because of lack of time and material. Howard and Fiske[12] record as short a period as nine days and as long a period as three weeks in the fall for the length of the life cycle in the host egg. Their work was done with the Browntail Moth in Massachusetts.

Incubation Period of Host Development of the Parasite

The parasite's life history cycle ran side by side with the incubation period of the host during the first part of the season. As the season grew warmer the incubation period of the host shortened while the cycle of the parasite remained at about the same place. Later in the season instead of finding the parasite emerging on the same day that the host larvae were hatching, it was emerging as long as twelve days after the hatching of the unparasitized host eggs.

The following chart gives comparative data.

LENGTH OF SIALIS INCUBATION COMPARED WITH PARASITE EMERGENCE

From Field Material (Emergence from 6/26 to 7/8/1926.)

No. of days by which parasite incubation exceeded host incubation	0	1	2	3	4	5	6	7	8	9	10	11	12
No. Cages	7	7	4	7	3	1	1	0	0	0	0	0	0

From Life History Material. (7/14 to 7/16/1926.)

No. Cages	0	0	0	0	0	4	1	5	2	1	0	0	0

LENGTH OF CHRYSOPS INCUBATION COMPARED WITH PARASITE EMERGENCE

From Field Material. (7/17 to 7/29/1926.)

No. of days by which parasite incubation exceeded host incubabation	0	1	2	3	4	5	6	7	8	9	10	11	12
No. Cages	0	0	0	0	0	0	0	0	0	0	0	8	2

From Life History Material. (7/20 to 7/25/1926.)

No. Cages	0	0	0	0	0	7	1	2	0	1	0	0	0

Number of Generations

During the two months spent working with these parasites there were four successive generations upon which notes were taken. At least five other generations, not successive but overlapping each other and the successive four, appeared. A sheet made up of emergence dates of field material, life history cages, and field notes, show that there was an almost daily emergence of the parasite throughout the season. No distinct generations appeared.

How the Parasite Overwinters

No one knows definitely just how the parasite does overwinter. Howard and Fiske[12] have published some temperature results that give a hint as to how this insect spends the winter. They say that "if the temperature falls below certain limits, the young parasites will hibernate or attempt to hibernate and thereafter their development may be delayed for several weeks, even months, even though they are exposed to continuous high temperature during this period." More than likely the winter is passed in some lepidopterous egg.

Percentage of Parasitism

In studying the charts of percentages of parasitism over the span of the season that the data were gathered, it can be inferred that in this particular season, and it would probably be true for other seasons, the numbers of the parasite that successfully pass the winter were few. The first host eggs found were those of *Sialis infumata* Riley. These eggs were, with the exception of one cage, parasitized very lightly. *Sialis* eggs are laid in a single decked mass so that it is very easy for the parasite to reach all the eggs in the mass. The average per cent of parasitism for the thirty-six cages of field material that were parasitized about the middle of June was .019 per cent counting approximately 2,045,075 eggs.

The next host that followed was *Chrysops*. In making counts of these eggs two numbers had to be taken into consideration—the number of eggs actually exposed to parasitism and the number of eggs in the whole mass. *Tabanid* eggs are usually laid in heaped masses, so that many of the eggs in the mass cannot be reached by the parasite. In the field cages that contained material parasitized during the last part of June and the first of July, there was a parasitism of 11 per cent for 22,468 eggs, the total number of eggs in the masses. When only the eggs exposed to the parasite were considered, the average was, of course, higher, being 17 per cent for 15,258 eggs.

The life history cages of the two hosts may be used as checks for the field material, for here all factors were practically the same for both hosts, which was not true in the field. Parasitism of the two hosts in the life history cages ran about parallel. The average for *Sialis* eggs was 16 per cent; for *Chrysops* eggs exposed to the parasite, 20.8 per cent, and for the actual number of eggs in the masses, 11.5 per cent. The average for these two percentages was 16 per cent. This would indicate that under the same conditions the *Sialis* eggs would be parasitized as heavily as the *Chrysops* eggs, which was not true in the field. One cage of *Sialis* eggs had a 40 per cent parasitism which indicates further that the parasite will parasitize *Sialis* eggs more heavily than the data obtained would indicate.

On August 8, 1926, six masses of *Chrysops* eggs were picked at random in the field and later counts made by counting the number of parasite emergence holes. The emergence hole of the parasite is very distinctive and can be recognized quite easily. It is a round, more or less jagged-edged hole, while the host larva emerges through a slit at the cephalic end of the egg. As the parasites emerged from these on the 10th of August, it was evident that they were parasitized some time during the last part of July. The per cent of parasitism of these masses was cut down because one mass was not parasitized, an unusual find in the field at this time of the season. The highest parasitism was 98 per cent and excluding the mass not parasitized, the lowest was 90 per cent. The average per cent for the eggs exposed to parasitism was 86.7 per cent and for the number of eggs in the masses 59.8 per cent; these two figures average 73 per cent.

Thus as the season advanced, the larger the numbers of the parasite grew, but yet they lagged so that the host was allowed to establish a good-sized brood before the parasite numbers were large enough to make any inroads on the numbers of the host. So the host is not threatened with extermination but rather parasitism acts as a factor in helping to maintain the balance of nature. This is done by the reduction of what might be called the surplus numbers of the host. This reduction lessens the danger of the species becoming exterminated by its own numbers. Furthermore, the reduction of these numbers prevents no more than a normal disturbance of some other species that might serve as host.

About the same situation exists with the European Corn Borer.[1,14] It has been published that ''this parasite is of little value in control of the European Corn Borer, except in subnormal seasons because its highest parasitism comes too late in the season to give the best results.''

Now when the time of the season has come that the parasite has increased its numbers so greatly and the egg laying season of the old host is past, it must find another host or hosts to support the large numbers that are now in the field. Unfortunately the Biological Station closed at this time so we are only able to offer suggestions as to what host that parasite now goes. We collected two large masses of *Tabanus* eggs and parasitized them in the laboratory and then killed the eggs in hot alcohol. Later the eggs were dissected.

It was found that there were usually three parasites in a single *Tabanus* egg. Often as many as five were found, as has been mentioned before. The number of eggs in a single mass was also greater than in a *Chrysops* mass, so that if the *Tabanus* masses became as numerous as the *Chrysops* masses were, they could support the larger numbers of parasites as easily as the *Chrysops* had supported the smaller numbers in the earlier part of the season. As the parasite has a large host list it is probable that other hosts absorb the increase.

While Girault[7] seems to think that the abundance of food is the only factor of importance that acts as a check on this parasite, there are other factors that might be pointed out that probably play an important part in keeping the numbers of the parasite reduced. Howard and Fiske have said that the toughness of the chorion of the host egg was effective in the reduction of the parasitism by this insect in the case of the browntail moth. Harland[8] reports that the oviposition of the parasite is not effective at times with the Corn Worm (*Laphygma frugiperda* S. & A.) because the felty covering of the egg varied in thickness so that with some eggs it was thick enough to keep the parasite out. Harland also thinks that they refused to oviposit in the eggs of the Bean Leaf Roller (*Eudamus proteus* L.) because of a thin layer of some viscous substance on the chorion that had a repellent effect on the parasite.

The willingness to oviposit is a factor in keeping the numbers reduced. The female will oviposit in an egg with an embryo almost matured as readily as she will in a fresh egg. Because of this trait many eggs are laid that perish very soon. This was observed both in the field and in the laboratory. Howard and Fiske mention in their report that this insect will oviposit in eggs containing embryos. Their observations were limited to the laboratory.

Winter is probably a very important factor in the reduction of the season's numbers. From the data collected it is evident that only a small number ever pass through the winter successfully.

Conclusion

This parasite is a very successful organism. One of the reasons for its success is because it has such a large number of hosts. From the present studies and from the literature it can be pointed out that the parasite numbers rarely become so large as to effectually reduce the numbers of the host to any appreciable extent. The parasite plays its part in the reduction of the numbers of the host only at the end of the laying season when a "pruning" is of more value than harm to the host. Another reason for its success is that its numbers are reduced at the end of each season by winter.

Chart of Sialis Egg Parasitism

From Field Material

Material Collected from 6/22/26 to 7/1/26

Cage No.	No. of Sialis Eggs	No. of Parasites	Percentage of Parasitism
1	5,075	178	.033
2	16,850	101	.006
3	150,000	300	.002
4	13,750	42	.003
5	30,875	198	.006
6	53,000	361	.006
7	12,870	126	.006
8	28,920	35	.001
9	61,000	472	.007
10	30,000	135	.0045
11	48,000	115	.002
12	50,000	100	.001
13	20,000	30	.002
14	25,000	68	.002
15	34,000	84	.002
16	70,000	160	.028
17	86,000	2,520	.003
18	57,600	225	.004
19	26,200	105	.008
20	47,705	360	.007
21	30,600	356	.012
22	48,300	49	.001
23	8,500	570	.065
24	85,600	295	.003
25	28,800	205	.007
26	16,000	52	.003
27	22,200	980	.044
28	85,600	295	.034
29	34,750	4,107	.118
30	46,000	16	.0003
31	26,400	2,086	.079
32	10,500	2,687	.255
33	19,200	25	.001
34	15,300	469	.030
35	8,000	3,200	.400
36	570,000	18,420	.320

39,457 parasites emerged from approximately 2,045,075 *Sialis* eggs, giving an average parasitism of .019 per cent.

Chart of Chrysops Egg Parasitism

From Field Material

Cages 68–77 Collected on 7/8/26, Cage 83 on 7/14/26

Cage No.	No. of Parasites	No. Exposed to Parasite	Per Cent Parasitism	No. in Mass	Per Cent of Parasitism
68	444	800	.555	1,582	.281
69	496	2,175	.228	2,950	.168
70	221	1,508	.140	2,316	.095
71	115	1,090	.105	1,365	.084
72	261	2,000	.130	2,900	.090
73	262	2,146	.179	6,197	.132
74	103	810	.127	1,300	.079
75	42	1,235	.037	2,000	.021
76	206	1,010	.203	1,630	.126
77	38	1,195	.039	1,730	.021
83	427	1,965	.217	2,720	.157

Two thousand six hundred and fifteen parasites emerged from egg masses that contained approximately 22,468 eggs for an average parasitism of 11.6 per cent. The number of eggs actually exposed to parasitism was 15,258 eggs for an average of 17.1 per cent.

On August 8, 1926, a number of *Chrysops* masses were collected that had been heavily parasitized. The following counts were obtained by counting the emergence holes. The parasites had been allowed to emerge in a large cage in the laboratory.

Cage No.	No. Eggs Exposed to Parasite	No. Eggs With Emergence Holes	Per Cent Para.	Eggs in Mass	Per Cent Para.
M–1	100	0	.000	170	.000
M–2	90	88	.967	160	.544
M–3	125	115	.928	175	.677
M–4	110	106	.964	160	.662
M–5	500	490	.980	650	.753
M–6	100	90	.900	170	.529

Eight hundred and eighty-nine parasites emerged from egg masses that contained 1,485 eggs for an average percentage of .598. The number of eggs actually exposed to parasitism was 1,025 for an average parasitism of .867.

Summary

1. *Trichogramma minutum* Riley is found in both hemispheres.

2. It has a host list that numbers well over one hundred and fifty species in seven orders.

3. The author reports *Sialis infumata* Newn., *Chrysops striatus* O. S., *Chrysops excitans* Walker, and *Tabanus lasiophthalmus* Macq. as new hosts.

4. The numbers of the winged females usually exceed those of the wingless males and females.

5. This parasite reproduces parthenogenetically.

6. The author reports an aberrant form that has the antennae clothed with long hairs.

7. It is believed that strong light has a negative effect upon the oviposition of this parasite.

8. While this insect has been known to oviposit in the juice globules of okra plants, yet it refuses to oviposit in the eggs of *Donacia,* Gyrinidae, the Cotton Stainer (*Dysdercus delauneyi*) and also no attention was paid to spider eggs.

9. Gatenby's sections were made from *Sialis* eggs and not *Donacia* eggs.

10. The average number of ova dissected from females was forty-one. The average number of progeny was twenty-three. The ova measured .089 mm. to 148 mm. in length.

11. The larva is a sac-like creature with no metameric segmentation of the body and the only appendages possessed are a pair of oral hooks. Tracheae are not present.

12. The larva rapidly swallows the contents of the host egg, no digestion taking place until the larva has distended itself to full size.

13. Only one larva is able to develop to maturity in the eggs of *Sialis* and *Chrysops. Tabanus* eggs usually support three. The maximum number of *T. minutum* R. reported emerging from one egg is ten.

14. There is a prepupal stage. Its length is not known.

15. The larval and egg stages last from six to seven days in a fourteen day cycle. The length of the pupal stage is from seven to eight days.

16. Wolcott proved that there is an emergence response to light.

17. The average life cycle ran fourteen days. The incubation period of the parasite ran from none to twelve days longer than the incubation period of the host.

18. In the same brood emergence continues for a day or two.

19. There were no clean cut generations. An almost daily emergence occurred.

20. The parasite probably overwinters in the egg, larval or pupal stage in some lepidopterous egg.

21. Only a small number of parasites survive the winter.

22. Checks show that *Sialis* eggs are parasitized as heavily as *Chrysops* eggs when subjected to the same conditions. In the field *Sialis* eggs were parasitized very lightly.

23. In normal seasons the parasite numbers lag behind the numbers of the host eggs in the field until the peak of the host egg-laying season is reached.

24. The toughness of the chorion, the thickness of the chorion of the host egg, the viscosity of the substance on the chorion, the willingness to oviposit in eggs of any age, and winter, act as checks on the numbers of this parasite.

25. This parasite is very successful, for it has a very large host list. It does not threaten to reduce its host's numbers materially, except in abnormal seasons. At the end of the season its large numbers are reduced very materially by the rigors of winter.

Tiphodytes gerriphagus (Marchal)
(Family Proctotrypidae)

European Literature

This very interesting parasite was first described by Marchal in 1900 in the Annales de la Société Entomologique de France, under the generic name *Limnodytes*. In 1902, Bradley, in the Canadian Entomologist, Vol. 34, p. 179, proposed the new name *Tiphodytes* for *Limnodytes*, which was preoccupied. Marchal found the insect through his embryological studies of Gerridae. He was aware of the parasite's presence by the undulating movements of larvae which he could see through the chorion of the gerrid egg. He first found a larva that the third form of the parasitic larva of *Platygaster*, described by Ganin, resembles. Later he found what he called the first form of the larva, which he thought differed from *Platygaster's* first form by the arrangement of the bristles and by the caudal hook, which he thought was without a spine.

He imprisoned the adults in a glass tumbler and observed that they used their wings equally well in flying or in swimming through the water. His plates show that the males possess moniliform antennae while the females have clavate antennae. He gave no definite data on the life history. He mentions that he collected the gerrid eggs on the 14th of May and that the adults of the parasite emerged in June.

In 1918, Henriksen published under the old generic name, *Limnodytes,* about the same information concerning the larvae as Marchal published, going more into detail in the description of the larvae. He published with his paper a plate showing the egg and three larval stages which he labels as *Limnodytes sp.* and marks "copied after Ganin." Evidently his plates were not made from material at hand.

American Literature

The only literature from America concerning this insect is the paper published in 1912 by Matheson and Crosby in the Annals of the Entomogolical Society of America, Vol. V, page 67, March, 1912. They describe the swimming of the species and the laying of eggs in the *Gerris* eggs while under water. They mention that their determination was verified by Marchal. The specimens that the author possesses were identified through the kindness of Dr. S. A. Rohwer of the National Museum.

Field Notes Taken at Douglas Lake

The adults were very numerous at the north-western end of the lake at Marl Bay and in Bessey Creek which emptied into the lake near the bay. They were found flying about the lily pads or walking over them. Sometimes only one female was on a pad and then again several were on the same pad. After the female landed on a leaf she usually walked straight to the edge of it. When a suitable place was found, she first dipped her head under the surface film of the water and after a few struggles with it, succeeded in pulling herself entirely under water. Clinging to the underside of the pad, she walked about searching for gerrid eggs. Usually she did not have to search long as the gerrid eggs are laid along the under edge of the pad.

Oviposition was begun as soon as the eggs were found. Several times the leaves were turned over under the water so that the female could be observed. After ovipositing in two or three eggs she would let go of the surface of the pad and come quickly to the top and fly away from the surface of the water. The passage through the water from the leaf to the water's surface was so rapid that it was never determined if the wings were used or if the buoyancy of the insect's body brought it to the surface. More than likely she used her wings.

In the laboratory it was possible to watch oviposition much more closely than in the field. As soon as the female entered the water she wrapped her wings tightly about her abdomen, making it appear much longer than normal. The antennae were held back over the head tightly against the dorsal side of the body with the clubs close together. The insect leaned forward while ovipositing. This position made her appear as though she were almost overbalancing herself by the strenuous effort she was exerting in making the oviposition. The ovipositor was driven into the chorion of the host egg at an angle of 90 degrees. Usually no motion was noticed as the ovipositor was being thrust through, though sometimes a rocking motion was evident before the ovipositor had been thrust all the way in. Throughout the operation the tip of the abdomen was held close to the chorion of the host egg.

In the field the writer observed a second manner of oviposition that neither Mathewson and Crosby nor others have observed. As usual the female alighted on the pad and walked to the edge but she did not go under the water. Instead she turned around and backed into the water and clung anchored to the lily pad with the front pair of legs, while the middle pair hung in the water, and the hind legs floated on the surface film of the water, as did the wings also. In this position the female was able to reach the gerrid eggs with her ovipositor and oviposit in them. After ovipositing about twenty seconds the insect crawled back to the surface of the pad, wiped the abdomen off with the hind pair of legs, and flew away to another pad.

In the laboratory the females were observed to try to oviposit in the gelatin that covered *Trepobates* eggs. Sometimes they attempted to oviposit in the gelatine as many as five or six times before finally striking an embedded egg. We were never able to find out if an egg was actually deposited. The female assumed the same position as when laying in a gerrid egg and sometimes the rocking motion was noticed. No discrimination was made as to the age of the egg. Eggs containing gerrid embryos almost ready to hatch were oviposited in as readily as eggs that were much fresher.

Technique in the Laboratory

To carry on studies on individual eggs, slides were covered with paraffine and holes made in the wax to contain the egg. Each egg's number was scratched in the wax beside it. The slide was kept in a finger bowl in enough water to almost submerge it. This way the eggs were kept from drying and yet data could be kept on individual eggs. Paraffine wax did not prove very satisfactory as it broke loose from the slide after being in the water for a time and had to be watched very carefully to prevent the eggs from becoming mixed. When further studies are made the slide will be covered with sealing wax.

Other laboratory studies were made with preserved material. This material was killed in boiling 70% alcohol and kept in 70% alcohol. Gerrid eggs did not seem to coagulate and become as dense and tough as *Trepobates* eggs.

In the laboratory the larvae or pupae could be easily seen under the binocular. Keeping the eggs under water, the chorion of the host egg was carefully cut and picked with a small curved and a flat knife-like dissecting needle, fashioned from steel insect pins and sharpened on an oil stone. After the chorion was removed the tough, rubber-like egg contents had to be cut open. A cross cut was usually made near the parasite which is found lying in a cavity from which it can be picked. Considerable care must be used in removing the larva or the skin will be broken and the specimen ruined. The larva should not be allowed to become dry but should be put on a slide immediately. If allowed to dry the shin shrinks and sloughs off, leaving only the solid part of the body contents which are not particularly interesting. Better success may be had in mounting first- and small second-stage larvae by mounting them in a bit of the host egg contents. By moving the cover-slip about, the larva can be moved into such a position that it can be easily seen.

The larvae were mounted from water in a gum arabic solution made up as follows:

Materials

Glycerine	20 cc.	Gum Arabic	40 gr.
Water	50 cc.	Chloral Hydrate	50 gr.

When the gum is dissolved in water, dissolve the chloral hydrate in this, add the glycerine and filter. Do not mount specimens from alcohol but wash them first in water and remove from water to the slide.

The Egg of *T. gerriphagus* (Marchal)

The egg is ovoid in shape with a micropyle that is about the same length as the egg itself and a fifth as wide. The total length of an ovum dissected was about .228 mm. and the width .059 mm. at the widest part. Eggs found in the gerrid eggs measured .15 mm. in length and .038 mm. in width. These particular eggs had lost their chorion and micropyles when removed from the host egg contents. In the host egg they are placed at right angles to the median longitudinal axis with the micropyle pointing toward the point in the chorion where the ovipositor entered. It is usually so placed that either end is about equidistant from the chorion of the egg of the host. Ova dissected were for the most part almost transparent with a faint tinge of white over the chorion. Eggs found in the host egg have the contents around the center greyish-white and the outside tinged with a yellowish color.

Number of Eggs in Host Egg

Usually several eggs are laid in a single gerrid egg. Several females will lay at different times in the same egg. The greatest number known to have been laid in one egg is four. Three is the usual number.

The Larva

The presence of the larva in the host is known by the undulating movement that Marchal mentions. Henriksen[20] says that the larva of *Anagrus brocheri* Schulz, which lives under similar conditions, keeps the contents of the host egg stirred up by turning and bending in different directions. We were never able to locate the larva of *T. gerriphagus* when it had the host egg contents in a turmoil. The first stage larva no doubt can keep the contents stirred by whipping about with the row of spines around the abdomen. The second stage might keep them stirred in the same way. We are at loss to explain how the third form can keep the contents agitated.

What was apparently the center of the disturbance was marked usually by a thin, bubble-like ring that moved back and forth through the contents of the host egg. If the oscillating movement was regular, it disappeared for an instant when the end of the egg was reached, appearing again almost immediately and moving back to the opposite end, and here disappearing and reappearing as before. At times two such rings appeared simultaneously at both ends of the host egg. The second ring usually met the first one somewhere near the middle of the host egg where it disappeared while the first ring continued. We can offer no explanation for the appearance and disappearance of the rings.

The appearance and disappearance of the ring is sometimes regular and at others irregular. When irregular the time for the ring to pass from one end of the egg to the other is lengthened. At some periods the ring was not present but the back and forth flow of the contents continued. At other times no movement was seen. The following notes were taken on the irregular movements of full-grown larvae almost ready to pupate. The time is the number of seconds that elapsed between the disappearance and appearance of the oscillating movements.

Larva No. 1.

First day.

	Continuous oscillating movements for
15 seconds	15 seconds
5 seconds	5 seconds
10 seconds	6 seconds
10 seconds	8 seconds
8 seconds	4 seconds
12 seconds	5 seconds
5 seconds	

Second day.

The oscillating movement was continuous without the irregular lapses between the disappearance and appearance of the ring.

Third day.

Movement continuous but slower.

Fourth day.

No movement. Quiescent for pupation.

Larva No. 2.

First day.

1 minute	20 seconds
40 seconds	16 seconds
20 seconds	12 seconds
20 seconds	25 seconds
25 seconds	15 seconds

Second day.

Movement still irregular.

Third day.

Movements regular.

Counts were made of the number of movements appearing in a half hour when the motion was continuous.

Larva No. 3—73 movements in 30 minutes.
Larva No. 4—65 movements in 30 minutes.
Larva No. 5—68 movements in 30 minutes.
Larva No. 6—70 movements in 30 minutes.
Larva No. 7—70 movements in 30 minutes.

The First Larval Stage. (Plate IV, fig. 1.)

Three distinct stages of the larva are found. The first stage measures from .10 mm. to .16 mm. in length. Some of the larger larvae of this stage measure .158 mm. from the dorsal side of the abdomen to the tip of the caudal spine; the cephalothoracic region measures about .066 mm. from the dorsal to the ventral side. The general color of this stage and the second stage is a grayish-white, the same color as the contents of the gerrid eggs.

The newly hatched larva is divided into three regions. The head region is the largest of the three. At the apex on the ventral side a pair of flattened, curved oral hooks are found. They are .017 mm. in length from the tip to the base. Across the base the width is about .007 mm. Just below the oral hooks is a chitinized, bill-like labium. The oral hooks can be moved about by the larva and can be crossed. The labium does not seem capable of such movement.

After the larva begins to feed the abdomen becomes more and more distended until it is larger than the head and thoracic regions. The thoracic region seems to fuse with the head region. A deep constriction now marks the cephalothoracic region from the abdominal. On the dorsal and lateral sides of the abdomen is a row of flat spines. These spines are placed close together at regular intervals. They are .017 mm. in length. As suggested before their probable function is to propel the larva about through the egg contents. At the caudal end of the abdomen is the caudal horn ("la corne caudale") that Marchal mentions. This is the appendage that possesses the spine that he was unable to find. The total length of the horn is about .099 mm. The tip, from the spine to the point, is rather slender, being between a third and a fourth as wide as the basal portion. As there is not much difference in the size of the larvae of this stadium, it is probable that this stage extends over only a short period.

The Second Larval Stage. (Plates IV and V.)

The smallest second stage larva found measured .184 mm. in length and .121 mm. in width. The largest one found was .75 mm. in length and .50 mm. in width. The cephalothoracic region is no longer distinctly marked by a deep constriction. The general shape is ovoid for most specimens.

Lying at a slightly sloping angle on the dorsal side of the cephalic region are two plate-like thickenings of the skin. These are each divided into a large oval lobe and a small more or less triangle shaped lobe having two sharp angles and a rounded angle. The two small lobes lie at the dorso-cephalic apex of the body. These details are not always distinct and cannot be found in many specimens. Just between and a little beneath the rounded angles are the oral hooks on the ventral surface. These measure from .038 mm. to .040 mm. in length and from .019 mm. to .020 mm. in width at the bases. The labrum is a short flap-like structure extending between the bases of the oral hooks. It has not been found in the other stages. The beak-like labium resembles that of the first stage, differing principally in being a little larger and a little broader. It is found in the same position beneath the oral hooks. As in the first stage, the oral hooks can be crossed and moved about but the labium seems to be stationary.

The spines on the abdomen are not any larger than those of the first stage. They have, however, a different arrangement. Instead of being spaced one by one at regular intervals, they are arranged in scattered groups of five or six.

Only a stump of a caudal horn is left. This is about the same size as the spine on the caudal horn of the first stage. It is placed on the median line of the ventral side, distad to the tip of the abdomen. Instead of curving upward as the caudal horn of the first stage, it curves downward.

It was found by a study of the material at hand that several larvae are usually present in one egg at the same time and that the first and second stages are cannibalistic. All three stages have been found together in the same egg. The first stage was found fastened to the second or third stage larva (Plate IV, fig. 6), usually at the caudal end of the body. The larvae hold on by piercing the thick skin with the oral hooks and labium and by thrusting the caudal horn through the skin. They live upon the body contents of the attacked larva. As more than one larva is almost always found in the gerrid egg where a first stage is present, it is believed that the first stage larva is almost wholly cannibalistic. However, if no other larvae are present, it will probably feed upon the yolk disclets.

The second stage has been found feeding upon all stages. The first larval stage and the young larvae of the second stage are held clutched between the oral hooks and the labium. Sometimes the oral hooks pierce through the skin and sometimes they do not. We have slides showing the crumpled larval skins of the first stage between the oral hooks and with the labium fastened in them. The larvae have been squeezed dry of their contents. When the larva is larger than the attacking larva, the stump of a caudal horn is also fastened in the attacked larva's skin. Where there are not enough larvae in the egg to complete one larva's growth, the last larva completes his growth by feeding upon the gerrid egg contents.

The Third Stage. (Plate IV, fig. 5.)

The smallest third stage larva found measured .813 mm. in length and .40 mm. in width. Larger larvae that were in the prepupal stage measured up to 1.375 mm. by .625 mm. The length is somewhat longer than that of the pupa.

This stage differs very much from the first two stages. The body is elongate-ovate with the cephalic region indistinctly marked and not appearing to be any larger than that of the second stage. The cephalic region with the oral hooks appear to have migrated somewhat caudad of their second stage position. The oral hooks are very much reduced in size, being very slender and thread-like with broad bases. As compared with the second stage they are reduced in length and point cephalad instead of caudad, as in the first two stages. In the larvae measured their length was between .022 mm. and .033 mm. The width at the base was about .006 mm. They are of an orange-yellow color. The labium is not evident and the spines around the abdomen are also lacking, as is the caudal horn. Probably not much feeding is done in this stage.

The Prepupal and Pupal Stages

Almost all the third stage larvae that were dissected were in the prepupal stage. Probably this stage is as long or longer than the third larval stage. The transition from the prepupal to the pupal stage is not marked by a sudden sloughing off of the larval skin. Sometimes the skin does not break until the insect is ready to emerge. It usually, gradually disintegrates until it appears as a yellowish-white colored, thin blanket of pressed material covering the pupa. In most pupae it breaks up at this stage and collects along the ventral region around the legs and wings where it undergoes further disintegration.

Congested masses often appear in the thoracic and abdominal regions of the prepupal stage. Later in the pupa they become more compact and appear only in the abdominal region. Here there may be one or two masses of various shapes. Some are cigar-shaped, pear-shaped, cone-shaped, oval-shaped with a constriction in the center and various other forms. In live material they have been observed to change their shape from day to day. In older pupae they break up into small granules. This is waste material that is defecated by the adult.

The fresh pupa is of a lemon-yellow color. At first the compound eyes and ocelli are of the same color but as the pupa ages they first turn pinkish-brown, then a reddish-brown and finally a very dark brown. After the eyes are dark colored, a black pigmentation of the other parts of the body becomes noticeable. At this time the sutures of the abdomen appear. When the pupa has become fully pigmented it is of a jet black color, the same color as the adults.

The pupae fill the host eggs quite snugly. Usually they are found lying on their dorsal side. When in this position and when the time for emergence comes, they probably make a full half turn so that the exit hole is cut through the surface of the chorion opposite the side glued to the leaf surface. Some individuals are found lying on their sides. Probably these do not make a turn before cutting through the chorion, but cut it through the side of the egg. Oftentimes eggs are found with the exit hole cut through the side.

Length of Pupal Stage

On July 30, 1926, four eggs that contained pupaing larvae were isolated. On the 31st the new pupae could be seen. The red eye spots appeared on the 2nd of August and by the 11th the shining jet black color was fully developed. The adults emerged on the 15th of August, making the pupal stage fifteen days long.

Size of the Pupae and Adults

The following data were obtained from specimens at hand:

Measurements of Pupa in the Larval Skin

	Total Length	Width of Abdomen
No. 1	.888 mm.	.325 mm.
2	.888 mm.	.325 mm.
3	.888 mm.	.325 mm.
4	.937 mm.	.450 mm.
5	.937 mm.	.450 mm.
6	1.000 mm.	.450 mm.
7	1.000 mm.	.450 mm.

Measurements of Pupae with Colored Eyes

(Pupa in larval skin)

8	.95 mm.	.25 mm
9	1.00 mm.	.475 mm.
10	1.00 mm.	.34 mm.
11	1.00 mm.	.45 mm.
12	1.00 mm.	.45 mm.

Measurements of Partially Pigmented Specimens

(Larval skin partially disintegrated)

13	1.00 mm.	.35 mm.
14	1.00 mm.	.35 mm.
15	1.00 mm.	.35 mm.
16	1.00 mm.	.35 mm.

Measurements of Wholly Pigmented Pupae

(Some specimens almost covered with disintegrated material, others having it collected along the ventral region)

17	1.00 mm.	.26 mm.
18	1.00 mm.	.26 mm.
19	1.00 mm.	.27 mm.
20	1.00 mm.	.27 mm.

Measurements of Adults

21	1.00 mm.	.25 mm.
22	1.00 mm.	.25 mm.
23	1.00 mm.	.26 mm.
24	1.00 mm.	.26 mm.
25	1.00 mm.	.27 mm.
26	1.00 mm.	.29 mm.

We wish to call attention to the buttonhole-like slits that are found in the thoracic and abdominal regions of the pupae and adults. In the thoracic region series of short slits are found along the margin of the sutures. Longitudinal slits are found in the second and third abdominal segments. Nothing has been discovered concerning their function.

Per Cent of Parasitism

Parasitism was very high in *Trepobates* eggs but only about a third as high in *Gerris* eggs. This is a peculiar fact when it is taken into consideration that *Trepobates* eggs are covered with gelatine, apparently making oviposition in these eggs more difficult than in *Gerris* eggs. Observations show that the female parasites do have difficulty in locating the egg in the gelatinous matrix. *Trepobates* eggs were found on the same leaves with *Gerris* eggs but the parasite seemed to exhibit a marked preference for the *Trepobates* eggs.

In the material at hand there was a parasitism of 23.9 per cent for 3,017 *Gerris* eggs, while for *Trepobates* eggs it was 72.5 per cent for 917 eggs. There were 128 rows of *Gerris* eggs. Ten of these rows were parasitized 100 per cent and 10 were parasitized 70 per cent or over. Only 17.8 per cent were parasitized 70 per cent or over. Out of the 47 rows of *Trepobates* eggs, 12 were parasitized 100 per cent and 11, 70 per cent or more.

Parasitism of Gerridae Eggs by Tiphodytes gerriphagus (M.)
(*Gerris* Eggs)

Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized	Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized
1	34	14	41.1	33	18	5	27.7
2	44	14	31.8	34	20	1	5.0
3	33	12	36.3	35	22	11	50.0
4	7	0	00.0	36	26	6	23.0
5	7	2	28.5	37	42	0	00.0
6	12	0	00.0	38	28	0	00.0
7	10	2	20.0	39	12	2	16.6
8	9	0	00.0	40	8	4	50.0
9	45	0	00.0	41	28	6	21.4
10	7	5	71.4	42	10	10	100.0
11	25	0	00.0	43	15	1	6.6
12	12	4	33.3	44	100	0	00.0
13	12	1	8.3	45	26	6	23.0
14	25	16	64.0	46	30	9	30.0
15	20	1	4.0	47	10	10	100.0
16	18	1	5.5	48	11	9	81.8
17	8	4	50.0	49	18	6	33.3
18	7	1	14.2	50	8	4	50.0
19	24	3	12.5	51	14	7	50.0
20	30	5	16.6	52	21	9	43.8
21	21	2	9.5	53	14	4	28.5
22	20	20	100.0	54	6	6	100.0
23	16	4	25.0	55	18	4	22.2
24	40	0	00.0	56	21	1	4.7
25	50	0	00.0	57	18	4	22.2
26	6	6	100.0	58	14	4	28.5
27	12	1	8.0	59	8	5	62.5
28	19	2	10.5	60	26	0	00.0
29	24	2	8.3	61	20	2	10.0
30	30	4	13.3	62	10	1	10.0
31	10	6	60.0	63	20	8	40.0
32	24	12	50.0	64	40	0	00.0

Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized	Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized
65	20	1	5.0	95	5	5	100.0
66	45	0	00.0	96	14	2	14.2
67	24	2	8.3	97	24	12	50.0
68	22	10	45.4	98	17	15	88.2
69	14	2	14.2	99	10	4	40.0
70	20	1	5.0	100	18	18	100.0
71	40	4	10.0	101	28	7	25.0
72	30	2	6.6	102	32	3	9.3
73	15	15	100.0	103	15	12	80.0
74	20	4	20.0	104	18	3	16.6
75	100	0	00.0	105	43	2	4.6
76	12	3	25.0	106	32	10	31.2
77	20	8	40.0	107	67	14	20.8
78	20	6	30.0	108	5	2	40.0
79	15	3	25.0	109	24	22	91.6
80	24	3	12.5	110	10	9	90.0
81	18	9	50.0	111	15	5	33.3
82	21	7	33.3	112	14	6	42.8
83	16	2	12.5	113	16	4	25.0
84	60	15	25.0	114	100	0	00.0
85	75	0	00.0	115	15	5	33.3
86	100	0	100.0	116	38	36	94.7
87	10	0	00.0	117	20	1	5.0
88	42	2	4.7	118	30	10	33.3
89	21	3	14.2	119	15	15	100.0
90	14	6	42.8	120	68	5	7.3
91	14	4	35.7	121	96	8	8.3
90	36	4	11.1	122	54	16	30.8
91	12	1	18.2	123	24	0	00.0
92	14	1	7.1	124	20	19	95.0
93	10	9	90.0	125	22	15	68.1
94	36	36	100.0	126	20	0	00.0

(*Trepobates* Eggs)

Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized	Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized
1	18	18	100.0	7	20	19	95.0
2	18	16	88.8	8	18	18	100.0
3	16	8	50.0	9	20	2	10.0
4	6	6	100.0	10	28	14	33.3
5	21	19	90.4	11	60	60	90.9
6	60	60	100.0	12	10	5	50.0

Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized
13	48	35	72.9
14	36	26	72.2
15	14	12	85.7
16	22	22	100.0
17	7	4	59.1
18	20	20	100.0
19	10	10	100.0
20	22	15	68.1
21	18	0	00.0
22	9	3	33.3
24	16	0	00.0
25	8	2	25.0
26	8	4	50.0
27	20	1	5.0
28	6	2	33.3
29	8	4	50.0
30	12	1	8.3
31	24	6	25.8

Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized
32	32	30	93.0
33	20	8	40.0
34	14	14	100.0
35	14	4	28.5
36	10	0	00.0
37	20	16	80.0
38	32	32	100.0
39	8	8	100.0
40	20	18	90.0
41	22	3	13.6
42	10	6	60.0
43	14	7	50.0
44	14	14	100.0
45	18	16	88.8
46	12	0	00.0
47	8	4	50.0
48	10	2	20.0

In some of the above counts more than one row of eggs is included in the count.

Summary

Tiphodytes gerriphagus (Marchal) lays its eggs in *Gerris* eggs in two ways. One by going under the water to reach them, and the other by backing over the edge of the lily pad and reaching them with the abdomen and ovipositor. The larvae pass through three stages. The first two stages are cannibalistic and also feed upon yolk disclets of the gerrid egg. Both the first and second stages make use of their oral hooks, bill-like labium, and caudal hook or horn, to hold on to the attacked larvae while feeding upon them. The row of flat spines around the abdomen is more than likely used to propel the larvae about through the contents of the gerrid egg. The third stage is elongate-ovate and does not resemble the first two forms. It lacks the bill-like labium, the spines on the abdomen, and the caudal hook. The oral hooks are reduced in size. Probably most of this stage is really the prepupal stage. The pupal stage is 15 days long. A preference is shown for *Trepobates* eggs.

Sialis infumata Newm.

Length of Adult Stage

On June 20th and 21st, 1926, great numbers of this insect swarmed along the shores of Douglas Lake, Michigan. The males seemed to be at this time in greater numbers than the females. On the 22nd the numbers of the females seemed to be greater than the males. At this time a great many eggs and pupae were collected, the pupae being found under logs, sticks, and other debris along the beach. The pupae were dropped in a live jar and when the laboratory was reached it was found that fully half the pupae collected had transformed to adults. All but one or two of this number were females. The following notes were kept on the abundance along the shore:

June 20—Large numbers of males.
21—Large numbers of males.
22—Large numbers of males and females.
24—Abundance of *S. infumata* continues.
27—Abundance of *S. infumata* continues.
July 1—Abundance of *S. infumata* continues.
2—Abundance of *S. infumata* continues.
5—Numbers of *S. infumata* noticeably decreased.
10—Very few *S. infumata* adults along beach.
14—Two females found laying in a sheltered bay, the only two that were seen during the day. The last ones that were seen during the rest of the season.

Oviposition

Davis' observations were that they prefer to lay eggs "on undersides of boat landings, on vertical sides of bridges and on stones projecting above creek or lake waters. They do not seem to select twigs of trees or shrubs when the above objects are accessible. The eggs are deposited on objects within the limits of running water."

At Douglas Lake the most common object on which the eggs were found was *Scirpus* stalks, which were standing in water from six inches to a foot and a half in depth. No eggs were found on *Scirpus* that was in deeper water. Eggs were also laid on the twigs of pussy-willow and other plants that over-hung the water's edge. No eggs were found on the boat-landings around the lake. Searches were made for eggs around the beach pools and on vegetation a short ways back from the water's edge but egg masses were found only once, these being on *Scirpus* that was eight or ten feet back from the water. The egg laying activities of the *Sialis* seemed to be confined to the southeast end of the lake, which was the point toward which the wind usually blew. No eggs were found around other parts of the lake.

On calm days great numbers of females could be found ovipositing, while on days when a strong wind was blowing, they were found under cover in the shrubbery along the shore. Sunshine did not seem to affect their laying activities, as they were found depositing eggs on cloudy as well as on sunny days.

After alighting on a stem the female usually runs rapidly about over the plant, searching for other egg masses. It seems to be easier for her to use the mass of another female as a marker for the one she lays than to start a new one. Davis gives a short description of oviposition as follows: ''The female deposits an entire row of from ten to twenty eggs and then begins another row . . . she now moves backward over the mass to reach the place for the succeeding row; thus her wings and body cover the mass until it is laid.''

The writer is able to give a more detailed account of the laying. When an egg is about to be laid, the lips of the valves of the ovipositor fit tightly against an egg or eggs already laid. Then the tip of the abdomen is lowered until the fine hairs on the caudal tip of it touch the surface on which the egg is to be deposited. The valves open slightly and the egg comes down. It is covered with a sticky, brown cement that turns darker brown upon drying. Some females secrete a cement that is much lighter in color than that of other females. Where several females lay on the same mass it is possible to tell precisely, several days after the eggs are laid, one female's mass from another by the color of the eggs. Upon touching the plant's surface the tip of the egg is immediately cemented to it. The abdomen is raised with a forward swing toward the egg or eggs opposite the one being deposited, thus setting the newly laid egg against its neighbors. The cement substance becomes dry immediately and thus the egg is cemented firmly to the leaf and to the eggs adjoining it.

The order followed in oviposition was as follows: The egg mass was composed of rows from 12 to 25 eggs long. A row was usually begun at the left end and the eggs were laid in one, two, three, four order toward the right. From four to six eggs were laid. When the fifth or sixth egg had been laid, the opposite end of the row was begun and five or six more were laid. Then the female returned to the unfinished left end and deposited five or six more eggs. This left to right and right to left action was continued until the row was finished at the center. Sometimes one or two more eggs were laid at the center for a new row. Then the left end of the new row was begun.

Laying was continuous until half the mass was complete, and then there was a pause of forty-five or fifty seconds, after which laying was resumed. Whether all females make this pause is not known, but all that were observed did. During the whole period of oviposition the female is not easily disturbed and it was possible to pluck the plant she was on and carry it about without disturbing her. When a mass of 300 or 400 eggs was complete the female flew away immediately.

The data for the following egg laying rates were secured from five females:

Female No. 1—67 eggs deposited in 5 minutes.
21 eggs deposited in 2 minutes.
64 eggs deposited in 5 minutes.

Female No. 2—60 eggs deposited in 5 minutes.
61 eggs deposited in 5 minutes.
23 eggs deposited in 2 minutes.

Female No. 3—60 eggs deposited in 7½ minutes.
35 eggs deposited in 3 minutes.

Female No. 4—60 eggs deposited in 6½ minutes.
60 eggs deposited in 6 minutes.

Female No. 5—58 eggs deposited in 5½ minutes.
60 eggs deposited in 6 minutes.

Time of Oviposition

No females were ever found laying during the morning or extremely late afternoon. Ovipositing females were found usually from midday until about four or five o'clock in the afternoon.

Notes on a Kansas Brood of Sialis infumata Newm.

At Lawrence, Kansas, further observations were made on the laying habits of a brood that has established itself at a reservoir on the campus of the University of Kansas. This place is popularly known as Potter's Lake.

The first insects found were males that appeared on April 9, 1927. The only other record known of this colony is from a series of 12 males and 45 females taken by Mr. Robert Guntert on April

14, 1922. As noted with the brood at Douglas Lake, Michigan, the males appeared two days before the females. The first eggs were found on April 12, 1927, one day after the first appearance of the females. Egg laying extended over a period of seven or eight days. On one day no eggs were laid because of a downpour of rain and on another because of extreme chilliness. The manner of oviposition and the length of time required to lay the eggs were the same as at Douglas Lake. The last adults were females seen on April 23, 1927.

Incubation

The incubation period of *Sialis* eggs at Douglas Lake covered a period of from seven to ten days. The daily average temperature was 64° F. In Kansas the period was from 9 to 15 days. The average daily temperature from April 9 to 23, 1927, was 57.2° F. Most of the larvae hatched on the 26th and 27th of April. The eggs laid on the 12th of April did not hatch until the 27th. A few masses hatched a little later.

Parasitism

No parasites emerged from the *Sialis* eggs taken in Kansas. *Trichogramma minutum* Riley has been reported in the vicinity of Lawrence.

Copulation of Sialis infumata Newm.

Several pairs were observed copulating and in each instance the procedure was the same. The female stood motionless, her head usually pointing toward the tip of the stem upon which she rested. The male approached from behind and crawled under the wings of the female until his head was even with her abdomen. He then curled his abdomen over the left side of his head, pushing aside his left pair of wings. As soon as the body of the male was in the shape of a letter U the tip of his abdomen came in contact with that of the female and copulation was completed. The male remained in this position for five or ten seconds, then straightened out and started to crawl away. Usually he came back and tried to copulate with the female a second time. In other instances the female refused to copulate and crawled rapidly away from the male. Several times as many as three males were seen to be following one female and many times two males followed the same female, but none seemed to be able to copulate with her on such occasions.

Hatching Dates of Aquatic Insect Eggs

The following hatching dates are recorded from material that was being watched for parasitism at the Douglas Lake Biological

Station of the University of Michigan. Large numbers of eggs were kept in a single cage.

Insect	No. Cages	Cage Date	Hatching Date
Ranatra	10	7/1/26	7/11 to 17/26
Galerucella	2	7/1/26	7/7/26
	2	7/4/26	7/7/26
Donacia	4	7/4/26	7/7/26
	3	7/5/26	7/17/26
	1	7/6/26	No emergence
Hydrophilus	2	7/4/26	7/7/26
	2	7/5/26	7/9/26
	2	7/8/26	7/17/26
Bothrothus	2	7/8/26	7/17/26
Notonectidae	4	7/8/26	7/24/26
	2	7/8/26	8/4/26
Zygoptera	2	7/8/26	7/24/26
	2	7/8/26	8/4/26
	1	7/26/26	No emergence
Anisoptera	2	7/8/26	No emergence
Gyrinidae	2	7/8/26	7/9/26
	4	7/22/26	7/22/26
	2	7/26/26	7/30/26
	2	7/4/26	7/17/26
Triaenodes	10	7/1/26	7/5/26
	2	7/1/26	7/7/26
Gerridae	6	7/22/26	7/24/26
	10	7/26/26	7/29/26
	2	7/26/26	7/30/26
	6	7/30/26	8/9/26
	1	8/2/26	8/10/26

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(For *Tiphodytes gerriphagus* (Marchal))

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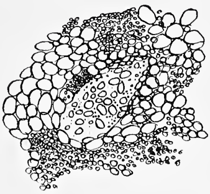
PLATE III

Fig. 1. An egg of *Trichogramma minutum* Riley among the yolk disclets of the host egg, *Sialis infumata* Newm.
Fig. 2. Eggs of *T. minutum* R.
Fig. 3. Antenna of abberrant form of *T. minutum* Riley.
Fig. 4. Emergence holes (round holes) of *T. minutum* Riley and hatching slits of *S. infumata* N.
Fig. 5. Gatenby's fig. 2.
Fig. 6. Gatenby's fig. 8.
Fig. 7. Gatenby's fig. 3.
Fig. 8. *Trichogramma minutum* R. copulating.



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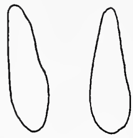

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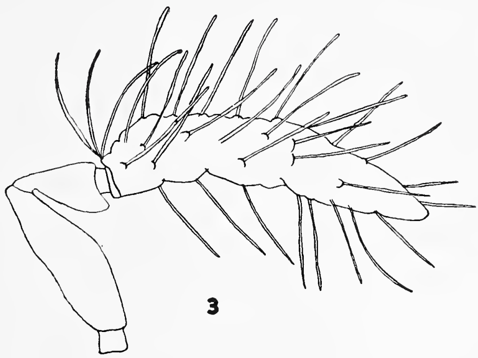

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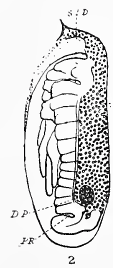

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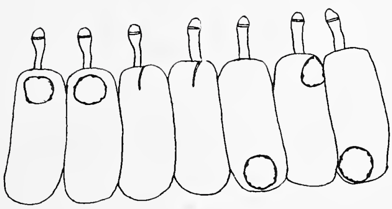

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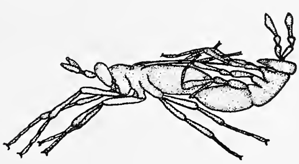

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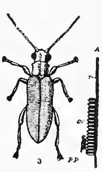

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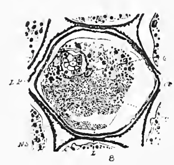

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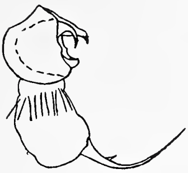
PLATE IV

Tiphodytes gerriphagus (Marchal)

Fig. 1. Newly hatched first instar larva.
Fig. 2. First instar almost ready to molt.
Fig. 3. Egg of *T. gerriphagus* (M.).
Fig. 4. Ventral view of second instar larva.
Fig. 5. Larger instar larva eating a smaller one.
Fig. 6. Third instar attacked by a first instar larva.



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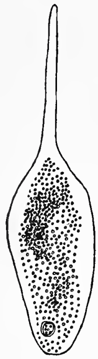

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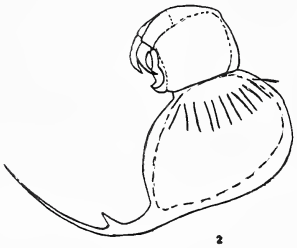

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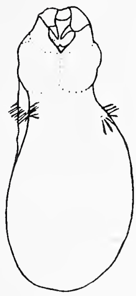

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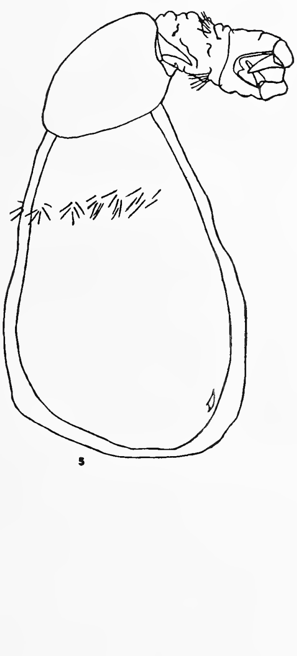

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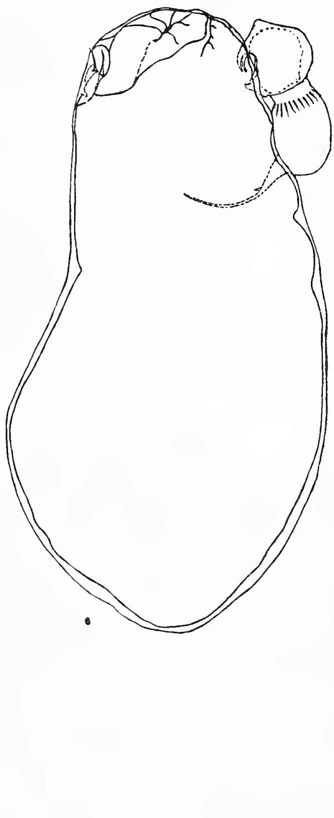

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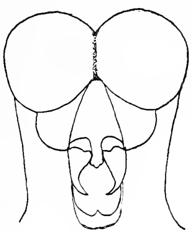
PLATE V

Tiphodytes gerriphagus (Marchal)

Fig. 1. A dorsal-ventral view of the cephalic region of second instar larva.
Fig. 2. A non-typical second instar larva.
Fig. 3. Abdomen of male with about one-third of penis extruded.
Fig. 4. Lateral view of cephalic region of second instar larva.
Fig. 5. Abdomen of female with ovipositor extruded full length.
Fig. 6. Lateral-ventral view of second instar larva.



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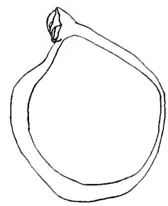

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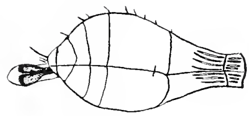

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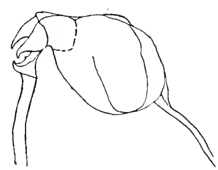

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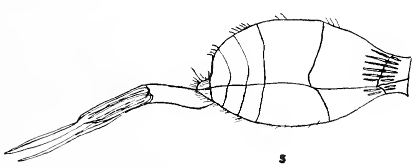

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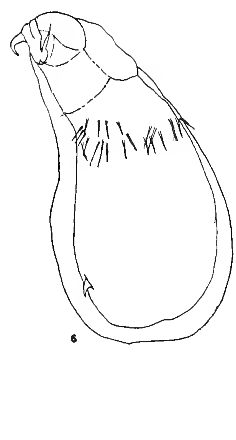

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A CONTRIBUTION TO THE KNOWLEDGE OF THE LIFE HISTORY OF BREMUS BIMACULATUS (CRESSON) (HYM.)*

By Theodore H. Frison

Illinois State Natural History Survey, Urbana, Illinois

A. Introduction

If I may quote from the late F. W. L. Sladen (1912), "Everybody knows the burly, good-natured bumblebee." It is because of this fact that the main features of the life history of the bumblebee have occupied for a long time a prominent place in our nature-story books and general entomological texts. Many early students of insect life, such as Goedart (1682), Swammerdam (1737), Réaumur (1742), Geoffroy (1798), and Hüber (1801), have pointed out some of the more salient features of the life of these conspicuous social bees. Other details, however, have been only recently correctly observed and interpreted, and much additional information still awaits the investigator.

* Contribution from the Entomological Laboratories of the University of Illinois, No. 123. Extract number seven from a thesis presented to the Faculty of the Graduate School of the University of Illinois in May, 1923, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

The present paper is the result of the study of various aspects of the biology of *Bremus bimaculatus* (Cresson), as revealed by the study of nests of this species which were established under both natural and controlled conditions. In 1917, the writer had under close observation five colonies of this species. Two of these colonies were started by *bimaculatus* queens in confinement, two obtained from artificial domiciles placed in the woods to which queens had been attracted, and one was found under a brush pile in the woods. In 1919, I had under observation three colonies; two of which were started by queens under confinement, and one a natural colony obtained from under an old log in the woods. In 1919, several additional colonies were also started under controlled conditions, but since these colonies were used for experiments which interfered with their normal development, nothing would be gained by a presentation of their history. Because of the data secured in 1917 and 1919, detailed studies of this species were not made in 1920, and the three colonies successfully started under controlled conditions were used for experimental purposes.

Since this is the first of a series of articles dealing with the biology of various species of bumblebees, a brief statement is necessary concerning my methods of keeping records, manipulations in general, etc. Full details regarding the attracting of queens in spring to artificial domiciles, the fertilization and hibernation of queen bumblebees, and the rearing of colonies under controlled conditions have already been published (Frison, 1926a, 1927a, and 1927b) and need not be reviewed here.

The keeping of exact records of all details of colony management, economy and manipulation, to say nothing of following each life cycle from the egg to the adult stage, is no easy matter and the writer has found it desirable to keep two different sets of notes. When a nest of bumblebees was removed from its natural or original location, when started by confining the queens, or when removed from a domicile, it was given a number, as "Exp. 29, 1917." Under the experiment number on small note-size paper were recorded all of my observations concerning the details of the care of the young, manipulation of pollen, number of individuals of each sex in the nest, parasites, inquilines, etc. All notes so recorded pertaining to each colony were kept together and arranged according to date and experiment number. In addition, a very elastic and detailed record system was required to get accurate comparative records of the duration of the various stages as well as other consecutive and progressive developments. It must be remembered that the bumblebee comb undergoes a constant change in size and form, so that to rely upon one's memory for the exact position of each egg, larva, or cocoon (there may be several hundred of them in a nest) is out of the question, even in the case of a single colony. Therefore, I found it necessary to draw a diagrammatic outline of the comb every few days, and then to relabel all its component parts. Drawings proved to be much better for this purpose than photographs. However, photographs of the comb were secured from time to time because they gave a much better conception of some things, such as a nest in its entirety, than was possible by a diagrammatic drawing or a verbal description. Each egg-mass was designated by a capital letter as soon as discovered, the numbers being successively assigned, depending upon the date when the eggs were first laid. Each egg was then given an additional Arabic number to distinguish it from the other eggs in the same mass, for example: "XIV, 5." The number first used to designate an egg-mass and eggs was retained for all following stages. In labeling the diagrammatic drawings of the comb, it was found desirable to label uniformly the eggs in one color, the larvae in another, and so on.

In order to simplify the tabulation of the data relating to the various stages of development, the following abbreviations were used:

Ec	= empty egg cell	Ae	= adult emerging
E	= egg	A	= adult
Me	= many eggs	A♂	= adult male
L	= larva	A♀	= adult queen
Ls	= larva spinning	A☿	= adult worker
Ml	= many larvae	D ?	= death from unknown cause
C	= cocoon	Dp	= death by parasitism
Cl	= cocoon containing larva	Da	= accidental death
Cp	= cocoon containing pupa	N	= no observations
P	= pupa	R	= removed

It was not possible for me to examine colonies every day from early spring until fall; accordingly, gaps may occur between observations. It requires considerable time to examine all the cells of even a small colony, and with a large number of colonies of varying size under scrutiny, the lack of observation on certain days is self-explanatory. Attention must be directed, also, to instances in which my tables might prove misleading. For instance, adults emerging from cocoons are recorded when first found in the nest.

This may be the very day of emergence, or three or four days later, depending upon the time of the last observation. The same state of affairs applies to all other stages. Sometimes eggs were laid just after the comb was examined and, therefore, these eggs or resulting larvae escaped being recorded until the time of the next examination. Such unavoidable conditions are responsible for many apparent discrepancies. In spite of the above sources of error, however, the average of the most complete records will give a good approximation of the length of the various stages.

The question may be asked as to how I knew certain castes emerged from cocoons found empty on a given date. A knowledge of the number of cocoons from which adults had emerged since the time of last observation, together with a count of the adults of all castes in the nest and the size of the cocoons, affords the solution. In some cases it was possible to decide almost exactly when some of these adults emerged, because of their color and the condition of their cocoons. During certain periods of the life of a colony so many eggs were found in adjacent cells at one time that a strict enumeration of them is not always given in the tables included in this paper even though a record was made of them at the time. Since nearly all examinations of this character were made between six in the morning and at least by six in the evening, the hour given in the table is usually not ambiguous as to whether it denotes morning or afternoon. In all those cases where the time may be incorrectly interpreted, a. m. or p. m. is inserted.

When one is working with bumblebees it is frequently necessary to remove them from one box and place them in another. I have found that the safest way to handle live bumblebees is to pick them up with forceps, grasping preferably one of the hind legs. The hind legs are strong and less likely to be injured than other easily grasped parts of the body. When examining a nest of bumblebees in one of my observation boxes it was often necessary to remove all the workers. In such a case the workers were temporarily confined in large bottles while the examination was being made and dumped back into the nest again when it was over. Bottles used for such a purpose should be kept perfectly dry to avoid matting down and soiling the pubescence of the bees and care should be taken to use the same bottles for the members of the same colony. If the bottles are mixed, the bees are very apt to acquire a foreign "aura," which will cause the bees to fight when again returned to their nest.

When two queens are placed in the same nest, they may be readily differentiated by clipping a notch in the wing margin of one of them. A few more "Don'ts" for investigators should be added. While examining a nest one must be careful not to breathe on the nest, for the odor of the human breath quickly agitates the bees. A nest should never be jarred prior to examination for it may throw the bees into a state of wild commotion and render observations difficult. The nests should always be kept in a place not exposed to extreme heat or cold; a room with a temperature of about 75° F. being preferable. Bright light is obnoxious to bumblebees when in the nest and it also has a deleterious effect on the eggs, larvae and pupae. When photographing a nest from which the bees have been removed, the bees should be replaced as soon as possible and the comb not exposed to intense light any more than is absolutely necessary. Bumblebees are not so vicious as they are commonly supposed to be and with due precaution in handling a colony the danger of being stung may be greatly minimized. I have had colonies under observation where it was not necessary to remove the queen when making an examination of the cells and where her majesty could be stroked with impunity.

B. Specific Life History Studies

1. Experiment 1, 1917

This experiment was begun on April 17, 1917, with two queens of *B. bimaculatus* which I collected in the University Woods. On April 20, both queens showed a decided interest in the artificial nest and on the next day they began the construction of the first egg cells, each of which measured about three millimeters in diameter. At the time of the next examination, April 22, eight or nine eggs were found in this lot, each egg seemingly occupying a separate cell. Fear of disturbing the queens prevented a close scrutiny of the contents of the cells at this time. In addition to the cells containing the eggs, three new empty cells were present on the pollen lump. One difference in the reaction to the same stimulus of the two queens, both of which were interested in the nest, was noted on April 24. Whenever the box containing the nest was jarred, the smaller of the two queens rushed excitedly from the nest. The larger queen, however, insisted on clinging to the pollen lump, or falling over on her back threatened to attack every object thrust towards her, as shown by suggestive movements of her mandibles, legs and the tip of her abdomen. It may be added that the exudation of wax gave the queens a "sweaty" appearance, which was quite noticeable during this early period in the growth of the comb.

More eggs were laid on April 24, and the bees began to store honey in the honey pot. In this particular experiment I never put any honey in the honey pot and its presence there proves the queens transferred it from a tin container. Such a procedure, unnecessary in the artificial nest, illustrates the fixity of an instinct which is necessary under natural conditions. An examination of the comb on April 27, revealed that some if not all of the eggs had now produced larvae.

During the last few days of April, the bees continued to store honey in the artificial honey pot and in a smaller one of their own making. Additional bits of pollen that I supplied to them from time to time were incorporated within a short time into the body of the incipient comb. By May 1, more eggs were laid. This time, however, more than one egg was laid in a cell, for in my notes I have recorded the accidental crushing of several eggs which occupied the same cell. For some reason the first larvae did not develop normally and the comb scarcely increased in size during the period from May 1 to May 15. By May 15, a wax-pollen roof had been made over the comb and a pillar of the same material connected the comb with the roof of the nest. The groove in which one of the queens rested while on the comb was also conspicuous on this date. Three days later, the comb began to swell—an indication of developing larvae—and more eggs were laid by the persevering queen.

On May 25, I captured in the University Woods two workers of *bimaculatus* which several hours later I introduced into this nest. These workers were not attacked by the queens and by the next day seemed to be quite at home in their new quarters. On May 27, both the workers were observed brooding on the comb and helping with the work. Several days later, three new honey pots were found in the nest, which I think were partially or even entirely the work of these introduced workers. I introduced another worker into the nest several days later and it was kindly received. A peculiar habit of a worker was observed on the 1st of June. When disturbed this worker fell over on its back and threatened to attack any object thrust at it in a fashion similar to that already described for the queen. In addition to this curious performance, a liquid was ejected for a considerable distance from the apex of the abdomen. Plath (1923), also, has observed this species resort to this "method of warfare."

On June 11, I found dead in a corner of the box one of the queens and the worker last introduced in the nest. Evidently, they had been dragged there by the bees. The death of this queen and worker, singularly, came at the time when the comb first looked as though the larvae it contained might be successfully reared. The day before this, both of the queens and the three workers appeared to be on the most friendly terms. This latter fact would suggest that the bees died naturally or from disease, but I am inclined to the belief that they were killed either by the queen or by the workers first introduced into the nest. Because the bees were so closely confined, I found it good policy to put a little pollen into the nest every day or so, and the incorporation of this pollen into the comb served to keep the captive bees busy. On June 15, there were ten honey pots in the nest and I believe that the number, large for this time of the year, was the direct result of this management. On this same date I began to keep a record of the development of the individual larvae and continued this record until this experiment was closed on July 25. These data are given in Table 1. I may add that on July 4 I placed in this colony two more workers of the same species which were removed from Experiment 5, 1917. These workers were received at first with considerable apprehension by the workers already in the nest, but fortunately this unfriendliness soon disappeared. The first cocoons were spun on July 10 and the larvae in them pupated on July 12. Four males eventually emerged from these cocoons, one appearing on July 19, one on July 21, and two others on July 25. It is very probable that these males were all the product of worker eggs, laid by the workers introduced into the nest during the later part of May.

2. Experiment 5, 1917

This colony was started on April 27, by placing together in an artificial nest two queens collected in the University Woods on April 29. The very next day the queens began to display an interest in the nest. This led to the construction of an egg cell on May 1. The following day the cell was closed over and contained an egg or eggs. On this same date, May 2, the bees built, in addition to the artificial one supplied them, a honey pot three-eighths inches in height and two-eighths inches in diameter. This was placed about three-quarters of an inch from the pollen lump and eggs. On May 14, it was evident that the comb contained moderately well developed larvae and the groove in which one of the queens rested while brooding over them was very conspicuous. This same day I introduced into the nest a worker which I captured in the University Woods and it

TABLE 1

Experiment 1, 1917 *Bremus bimaculatus* (Cresson)

June																
Day Hour	15 9	16 9	17 9	18 9	19 9	20 8	21 7	22 9	23 8	24 5	25 1	26 7	27 7	28 7	29 7	30 7
A, 1	L	L	Ls	L	L	C1	C	C	C	C	C	D?				
B, 1	L	L	L	Ls	L	L	D?									
C, 1	L	L	L	Ls	L	L	L	L	D?							
D, 1								E	E	E	E	E?	L	L	L	L
2								E	E	E	E	E?	L	D?		
3								E	E	E	E	D?				
4								E	E	E	E	D?				
5								E	E	E	E	D?				
E, 1									E	E	E	E	E	?	L	L
2										E	E	E	E	?	L	D?
3											E	E	E	E	E	D?
4											E	E	E	E	E	L
5											E	E	E	E	E	L
6											E	E	E	E	E	L
7											E	E	E	E	E	L

TABLE 1

Experiment 1, 1917 *Bremus bimaculatus* (Cresson)

July																
Day Hour	2 10	3 12	4 12	5 6pm	6 6pm	7 6pm	8 9	9 12	10 12	11 8	12 8	13 6pm	14 1	15 10	16 5	17 5
E, 1	L	L	L	L	L	L	L	L	C1	C1	Cp	P	P	P	P	P
4	L	L	L	L	L	L	L	L	L	L	L	Ls	C1	C	P	P
5	L	L	L	L	L	L	L	L	L	L	L	L	C1	C	P	P
6	L	L	L	L	L	L	L	L	L	L	L	L	C1	C	P	P
7	L	L	D?													
D, 1	L	L	L	L	L	L	Ls	C1	C1	Cp	P	P	P	P	P	P

TABLE 1

Experiment 1, 1917 *Bremus bimaculatus* (Cresson)

July								
Day Hour	1 18	9 19	1 20	1 21	9 22	— 23	— 24	— 25
D, 1	P	A ♂						
E, 1	P	P	P	A ♂				
4	P	P	P	P	P	P	P	A ♂
5	P	P	P	P	P	P	P	A ♂
6	P	P	P	D?				

was kindly received. It was quite evident by May 19, that one queen was more attached to the developing brood than the other. Correlated with this attachment for the brood on the part of one queen, there arose a violent animosity towards the other queen, and I was obliged to remove the latter on May 22 to prevent serious fighting. The first larvae began to spin their cocoons on May 19 and the wax was all removed from them by the next day. As the development of the various castes in this nest is shown in detail in table 2 only a few remarks concerning them need be given here.

As the comb developed more honey pots were made and on May 23 two honey pots were in position alongside the original artificial one. On the 25th of May, I introduced into the nest three workers which I caught in the University Woods. These were received at first with suspicion and the queen made several rushes at them. When thus attacked, the workers drew their legs and wings close to the body and lay motionless. This unfriendliness, however, soon diminished and all the bees were apparently on good terms the next day. On May 27, one of these last-introduced workers was found dead, but the other two were busily engaged in working on the comb. The first workers emerged on May 28 and thereafter others continued to emerge until June 30. Figure 1 shows the appearance of the comb on May 31 and one of the workers which has just emerged and not as yet acquired its normal coloring.

The first empty cocoons were almost immediately utilized by the bees and two days after the adults had emerged they were found filled with honey. The cocoons thus adapted for the storage of honey were partially capped over on top with a lid of wax-pollen composition. It is also interesting to note that by the end of May the egg cells were made almost invariably on the tops of or in depressions between cocoons. After the appearance of the workers, the queen became more attached to the nest than ever and she could scarcely be induced to leave the comb. The bees were allowed their freedom at eight o'clock in the morning on June 1 and the first worker left about ten minutes afterwards. At one o'clock on this same day I saw a worker return to the nest with pollen on its corbicula, proving that it did not take a worker long to acquaint itself with the location of the nest and to adapt itself to the collecting of pollen.

On June 6, I found as many as five eggs in a single cell. It was about this time, also, that the queen first began to show the effects of her labors, as evidenced by the loss of pubescence on her thorax and dorsal abdominal segments. One peculiarity of the queen, when brooding on the comb, was to devote most of her attention to the cells containing eggs and small larvae. By the middle of June the nest always contained about twenty workers and others were undoubtedly in the field when the nest was examined. On June 15, it was discovered that the brood was suffering from the attacks of a parasite, *Brachycoma sarcophagina* (Towns.). Measures were immediately adopted to check the increase of these parasites; a matter of removing all the larvae and puparia of this dipteron which were found in the nest. The first male bumblebees emerged on June 18, and the queens began to appear on July 3.

The largest number of workers that I ever found in this nest at one time was on June 24, when I counted thirty-one of them. During June the workers were exceedingly vicious and on several occasions I narrowly missed getting stung by them. They were, however, not so prone to attack one as the workers of *B. impatiens* (Cresson). Frequently when I tried to remove the workers to examine the nest, they would fall over on their backs and squirt a watery substance (waste products) at me from their anus. It should be mentioned that with the increase in the number of the workers, there was also a corresponding increase in the average size of the workers. In other words, many of the workers that emerged during the middle and last of June were very large compared with those that had emerged earlier in the season. When the nest was jarred, the larger workers were generally the first ones to leave the comb and to fly out to attack the evil-doer.

On July 4, the comb consisted of at least fifty larvae and ten egg masses of various sizes. Some of these egg masses contained as many as seven or eight egg cells. Two days later, I was astonished to observe that the new queens were producing wax. The detailed record of emerging adults was discontinued on July 7. On July 12, I saw several bees, which I am certain were young queens, enter the nest with pollen on their corbicula. Evidently, the males soon left the parent nest after emerging, for no males were in the nest on July 17 which were there at the time of the last observation. I am certain of this fact, because when new males and queens appeared, I marked them by clipping small triangular notches in the hind margins of one of the fore-wings.

The last of July the old, battered mother queen died and she was dragged by her offspring to a remote corner of the nest. On August 3, I introduced a queen of *Psithyrus variabilis* (Cresson) into the nest and she was accepted without any opposition. A couple of days later I saw her flying around the entrance to the nest and on August 5 she left the nest never to return. The nest contained at this time eleven workers and eleven young queens. By the middle of August, the nest had continued to decline until but four workers and two new queens remained. At this stage of affairs I introduced an old queen of *B. americanorum* (Fabricius) into the nest and she was immediately attacked by the workers. The attacks, however, soon ceased and on August 17 this queen completely dominated the nest. Though this queen laid eggs and jealously guarded them from the workers, the larvae which emerged did not develop properly. This was probably due to the lateness of the season and to the care they received. It should be added that a new queen of *bimaculatus* emerged on August 27 and that she was not molested by the queen of *americanorum* then ruling the nest. On September 1, I found this young queen of *bimaculatus* dead, but could not determine the cause of her death. Several males of *bimaculatus* emerged between the sixth and eighth of September, and I am sure they were the product of worker eggs. Two workers of *bimaculatus* were alive on September 8, but when the nest was next examined on September 13 the history of this colony had come to an end.

3. Experiment 11, 1917

This colony was removed on May 26 from a domicile which was ''planted'' at the base of an old tree stump in the University Woods on April 17. On April 25, I discovered that this domicile was inhabited by a bumblebee queen, but refrained from removing the domicile at this time in order that the colony might get a good start. At the time of removal, the colony consisted of the mother queen, seven small workers, two egg masses of five eggs each, thirteen larvae, fifteen cocoons and one empty egg cell. Although the workers were all small, a considerable variation in size existed among them. As soon as the nest was removed from the domicile and placed in one of my observation boxes, the writer began a detailed study of the duration of the various immature stages, the data of which are given in Table 3. In addition to this study, I spent considerable time in observing the habits of the adult bees.

It is well to mention here that I closed up the entrance to the nest several hours before digging up the domicile. This prevented any workers from leaving the nest, and by catching those that later returned I was able to bring back to the laboratory all of the first

	May									June							
Day	1	2	13	19	22	24	28	30	31	1	2	3	4	5	6	7	8
Hour	3	3	N	1	10	4	5	8	10	8	10	9	11	12	9	9	10
A, 1	Ec	E	L	Cl	C	C	A☿										
2		E	L	Cl	C	C	A☿										
3		E	L	Cl	C	C	A☿										
4		E	L	Cl	C	C	A☿										
5		E	L	Cl	C	C	C	C	A☿								
B, 1						E?	L	L	L	Ls	Ls	Cl	Cl	Cp	P	P	P
2						E?	L	L	L	Ls	Ls	Cl	Cl	Cp	P	P	P
3						E?	L	L	L	L	Ls	Cl	Cl	Cp	P	P	P
4						E?	L	L	L	L	Ls	Cl	Cl	Cp	P	P	P
5						E?	L	L	L	L	Ls	Cl	Cl	Cp	P	P	P
6						E?	L	L	L	L	Ls	Cl	Cl	Cp	P	P	P
7						E?	L	L	L	L	Ls	Cl	Cl	Cp	P	P	P
8						E?	L	L	L	L	Ls	Cl	Cl	Cp	P	P	P
9						E?	L	L	L	L	Ls	Cl	Cl	Cp	P	P	P
10						E?	L	L	L	L	Ls	Cl	Cl	Cp	P	P	P
11						E?	L	L	L	L	Ls	Cl	Cl	Cp	P	P	P
C, 1								L	L	L	L	L	Ls	L	L	Cl	Cl
D, 1								L	L	L	L	L	L	Ls	L	L	L
2								L	L	L	L	L	L	Ls	L	L	L
3								L	L	L	D?						
E, 1								L	L	L	L	L	L	Ls	L	Cl	Cl
2								L	L	L	L	L	L	Ls	L	Cl	Cl
3								L	L	L	L	L	L	Ls	L	Cl	Cl
4								L	L	L	L	D?					
F, 1								L	L	L	L	L	Ls	L	L	L	L
2								L	L	L	L	L	Ls	L	L	L	L
3								L	L	L	L	L	Ls	L	L	L	L
4								L	L	L	L	L	Ls	L	L	L	L
5								L	L	L	L	L	Ls	L	L	L	L
6								L	L	L	L	L	Ls	L	L	L	L
7								L	L	L	L	L	Ls	L	L	L	L
G, 1								E	E	L	L	L	L	Ls	L	L	L
2								E	E	L	L	L	L	Ls	L	L	L
3								E	E	L	L	L	L	Ls	L	L	L
4								E	E	L	L	L	L	Ls	L	L	L
5								E	E	L	L	L	L	Ls	L	L	L
6								E	E	L	L	L	L	Ls	L	L	L
H, 1											E	E	E	E	E	L	L
2											E	E	E	E	E	L	L
3											E	E	E	E	E	L	L
4											E	E	E	E	E	L	L
I, 1											Ec	E	E	E	E	E	L
2												E	E	E	E	E	L
3												E	E	E	E	E	L
4												E	E	E	E	E	L
J, 1												E	E	E	E	E	L
2												E	E	E	E	E	L
3												E	E	E	E	E	L
4												E	E	E	E	E	L

TABLE 2

Experiment 5, 1917 *Bremus bimaculatus* (Cresson)

June																		
Day Hour	3 9	4 11	5 12	6 9	7 9	8 10	9 10	10 10	11 9	12 10	13 9	14 9	15 9	16 9	17 10	18 10	19 9	20 8
J, 5	E	E	E	E	E	L	L	L	L	L	L	Ls	L	L	L	L	L	Cl
6	E	E	E	E	E	L	L	L	L	L	L	Ls	L	L	L	Cl	Cl	Dp
B, 1							P	P	P	P	P	A ☿						
2							P	P	P	P	P	P	A ☿					
3							P	P	P	P	P	P	A ☿					
4							P	P	P	P	P	A ☿						
5							P	P	P	P	A ☿							
6							P	P	P	P	A ☿							
7							P	P	P	P	A ☿							
8							P	P	P	A ☿								
9							P	P	P	A ☿								
10							P	P	P	A ☿								
11							P	P	P	A ☿								
C, 1							Cl	Cp	P	P	P	P	P	P	A ☿			
D, 1							L	L	L	L	Cl	C	P	P	P	P	P	B?
2							L	L	L	L	Cl	C	P	P	Dp			
E, 1							Cl	Cp	P	P	P	P	A ☿					
2							Cl	Cp	P	P	P	P	P	A ☿				
3							Cp	P	P	P	P	P	P	A ☿				
F, 1							L	L	L	L	Cl	Cl	Dp					
2							L	L	L	L	Cl	Cl	Dp					
3							L	Cl	Cl	Cp	P	P	P	P	P	P	A ☿	
4							L	Cl	Cl	Cp	P	P	P	P	P	P	A ☿	
5							Cl	Cl	Cl	Cp	P	P	P	P	P	P	A ♂	
6							Cl	Cl	Cl	Cp	P	P	P	P	P	A ♂		
7							Cl	Cl	Cl	Cp	P	P	P	P	P	A ♂		
G, 1							Cl	Cl	Cp	P	P	P	P	A ☿				
2							Cl	Cl	Cp	P	P	P	P	P	D?			
3							Cl	Cl	Cp	P	P	P	P	P	D?			
4							Cl	Cl	Cp	P	P	P	P	P	A ☿			
5							L	Cl	Cl	Cp	P	P	P	P	P	A ☿		
6							L	Cl	Cl	Cp	P	P	P	P	P	A ☿		
H, 1							L	L	L	L	L	Ls	L	L	L	L	L	L
2							L	L	L	L	L	Ls	L	L	L	L	L	L
3							L	L	L	L	L	Ls	L	L	L	L	L	L
4							L	L	L	L	L	Ls	L	L	L	L	L	L
I, 1							L	L	L	L	Ls	Cl	Cl	Dp				
2							L	L	L	L	L	Ls	Cl	Dp				
3							L	L	L	L	L	Ls	Cl	Dp				
4							L	L	L	L	L	D?						
J, 1							L	L	L	L	L	Ls	L	L	L	L	L	Cl
2							L	L	L	L	L	Ls	L	L	L	L	L	Cl
3							L	L	L	L	L	Ls	L	L	L	L	L	Cl
4							L	L	L	L	L	Ls	L	L	L	L	L	L
K, 1							E	E	E	E	E	L	L	L	L	L	Ls	L
2							E	E	E	E	E	L	L	L	L	L	Ls	L
3							E	E	E	E	E	L	L	L	L	L	Ls	L
4							E	E	E	E	E	L	L	L	L	L	Ls	L
L, 1			E	E	E	E	L	L	L	L	L	Ls	L	L	L	Cl	Dp	
2			E	E	E	E	L	L	L	L	L	Ls	L	L	L	Cl	Cl	Dp

TABLE 2

Experiment 5, 1917 — *Bremus bimaculatus* (Cresson)

	June																	
Day	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Hour	12	9	9	10	10	10	9	10	9	9	9	9	10	10	9	8	8	9
L, 3	E	E	E	E	L	L	L	L	L	Ls	L	L	L	Cl	Cl	Cl	Dp	
4	E	E	E	E	L	L	L	L	L	Ls	L	L	L	L	Cl	Cl	Dp	
5	E	E	E	E	L	L	L	L	L	Ls	L	L	L	L	Cl	Cl	C	C
6	E	E	E	E	L	L	L	L	L	Ls	L	L	L	L	Cl	Cl	Dp	C
7	E	E	E	E	L	L	L	L	L	Ls	L	L	L	L	Cl	Cl	Cl	C
M, 1	E	E	E	E	E	L	L	L	L	Ls	L	L	L	L	L	L	Cl	Dp
2	E	E	E	E	E	L	L	L	L	Ls	L	L	L	L	L	L	Cl	Dp
3	E	E	E	E	E	L	L	L	L	Ls	L	L	L	L	L	L	Cl	Dp
4	E	E	E	E	E	L	L	L	L	Ls	L	L	L	L	L	L	Cl	Dp
5	E	E	E	E	E	L	L	L	L	Ls	L	L	L	L	L	L	Cl	Dp
6	E	E	E	E	E	L	L	L	L	Ls	L	L	L	L	L	L	Cl	Dp
7	E	E	E	E	E	L	L	L	L	Ls	L	L	L	L	L	L	Cl	Dp
8	E	E	E	E	E	L	L	L	L	Ls	L	L	L	L	L	L	Cl	Dp
9	E	E	E	E	E	L	L	L	L	Ls	L	L	L	L	L	L	Cl	Dp
N, 1		E	E	E	E	L	L	L	L	L	Ls	L	L	L	L	L	L	Cl
2		E	E	E	E	L	L	L	L	L	Ls	L	L	L	L	L	L	L
3		E	E	E	E	L	L	L	L	L	Ls	L	L	L	L	L	L	L
4		E	E	E	E	L	L	L	L	L	Ls	L	L	L	L	L	L	L
5		E	E	E	E	L	L	L	L	L	Ls	L	L	L	L	L	L	Cl
6		E	E	E	E	L	L	L	L	L	Ls	L	L	L	L	L	L	L
7		E	E	E	E	L	L	L	L	L	Ls	L	L	L	L	L	L	L
8		E	E	E	E	L	L	L	L	L	Ls	L	L	L	L	L	L	L
9		E	E	E	E	L	L	L	L	L	Ls	L	L	L	L	L	L	D?
10		E	E	E	E	L	L	L	L	L	Ls	L	L	L	L	L	L	D?
O, 1						E	E	E	E	E	L	L	L	L	Ls	L	L	L
2						E	E	E	E	E	L	L	L	L	Ls	L	L	L
3						E	E	E	E	E	L	L	L	L	Ls	L	L	L
4						E	E	E	E	E	L	L	L	L	Ls	L	D?	
5						E	E	E	E	E	L	L	L	L	Ls	L	D?	
P, 1							Ec	E	E	E	E	E	L	L	Ls	L	L	L
2								E	E	E	E	E	L	L	Ls	L	L	L
3								E	E	E	E	E	L	L	Ls	L	L	L
4								E	E	E	E	E	L	L	Ls	L	L	L
Q, 1									E	E	E	E	E	L	L	L	Ls	L
2									E	E	E	E	E	L	L	L	Ls	L
3									E	E	E	E	E	L	L	L	Ls	L
R, 1									Ec	E	E	E	E	E	L	L	L	L
2										E	E	E	E	E	L	L	L	L
3										E	E	E	E	E	L	L	L	L
S, 1													E	E	E	E	E	L
2													E	E	E	E	E	L
3													E	E	E	E	E	L
4													E	E	E	E	E	L
5													E	E	E	E	E	L
6													E	E	E	E	E	L
7													Ec	E	E	E	E	E
8														E	E	E	E	E

TABLE 2

Experiment 5, 1917 *Bremus bimaculatus* (Cresson)

	June													July				
Day	18	19	20	21	22	23	24	25	26	27	28	29	30	2	3	4	5	6
Hour	10	9	8	8	9	9	5am	5pm	7	7	7	7	7	8	7	7	12	7
T, 1	Ec	Ec	E	E	E	E	E	L	L	L	L	L	L	N	P	P	P	P
2			E	E	E	E	E	L	L	L	L	L	L	N	Cl	P	P	P
3			E	E	E	E	E	L	L	L	L	L	L	N	Cl	P	P	P
4			E	E	E	E	E	L	L	L	L	L	L	N	Cl	P	P	P
D, 1				P	P	D?												
H, 1				Cl	C	P	P	P	P	P	P	P	P	A?				
2				Cl	C	Dp												
3				Cl	Dp													
4				Cl	C	Dp												
J, 1				Dp														
2				Cl	Dp													
3				Cl	Cl	C	Cp	P	P	P	P	P	P	P	P	A ♀		
4				Cl	Cl	C	Cp	P	P	P	P	P	P	P	P	A ♀		
5				Dp														
K, 1				L	Cl	Dp												
2				L	Cl	Dp												
3				Dp														
4				Dp														
L, 5						C	C	C	C	P	P	P	A ☿ (large)					
7						Dp												
N, 1						Cl	C	P	P	P	P	P	P	P	P	P	A ♀	
2						L	L	Cl	Cl	Cp	P	P	P	P	P	P	P	P
3						Cl	C	Cp	P	P	P	P	P	P	P	P	A ♀	
4						Cl	C	Cp	P	P	P	P	P	P	P	P	A ♀	
5						Cl	C	P	P	P	P	D?						
6						L	L	Cl	Cl	Cp	P	P	P	P	P	P	?	
7						Cl	Cl	Cl	P	P	P	P	P	P	P	P	P	P
8						L	Cl	Cl	Cl	P	P	P	P	P	P	P	P	A ♀
O, 1						L	Cl	Cl	Cl	P	P	P	P	P	P	P	P	A ♀
2						L	Cl	Cl	Cl	P	P	P	P	P	P	P	P	A ♀
3						L	Cl	Cl	Cl	P	P	P	P	P	P	P	P	A ♀
P, 1						Cl	Cl	Cp	P	P	P	P	P	P	A ♂			
2						Cl	Cl	Cp	P	P	P	P	P	P	P	A ♂		
3						Cl	Cl	Cp	P	P	P	P	P	P	P	A ♂		
4						Cl	Cl	Cp	P	P	P	P	P	P	A ♂			
Q, 1						L	L	Cl	Cl	Cl	P	P	P	P	P	P	A ♂	
2						L	L	Cl	Cl	Cl	P	P	P	P	P	P	A ♂	
3						D?												
R, 1						L	L	Cl	Cl	Cl	P	P	P	P	P	P	A ♂	
2						D?												
3						D?												
S, 1						L	L	L	L	L	Cl	Cl	Cl	P	P	P	D?	
2						L	L	L	L	L	L	Cl	Cl	Cl	P	P	P	P
3						L	L	L	L	D?								
4						L	L	L	L	D?								
5						L	L	L	L	D?								
6						L	L	L	L	D?								
7						L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl
8						L	L	L	L	D?								

TABLE 2

Experiment 5, 1917 *Bremus bimaculatus* (Cresson)

	July		
Day	7	8	Discontinued
Hour	5		
N, 2	A		
7	A		
S, 2	A		
7	P		
T, 1	P		
2	P		
3	P		
4	P		

progeny of the queen, a total of seven workers. This number represented all the workers thus far produced, because there were but seven empty cocoons in the nest. One of these empty cocoons contained some pollen and several others looked as if a little honey had once been placed in them. Though a honey-pot was not found isolated from the comb, there were good reasons to indicate that the first honey pot had now been merged with the comb, which at this time was about one and three-fourths inches in diameter.

By the end of May the colony contained twenty-five workers, eighteen of which had emerged since the nest was removed from the domicile. There were now, also, eight wax-pollen honey-pots, the largest of which measured fourteen millimeters in height and ten millimeters at its greatest diameter. On May 31, two new egg cells were discovered that had been built on recently spun cocoons. One of these cells contained one egg and the other contained three eggs. As in other experiments with this species, I found the workers to be very irritable and aggressive, but less so than those of *B. impatiens* (Cresson). In marked contrast to the behavior of the workers, the queen at this period in the development of the colony never displayed any inclination to leave the nest. In fact, I had to pull her from the comb when I wished to examine the cells. Figure 2 shows how the comb looked the last of May.

On the first of June, at nine o'clock in the morning, the workers were allowed their liberty and by one in the afternoon workers were observed returning to the nest with pollen on their corbicula. As observed in other colonies of this species, the workers frequently fell over on their backs when disturbed and threatened to attack objects thrust at them by movements of their mandibles, legs and abdomen. At various times during the fore part of June, I saw the workers feed the larvae. In order for the workers to do so, it was necessary for the bees to make a small hole in the center of the top of the larval cell. Through this opening a small quantity of liquid food was injected into the cell. The curled position assumed by the separate larvae in their cell, together with the cylindrical shape of their body, created an admirable cup-shaped receptacle for the holding of the liquid food. I have often seen the larvae thrust their heads into the liquid thus held and eagerly consume it.

The number of eggs laid in a single cell during the first of June varied from two to six, and the average number of eggs for the cells was four. This was an increase over the number of eggs found in the cells in the month of May. Naturally, in a cell containing more than one egg, the emerging larvae were at first protected by the same cell. The position assumed by the larvae, together with the manner in which the workers added to their cells, brought about a separation of these larvae within a few days and each larva eventually occupied its own cell in a closely connected group of larval cells. I frequently found strands of silk in the cell wall within four days after the larva had emerged from the egg. As the larva developed and the cell increased in size, this silk played an ever-increasing part in maintaining the unity of the cell. It is interesting to note that whenever a larval cell became badly broken and the larva considerably exposed to view, the workers were very apt to carry the larva into a corner of the nest where it would soon perish.

On June 6, several very large larval cells were observed—about fourteen millimeters in diameter—which consisted almost entirely of silk. The larvae in them had not completed their development, for they were still lying in a horizontal position. The workers supplied them with food through a circular hole left in the center of the upper portion of the silken larval cells. These openings were about four millimeters in diameter and between periods of feeding they were closed over with pollen, which probably was mixed with some wax.

During the second week in June, the growth of the comb continued unretarded, and Figure 3 shows the comb as it appeared on June 14. Several things were observed during this period which deserve mention here. During this period the workers produced a considerable amount of wax and it was interesting to watch them scrape the wax from their bodies, a performance which usually took place when the workers were standing on egg cells or a group of larval cells. On June 9, when watching workers making egg cells, the mother queen every now and then was observed to come around to inspect them and occasionally she worked a few moments on them herself. Several hours later I saw the queen deposit eggs in these cells. In order to lay the eggs in the cell it was necessary for the queen to take a position near the egg cells, face in an opposite direction from them and then insert the tip of her abdomen into the cell. In this particular instance, four eggs were laid, one after another, the whole performance taking less than a minute. The laying of the eggs was accompanied by a twitching of the legs and a contraction of the abdomen. In order to afford the eggs passage, the sting was extended and rested on the brim of the egg cell. On June 22, I again saw the queen laying eggs in the manner described above, except that in this instance the sting was thrust through the thin side of the egg cell. Both times after laying the eggs, the queen wheeled around and searched for the cell containing the eggs. Upon finding them (in one case she had trouble in locating the right cell) she promptly sealed them. One of the egg cells in which the queen laid eggs on June 9 measured four and one-half millimeters in length and over three millimeters in height. During June and the remainder of her life, when not laying eggs, the queen devoted most of her attention to brooding over cells containing eggs and small larvae.

Frequently workers were seen returning to the nest bringing back supplies of both pollen and honey. Several workers thus laden proceeded to regurgitate the honey in cells before they scraped the pollen from their corbicula. It was evident in many instances that the workers collected honey without gathering pollen, because several workers returned to the nest to regurgitate honey without bringing pollen with them.

The first males were found in the nest on June 18 and two days later new queens emerged. Workers still continued to emerge at this time, and as a rule they were much larger than those produced earlier in the season. In fact, I was sometimes puzzled to know whether I was watching a new queen or a very large worker. Several days after the new queens emerged, I saw them helping the workers with their work, and they frequently flew from the nest and then returned after a short time. During the first few days of their existence, many of the males returned to the nest before evening, but most of them soon deserted the nest for good. Another interesting fact about these young queens was that they produced some wax. This was first noticed on the bodies of young queens on June 28 and frequently thereafter.

On July 3, at five-thirty in the evening, the nest contained the old, partially hairless queen, twenty-seven workers, eleven males, six young queens, sixty-three larvae in various stages of development, and seven egg cells. An examination of the egg cells at this time showed that the number of eggs being laid in a single cell was diminishing; three cells contained but one egg each and only one cell contained as many as three eggs. These egg cells were all made on the tops of cocoons and in several instances I found a little pollen in the bottom of the cell. During this period in the development of the colony the pollen was stored in the especially constructed wax-pollen cells and in empty cocoons. The same may be said of the storage of honey. Several times during July young queens return to the nest with pollen on their corbicula.

After the first week in July the number of workers in the nest steadily declined, and, as all castes had been reared, a study of the developmental stages was discontinued. The largest number of workers that were ever found in this nest at one time was on July 2, when there were thirty of them. Many others were undoubtedly foraging in the field at this time and so escaped being counted. The males deserted the nest much earlier than the new queens. On July 6, six males were in the nest with clipped wings and one that had recently emerged. After this date I never found males in the nest which were over four or five days old. The queens, on the other hand, often remained in the nest for a week or more. Not only did the males in this colony leave the nest earlier than the young queens, but also most of them emerged before the majority of the queens made their appearance. The largest number of queens found in this nest at one time was on July 23, when there were forty of them, thirty-eight of which had emerged since the time of last examination on July 18. Because no detailed record was kept of the developmental stages of the many eggs laid after June 18, table 3 does not show all the adults produced by this colony. On August 3, the old mother queen disappeared from the nest and by the middle of August the comb was entirely deserted by the bees. It is also worth mentioning that the bees did not excrete their faeces on the comb, but always emptied their alimentary tract in a far corner of the nest, while standing facing the comb. Figure 4 shows a top view of the comb as it looked at the close of the season.

In order to determine whether or not these young queens would start colonies the same season that they were produced, three sub-experiments were started with queens produced by this colony. The first experiment was started on June 21 with one queen and several males. After confining the queen and males together in the manner usually employed to induce mating, I removed the queen on July 6 to a small observation box containing an artificial nest. Though I did not see a male and the queen *in coitu*, one male was seen to make frequent attempts to copulate with the queen and copulation probably took place when the jar containing them was not under observation. When the queen was first placed in the nest she became very excited—several of the honey-pots were from her previous home—and immediately took an interest in the comb. When observed the next day, however, she seemed to have lost her interest in the nest and on July 8 two workers from another colony were placed in the box with her. For twelve days after this the workers and queen lived on friendly terms with one another and spent their time remolding the honey-pots and keeping the comb in order. On July 22 the experiment became more interesting, because of the finding of a closed egg cell containing one egg and an empty egg cell on the pollen lump. The next day the second cell was closed and no doubt contained an egg or eggs. Judging from the actions of the queen at this time, and the fact that one of the workers devoted all her time to these cells during the following week, I was forced to believe that the eggs were laid by the worker most interested in the cells. I failed to discover whether these eggs hatched, but do know that they never produced large larvae.

On July 31, another queen and four workers of the same species were introduced into this nest and they were accepted after some quarreling, which took place particularly among the workers. The seventh of August, a large lump of rye flour, formed by moistening the flour with honey, was placed in the nest. To my surprise when the nest was next examined on August 11, the lump was covered with egg cells, many of which contained eggs. This time, also, it was evidently the workers which laid the eggs, and judging by the number of the eggs most of the workers participated in their laying. On August 14, some of the cells contained small larvae, but none of these ever developed to maturity. By the end of August, the queens became very lethargic and on September 3 they were placed in hibernating quarters. One of these queens was found dead on October 1, but the other one was in the best of condition on the same date. On March 2, 1918, I again dug up the remaining queen and to my delight I found that she had successfully passed the winter in the hibernaculum provided her.

The third experiment in trying to induce young queens to lay eggs and start a colony the same season in which they were produced gave the same result as the first experiment. In this experiment one queen and two workers were used. The queen was placed with males on June 21 and removed to an artificial nest on July 8. Copulation was not observed during the period from June 21 to July 8, but it may have taken place. The workers took the greatest interest in the nest and an egg cell was made by them on July 22. Two days later there was an egg in this cell, and a worker brooding over it. It is probable that the pollen lump contained another egg cell or so on this date. No larvae ever developed and the experiment was ended on July 27.

Judging by the three experiments just described, the young queens of *B. bimaculatus* in this region do not establish colonies during the same season that they are produced. There is other evidence to support this conclusion, which will be given elsewhere under a discussion of the appearance time of the various castes.

4. Experiment 13, 1917

This colony was removed on June 11 from a domicile placed in a tree stump in the University Woods on April 12. I first discovered that the domicile was inhabited on May 14, but did not examine the nest at this time. On May 26, an examination of the domicile revealed that it was inhabited by *B. bimaculatus.* At this time the nest contained three workers, but no queen. Because of the absence of the queen the domicile was not removed.

When the nest was finally removed it contained ten empty cocoons, seven workers, five cocoons containing pupae, and two small groups of larvae. This time, also, the queen was absent from the nest and the general condition of the colony indicated that she had been missing for some time. In fact, I believe that the queen disappeared previous to May 26, when the nest was first examined. There were two reasons for this belief: Firstly, ample time was allowed the queen to reappear if she was foraging on this date; and secondly, the two small larvae found in the nest on June 11 produced males, which is an indication that they were produced by workers. In an effort to maintain this colony, a queen of this same species was successfully introduced into the nest on June 11 without being molested by the workers.

TABLE 3

Experiment 11, 1917 *Bremus bimaculatus* (Cresson)

	May				June												
Day Hour	26 3	29 8	30 8	31 10	1 5	2 5	3 4	4 4	5 6pm	6 5	7 6pm	8 6pm	9 5	10 6pm	11 5	12 5	13 5
A, 1	C	A ☿															
2	C	A ☿															
3	C	A ☿															
4	C	A ☿															
5	C	A ☿															
6	C	A ☿															
B, 1			L	L	L	L	L	L	Ls	L	L	L	L	L	L	L	Cl
2			L	L	L	L	L	L	Ls	L	L	L	L	L	Cl	Cl	Cl
3			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cp	P
4			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cp	P
5			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cp	P
6			L	L	L	L	L	L	L	L	L	Cl	Cl	Cp	P	P	P
7			L	L	L	L	L	L	L	L	L	Cl	Cl	Cp	P	P	P
8			L	L	L	L	L	L	L	L	L	D?					
C, 1	C	C	A ☿														
2	C	C	A ☿														
3	C	C	A ☿														
4	C	C	C	A ☿													
D, 1	L	L	L	L	Ls	L	L	L	L	L	L	Cl	Cl	Cp	P	P	P
2	L	L	L	L	Ls	L	L	L	L	L	L	Cl	Cl	Cp	P	P	P
3	L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cp	P	P	P
4	L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cp	P	P	P
5	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl	Cp	P	P	P
6	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl	C	P	P	P
7	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl	Cp	P	P	P
8	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl	C	P	P	P
9	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl	C	P	P	P
10	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl	C	P	P	P
11	L	L	L	L	L	L	L	L	L	L	L	Da (Large larva)					
12	L	L	L	L	L	Cl	Cl	Cl	Cp	P	P	P	P	P	P	A ☿	
13	L	L	L	L	L	Cl	Cl	Cl	Cp	P	P	P	P	P	P	P	A ☿
14	L	L	L	L	L	Cl	Cl	Cl	Cp	P	P	P	P	P	A ☿		
15	L	L	L	L	L	Cl	Cl	Cl	Cp	P	P	P	P	P	P	A ☿	
16	L	L	L	L	L	Cl	Cl	Cl	Cp	P	P	P	P	P	P	P	A ☿
E, 1	Cp	A ☿															
2	Cp	A ☿															
3	Cp	A ☿															
4	Cp	A ☿															
5	Cp	A ☿															
6	Cp	A ☿															
F, 1			E	E	L	L	L	L	L	Ls	L	Cl	Cl	Cl	Cp	P	P
2			E	E	L	L	L	L	L	Ls	L	Cl	Cl	Cl	Cp	P	P
3			E	E	L	L	L	L	L	Ls	L	Cl	Cl	Cl	Cp	P	P
G, 1			E	E	L	L	L	L	L	L	L	Cl	Cl	Cl	Cp	P	P
H, 1	P	P	P	A ☿													
2	P	P	P	A ☿													
3	P	P	P	P	P	P	P	A ☿									
4	P	P	P	P	P	P	P	P	?								
5	P	P	P	P	?												
6	P	P	P	P	?												

TABLE 3

Experiment 11, 1917 *Bremus bimaculatus* (Cresson)

	May				June											
Day	26	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12
Hour	3	8	8	10	5	5	4	4	6pm	5	6pm	6pm	3	6pm	5	5
H, 7	P	P	P	P	P	P	A ☿									
8	P	P	P	P	P	P	A ☿									
9	P	P	P	P	P	P	A ☿									
I, 1			L	L	L	L	L	L	Ls	L	Cl	Da				
2			L	L	L	L	L	L	Ls	L	Cl	Cl	Cl	Cl	C	Cp
3			L	L	L	L	L	L	Ls	L	L	Cl	Cl	Cl	Cl	Cp
4			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	C?
5			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl
6			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl
7			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl
8			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl
9			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl
10			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl
J, 1			L	L	L	L	L	L	Ls	L	L	L	L	Cl	Cl	Cl
2			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl
3			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cp
4			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cp
5			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cp
6			L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cp
7			L	L	L	L	L	L	L	Cl	Cl	Cl	Cp	P	P	P
8			L	L	L	L	L	L	L	L	Cl	Cl	Cl	Cp	P	P
9			L	L	L	L	L	L	L	L	Cl	Cl	Cl	Cp	P	P
K, 1					E	E	E	E	E	?	L	L	L	L	L	Ls
2					E	E	E	E	E	?	L	L	L	L	L	L
3					E	E	E	E	E	?	L	L	L	L	L	L
4					E	E	E	E	E	?	L	L	L	L	L	L
L, 1							Ec	E	E	E	E	L	L	L	L	Ls
2								E	E	E	E	L	L	L	L	L
3								E	E	E	E	L	L	L	L	L
4								E	E	E	E	L	L	L	L	L
M, 1								E	E	E	E	E	L	L	L	L
2								E	E	E	E	E	L	L	L	L
3								E	E	E	E	E	L	L	L	L
4								E	E	E	E	E	L	L	L	L
5								E	E	E	E	E	L	L	L	L
6								E	E	E	E	E	L	L	L	L
N, 1									E	E	E	E	E	L	L	L
2									E	E	E	E	E	L	L	L
3									E	E	E	E	E	L	L	L
4									E	E	E	E	E	L	L	L
5									E	E	E	E	E	L	L	L
6									Ec	E	E	E	E	L	L	L
7										E	E	E	E	E	L	L
8										E	E	E	E	E	E	L
9										E	E	E	E	E	L	L
10										Ec	E	E	E	E	L	L
11											E	E	E	E	L	L
12											E	E	E	E	L	L

TABLE 3

Experiment 11, 1917 *Bremus bimaculatus* (Cresson)

June

Day Hour	7 6pm	8 6pm	9 3	10 6pm	11 5	12 5	13 5	14 3	15 5	16 2	17 5	18 4	19 4	20 6pm	21 5	22 3	23 5	24 —
O, 1	E	E	E	E	E	L	L	L	L	L	L	L	L	Cl	Cl	Cp	P	P
2	E	E	E	E	E	L	D?											
3	Ec	Ec	E	E	E	E	L	L	L	L	L	L	L	L	L	Cl	Cl	—
4			E	E	E	E	D?											
P, 1		E	E	E	E	E	?	L	L	Ls	L	L	L	L	L	Cl	Cl	—
2		E	E	E	E	E	?	L	L	L	L	L	L	L	Cl	Cl	Cp	P
3		E	E	E	E	E	?	L	L	L	L	L	L	L	Cl	Cl	Cp	P
4		E	E	E	E	E	?	L	L	L	L	L	D?					
5		E	E	E	E	E	?	L	L	L	L	L	D?					
Q, 1		Ec	E	E	E	E	L	L	L	Ls	L	D?						
2			E	E	E	E	L	L	L	L	L	D?						
R, 1		E	E	E	E	E	L	L	L	Ls	Ls	L	L	L	L	L	L	—
2		E	E	E	E	E	L	L	L	L	L	L	L	L	L	L	D?	
3		E	E	E	E	E	L	L	L	L	L	L	L	L	L	L	L	—
4		E	E	E	E	E	L	L	L	L	L	L	L	L	L	Cl	Cl	—
5		E	E	E	E	E	L	L	L	L	L	L	L	L	Cl	Cl	Cp	P
S, 1			E	E	E	E	E	L	L	Ls	L	L	L	L	L	L	L	—
2			E	E	E	E	E	L	L	L	L	L	L	L	L	L	L	—
3			E	E	E	E	E	L	L	L	L	L	L	L	D?			
4			E	E	E	E	E	L	L	L	L	L	L	L	D?			
5			E	E	E	E	E	L	L	L	L	L	L	L	D?			
6			E	E	E	E	E	L	L	L	L	?						
T, 1			Ec	E	E	E	E	L	L	L	Ls	L	L	L	L	Cl	Cl	—
2				E	E	E	E	L	L	L	L	L	L	L	L	L	L	—
3				E	E	E	E	E	L	L	L	L	L	L	L	L	L	—
4				E	E	E	E	E	L	L	L	L	L	L	L	L	L	—
U, 1				E	E	E	E	E	L	L	L	L	Ls	L	L	L	Cl	
2				E	E	E	E	E	L	L	L	L	L	L	L	L	Cl	—
3				E	E	E	E	E	L	L	L	L	L	Da				
4				E	E	E	E	E	L	L	L	L	L	L	L	L	L	—
5				E	E	E	E	E	L	L	L	L	L	L	L	L	L	—
6				E	E	E	E	E	L	L	L	L	L	L	L	L	L	—
V, 1				E	E	E	E	E	L	L	L	L	L	L	L	L	Cl	
2				E	E	E	E	E	L	L	L	L	L	L	L	L	Cl	
3				E	E	E	E	E	L	L	L	L	L	L	L	L	D?	
W, 1					E	E	E	E	E	L	L	L	L	L	L	L	L	
2					E	E	E	E	E	L	L	L	L	L	L	D?		
3					E	E	E	E	E	L	L	L	L	L	L	D?		
4					E	E	E	E	E	L	L	L	L	L	L	D?		
5					E	E	E	E	E	L	L	L	L	L	L	D?		
6					E	E	E	E	E	L	L	L	L	L	L	D?		
7					Ec	E	E	E	E	E	L	L	L	L	L	L	L	—
8						E	E	E	E	E	L	L	L	L	L	L	L	—
9						Ec	E	E	E	E	E	L	L	L	L	L	L	—
10						Ec	E	E	E	E	E	L	L	L	L	L	L	—
X, 1					E	E	E	E	E	L	L	L	L	L	L	L	Cl	—
2					E	E	E	E	E	L	L	L	L	L	L	L	L	—
3					E	E	E	E	E	L	L	L	L	L	L	L	L	—
4					E	E	E	E	E	L	L	L	L	L	L	L	L	—

TABLE 3

Experiment 11, 1917 *Bremus bimaculatus* (Cresson)

	June																	
Day	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Hour	5	5	5	3	5	2	5	4	4	6pm	5	3	5	N	4	5	6pm	5
Y, 1	Ec	Ec	E	E	E	E	E	L	L	L	L	L	L	?				
2			E	E	E	E	E	L	L	L	L	L	L	?				
3			E	E	E	E	E	L	L	L	L	L	L	?				
4			E	E	E	E	E	L	L	L	L	L	L	?				
5			E	E	E	E	E	L	L	L	L	L	L	?				
6			E	E	E	R												
7			E	E	E	R												
8			E	E	E	R												
Z, 1		E	E	E	E	E	Da											
2		Ec		E	E	E	Da											
Aa, 1			Ec	E	E	E	D?											
2				E	E	E	D?											
Bb, 1			E	E	E	E	D?											
B, 1				Cl	Cl	C	P	P	P	P	P	P	P	?				
2				Cp	P	P	P	P	P	P	P	A ☿ (Very large size)						
3				P	P	P	P	P	P	P	A ☿ (Large)							
4				P	P	P	P	P	P	A ☿ (Large)								
5				P	P	P	P	P	P	P	A ☿ (Large)							
6				P	P	P	A ☿											
7				P	P	P	P	A ☿										
D, 1				P	P	P	P	P	A ☿	(Very large size)								
2				P	P	P	P	P	P	A ♀								
3				P	P	P	P	P	A ☿	(Very large size)								
4				P	P	P	P	P	P	P	A ♀							
5				P	P	P	P	P	A ☿	(Very large size)								
6				P	P	P	P	P	A ☿	(Very large size)								
7				P	P	P	P	P	A ☿	(Very large size)								
8				P	P	P	P	P	P	A ♀								
9				P	P	P	P	P	A ☿	(Very large size)								
10				P	P	P	P	P	P	A ♀								
F, 1				P	P	P	A ☿											
2				P	P	P	P	A ♂										
3				P	P	P	P	A ♂										
G, 1				P	P	P	P	P	A ☿	(Very large size)								
I, 2						P	P	P	P	P	P	P	A ♀					
3						P	P	A ☿										
5						P	A ☿											
6						P	P	P	P	P	A ☿ (Very large size)							
7						P	P	P	P	A ☿ (Large size)								
8						P	P	P	P	P	A ☿ (Large size)							
9						P	P	P	P	A ☿								
10						P	P	P	?									
J, 1						P	P	P	P	P	P	A ♀						
2						P	P	P	A ☿	(Large size)								
3						P	P	P	P	A ☿ (Large size)								
4						A ☿												
5						P	A ☿											
6						P	P	A ☿										
8						P	P	P	P	A ☿								
9						P	P	A ☿										

TABLE 3

Experiment 11, 1917 *Bremus bimaculatus* (Cresson)

June																		
Day Hour	7 6pm	8 6pm	9 3	10 6pm	11 5	12 5	13 5	14 3	15 5	16 2	17 5	18 4	19 4	20 6pm	21 5	22 3	23 5	24 —
K, 1							L	L	Cl	Cl	Cl	Cl	Cp	P	P	P	P	P
2							L	L	L	Cl	Cl	C	P	P	P	P	P	P
3							L	L	L	Cl	Cl	D?						
4							L	L	L	Cl	Cl	D?						
L, 1							L	L	L	L	Cl	Cl	Cl	Cp	P	P	P	P
2							L	L	L	L	Cl	Cl	Cl	Cp	P	P	P	P
3							L	L	L	L	Cl	Cl	Cl	Cp	P	P	P	P
4							L	L	L	Cl	Cl	Cl	Cl	Cp	P	P	P	P
M, 1							Ls	L	L	L	L	Cl	Cl	Cl	Cp	P	P	P
2							L	L	L	L	L	L	L	Cl	C	C	P	P
3							L	L	L	L	L	Cl	Cl	C?	C?	Cp	P	P
4							L	L	L	L	L	Cl	Cl	C	C	Cp	P	P
5							L	L	L	L	L	L	Cl	Cl	Cl	Cp	P	P
6							L	L	L	L	L	L	Cl	Cl	Cl	Cp	P	P
N, 1							Ls	L	L	L	Cl	Cl	C	P	P	P	P	P
2							Ls	L	L	L	Cl	Cl	C	P	P	P	P	P
3							Ls	L	L	L	Cl	Cl	D?					
4							Ls	L	L	L	D?							
5							L	L	L	L	D?							
6							L	Da	L									
7							L	L	L	L	L	L	Cl	Cl	Cl	Cp	Cp	P
8							L	L	L	L	L	?						
9							L	L	L	L	D?							
10							L	L	L	L	L	L	Cl	Cl	Cl	Cp	Cp	P
11							L	L	L	L	L	?						
12							L	L	L	L	D							
Cc, 1									E	E	L	L	L	L	L	L	L	N
2									E	E	L	L	L	L	L	L	L	N
3									E	E	L	L	L	L	L	L	L	N
Dd, 1									E	E	E	L	L	L	L	L	L	N
Ee, 1										Ec	E	E	E	E	E	L	L	L
2											E	E	E	E	E	L	L	L
3											E	E	E	E	E	L	L	L
4											E	E	E	E	E	L	L	L

TABLE 3

Experiment 11, 1917 *Bremus bimaculatus* (Cresson)

	June											
Day Hour	25 4	26 5	27 6pm	28 5	29 5	30 7	2 11	3 5	4 1	5 5	6 5	7 5
K, 1	P	P	P	A ♀								
2	A ♂											
L, 1	P	P	P	A ♂								
2	P	P	P	?								
3	P	P	P	A ♂								
4	P	P	P	A ♂								
M, 1	P	P	P	P	A ♀							
2	P	P	D?									
3	P	P	A ♂									
4	P	P	P	A ♂								
5	P	P	P	P	P	A ☿		(Large)				
6	P	P	P	P	P	P	A ♀					
N, 1	P	P	P	P	P	?						
2	P	P	A ♂									
7	P	P	P	P	P	?						
10	P	P	P	P	P	A ♀						
O, 1	P	P	P	P	P	A ♂						
3	P	P	P	P	P	P	P	P	A ♀			
P, 1	P	P	P	P	P	P	P	P	A ♀			
2	P	P	P	P	P	P	A ♂					
3	P	P	P	P	P	A ♂						
R, 1	Cl	Cp	P	P	P	P	A ♂					
3	Cl	Cl	Cp	P	P	P	P	P	P	P	A ♀	
4	Cp	P	P	P	P	P	A ♂					
5	P	P	P	P	P	P	A ♂					
S, 1	Cl	Cp	P	P	P	P	P	A ♂				
2	Cl	Cl	Cp	P	P	P	P	P	P	P	A ♀	
T, 1	Cp	P	P	P	P	P	A ♂					
2	Cl	Cl	Cp	P	P	P	P	P	P	P	A ♀	
3	Cl	Cl	Cp	P	P	P	P	P	P	P	A ♀	
4	Cl	Cl	Cp	P	P	P	P	P	A ♂			
U, 1	Cl	Cp	P	P	P	P	P	P	P	A ♀		
2	Cl	Cp	P	P	P	P	P	A ♂				
4	Cl	Cp	P	P	P	P	P	P	P	A ♀		
5	Cl	Cl	Cp	P	P	P	P	P	P	P	A ♀	
6	Cl	Cl	Cp	P	P	P	P	P	P	P	A ♀	
V, 1	Cl	Cp	P	P	P	P	P	A ♂				
2	Cl	Cl	P	P	P	P	P	P	P	P	A ♀	
W, 1	Cl	Cl	Cl	Cp	P	P	P	P	P	P	P	A ♀
7	Cl	Cl	Cp	P	P	P	P	P	P	A ♂		
8	Cl	Cl	Cp	P	P	P	P	P	P	A ♂		
9	Cl	Cl	Cp	P	P	P	P	P	P	P	P	A ♀
10	L	Cl	Cl	Cl	Cp	P	P					
X, 1	Cl	Cp	P	P	P	P	A ♂					
2	Cl	Cl	Cl	Cp	P	P	P	P	P	P	P	?
3	Cl	Cl	Cl	Cp	P	P	P	P	P	P	P	?
4	Cl	Cl	C	Cp	P	P	P	P	P	P	P	?
Cc, 1	Cl	C	C	C	C	C	?					
2	Cl	C	C	C	C	C	?					
3	Cl	C	C	C	C	C	?					
Dd, 1								P	A ♂			
Ee, 1								P	P	P	P	A ♂

The next day I expected to find that the queen had adopted this colony, but I found instead that she preferred to keep as far as possible from the comb. On June 13, the queen was found in a paralyzed condition in a far corner of the box and the following day she was dead. In all probability this queen was stung by one or more workers, for there were no indications that she had met her death by parasitism. On June 14, one of the largest workers was seen apparently acting as the queen. Whenever the nest was jarred this worker acted exactly like a queen as shown by buzzing loudly, crawling about over the comb, and leaving it to the other workers to attack the trouble-maker. On this last mentioned date, several more eggs were found in cells which were undoubtedly the product of this large worker. No marked difference was observed in the manner in which these eggs were laid as compared with those laid by queens. By the eighteenth of June, five more workers had emerged, making a total of twelve in the nest. More egg cells were made from time to time and usually but a single egg laid in each of them. As there was no queen in the nest at this time, the eggs were laid by one or more of the workers.

On June 19, the day the bees were allowed their liberty, my notes record that some of the eggs laid on June 14 had hatched. During the next few days most of the workers frequently left the nest on foraging expeditions but the one large worker apparently acting as the queen never did so. One wing of this worker was slightly malformed and accordingly it was an easy matter to keep track of her. No doubt, she was responsible for most if not all of the eggs that were now being laid in cells on the tops of cocoons. Except for the gradual development of some of the larvae, which emerged from the worker eggs, and the addition of more eggs, the comb made little progress.

The first male emerged in the afternoon of July 3. This male developed from one of the tiny larvae which was found in the nest when it was removed on June 11. During the following week several more males emerged which were the product of worker eggs. On July 6, I tried to introduce another queen of *bimaculatus* into the nest, but she was attacked so viciously by the workers that she had to be removed. The same experiment was repeated on July 8. This time the queen was received more graciously, and remained in the nest for several days but she, too, finally left never to return. On several occasions new queens were found in this nest during the last half of July. Their presence here was probably due to the fact that the entrance of another colony of the same species was but a foot or so away from that of this nest, and queens belonging to this other colony in returning from the field entered the wrong box.

During the latter part of July the number of workers declined until but seven remained. A feature of the history of this colony during July was the heavy mortality among the larvae resulting from the worker eggs. The cause of this heavy mortality was due, I believe, to the improper feeding of the larvae resulting from the bad state of affairs existing in the nest rather than to an inherent weakness in the progeny of workers. Though this colony never attained great size, the experiment was very interesting and clearly demonstrated that parthenogenetic eggs in this species produce only males. The data relating to the development of males in this colony is given in table 4.

TABLE 4

Experiment 13, 1917 *Bremus bimaculatus* (Cresson)

	June																
Day	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Hour	4	9	8	9	9	9	9	9	9	8	8	9	9	6am	1	1	1
A, 1	Ls	L	L	Cl	C	C	C	P	P	P	P	P	P	P	A ☿		
2	Ls	L	L	Cl	C	C	C	P	P	P	P	P	P	A ☿			
B, 1	C	C	C	C	C	A ☿											
C, 1	L	L	L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl	Cp
2	L	L	L	L	L	L	L	L	L	L	L	L	L	Cl	Cl	Cl	Cp
D, 1	C	C	C	C	C	A ☿											
2	C	C	C	C	C	C	A ☿										
E, 1				E	E	E	E	Da									
2				E	E	E	E	E	L	L	L	L	L	L	L	L	L
3				E	E	E	E	E	L	L	L	L	L	L	L	L	L
4				E	E	E	E	E	L	L	L	L	L	L	L	D?	
F, 1				L	L	L	L	L	L	L	D?						
2				L	L	L	L	L	L	L	D?						
G, 1					Ec	E	E	E	E	L	L	L	L	L	L	L	L
2						E	E	E	E	L	L	L	L	L	L	L	L
3						E	E	E	E	L	L	L	L	L	L	L	L
4						Ec	E	E	E	E	E	L	L	L	L	L	L
5							E	E	E	E	E	L	L	L	L	L	L
6							E	E	E	E	E	L	L	L	L	L	L
H, 1													E	E	E	E	E
2													E	E	E	E	E
3														E	E	E	E
4														E	E	E	E
5														E	E	E	E
6														E	E	E	E
I, 1															E	E	E
2															E	E	E
3																E	E
4																E	E

TABLE 4

Experiment 13, 1917 *Bremus bimaculatus* (Cresson)

	June			July													
Day	28	29	30	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hour	1	5	7	9	12	8	12	12	8	7	1	5	12	12	5	1	2
C, 1	P	P	P	P	P	P	A ♂										
2	P	P	P	P	P	A ♂											
E, 2	Cl	Cl	Cp	P	P	P	P	P	P	A ♂							
3	Cl	Cl	Cp	P	P	P	P	P	P	P	A ♂						
G, 1	L	L	L	Cl	Cp	P	P	P	P	P	P	P	P	P	A ♂		
2	L	L	L	Cl	Cl	Cp	P	P	P	P	P	P	P	P	A ♂		
3	L	L	L	L	Cl	Cl	P	P	P	P	P	P	P	P	P	P	D ♂
4	L	L	L	Cl	Cl	D?											
5	L	L	L	Cl	Cl	Cl	P	P	P	P	P	P	P	A?			
6	L	L	L	Cl	Cl	Cl	P	P	P	P	P	P	P	P	P	P	P
H, 1	E	L	L	L	L	L	L	L	D?								
2	E	L	L	L	L	L	L	L	D?								
3	E	L	L	L	L	L	L	D?									
4	E	E	L	L	L	Da											
5	E	E	L	L	L	Da											
6	E	E	L	L	L	Da											
I, 1	E	L	L	L	L	L	L	L	L	L	L	L	L	L	D?		
2	E	L	L	L	L	L	L	L	L	L	D?						
3	E	L	L	L	L	L	D?										
4	E	L	L	L	L	L	D?										
J, 1	E	E	E	E	E	L	L	L	L	L	L	L	L	L	L	L	D ♂
2	E	E	E	E	E	L	L	L	L	L	D?						
3	E	E	E	E	E	L	L	L	L	D?							
4	E	E	E	E	E	L	L	L	L	D?							
K, 1	E	E	E	E	E	L	L	L	L	L	L	L	L	L	L	L	L
2	E	E	E	E	E	L	L	L	L	L	L	L	L	L	L	L	L
3	E	E	E	E	E	L	L	L	L	L	L	L	L	L	L	L	L
4	E	E	E	E	E	L	L	L	L	L	L	L	L	L	L	L	L

TABLE 4

Experiment 13, 1917 *Bremus bimaculatus* (Cresson)

	July					
Day	16	17	20	22	23	
Hour	1	5am	1	10	5	
G, 6	P	A ♂				
K, 1	L	L	L	C	C	(Small)
2	L	L	L	C	C	(Small)
3	L	L	L	D?		

5. Experiment 15, 1917

This colony was of particular interest because it was started by a queen under natural conditions. The nest was first discovered on June 21, when workers were seen going and coming from a brush pile in the University Woods. I removed the nest on June 23 and found that the comb was situated in an old mouse nest under an accumulation of leaves. The bees entered the nest through several tunnels which they had made in densely packed masses of leaves. When the nest was opened, the large workers were much more active in protecting their home than were the small ones.

The nest contained on June 23, fifty-six workers, four males, one young queen, the parent queen, seventy-eight cocoons, forty-one larvae in various stages of development, seventeen eggs and eighteen wax-pollen cells. The wax-pollen cells were on the side of the comb and contained both pollen and honey. The egg cells were all made on cocoons containing pupae and contained from one to four eggs in a cell. The old queen plainly showed the effects of her labors, for she had lost most of her pubescence, part of her right middle leg was missing and her movements were very feeble. The comb presented a very neat appearance, and undoubtedly the colony was quite typical in structure, form, size and development of that of this species produced under most favorable natural conditions.

No detailed study was made of this nest and accordingly only a little more need be said concerning it. By the first of July, many more males and queens had emerged. Several of the workers died soon after the colony was placed in an observation box and these were promptly dragged into a far corner of the nest by other workers. It was interesting to me to find that the slightest jar set the entire colony in an uproar, whereas less attention was paid to an equivalent treatment in other colonies of the same species reared in confinement. At times even young queens flew out of the nest to attack me when the nest was disturbed. The old queen died the first week in July and from then on the number of workers in the nest steadily diminished.

On July 24, the nest contained eleven workers, six new queens, eighteen cocoons from which adults had not emerged and thirteen larvae of various sizes. In the débris about the comb I found the remains of ten workers, one queen and one male. None of these dead bees showed evidence of parasitism and no parasites were ever found in the nest. The latter part of July eggs were found, which were undoubtedly laid by a worker or workers. A few males and young queens continued to emerge until August 5. The males apparently left the nest sooner than the queens for I seldom found more than two males in the nest at one time. On August 2, I killed the eight remaining workers. Figure 5 shows a side view of the comb of this nest taken on September 6.

6. Experiment 1, 1919

This experiment was started with a queen of *B. bimaculatus* collected in the University Woods on April 4. Previous to being placed in an artificial nest on April 10, this queen was kept in a manner to cause her to become "broody." When the nest was examined on April 11, the queen was manifesting an interest in the nest. Three days later another queen of the same species, which I caught in the Brownfield Woods on April 12, was placed in the nest. At this time the queen first in the nest (a notch was clipped in the margin of one of her wings as a recognition mark) was still interested in the nest and invariably rushed from the nest buzzing excitedly whenever she was disturbed. During the two-day interval since the time of last observation, she had constructed a small honey-pot. There was also a place on the pollen lump which appeared to be a sealed egg cell.

From the very first the two queens adopted a friendly attitude towards each other and on April 16 both of them were at work on the pollen lump. At this time there were four empty egg cells on the pollen lump and both queens were seen laying eggs in them on the next day. Though the first egg cells were not closely examined during the early stage of the comb, the appearance of the pollen lump at one place on April 22 looked as if some of the larvae had emerged. I am certain, however, that larvae were present in the nest on April 24, as well as eggs. The last of April, a queen of *Psithyrus variabilis* (Cress.) was placed in the nest and she was not attacked. As this *Psithyrus* queen insisted on staying out of the nest proper, she was removed the next morning. On May 9, after being absent for a few days, I found that six of the larvae had spun cocoons and that a new egg cell containing four eggs had been constructed. During all the time previous to the spinning of the cocoons, the two queens remained on the best of terms and ran the nest on a partnership basis.

On May 10, several more egg cells were found in the nest, each of which contained from two to four eggs. These last cells were constructed on the tops of the cocoons. During the next few days several more egg cells were made and on May 15 a worker emerged. Workers continued to emerge from the first batch of cocoons until May 19, when there were six of them in the nest. Because of the success attained in rearing this species in 1917, the character of this experiment was changed on May 21 by introducing a queen of *Psithyrus variabilis* into the nest. On this same date, a detailed record of the developmental stages was started. In view of the developmental tables already given for this species, this record will not be presented.

A complete description has been published (Frison, 1926b) of the manner in which this queen *Psithyrus* was received. It may be mentioned, however, that the queen was not attacked, though she was received at first with some suspicion. On May 30, I removed the queen of *bimaculatus* that was least interested in the nest, and temporarily placed her in a bottle with the *Psithyrus* queen, which I had also removed in order to examine the nest. In scrambling around trying to get out of the bottle they started fighting with the result that the *Psithyrus* stung the *Bremus* queen. Within five minutes after being stung, the *Bremus* queen was dead. The *Psithyrus* was then replaced in the nest. During the fore part of June several more workers emerged and on June 9 there were fourteen workers in the nest. On this latter late, I found the *Psithyrus* outside the nest proper in the tin containing honey and hardly able to move. As the queen was in good condition on June 8 and on friendly terms with the bumblebees, I think that her plight was the result of falling into the honey and getting badly smeared with it. Her condition was such that it was necessary to remove her from the nest.

The second week in June several more workers emerged and the colony was progressing very nicely. On June 11, the bees were allowed the privilege of gathering their own food supply. When the colony was next examined on June 13, the old queen was missing. As to her fate, I can only conjecture that she wandered out of the box and fell from the entrance ledge to the ground and was not able to get back to the nest. The entrance hole to the nest box was three feet above the ground and could only be reached by flying.

Within a few days after the disappearance of the queen, several workers appeared to have assumed the duties of the queen. By the end of the third week of June, there were five large groups of egg cells on the comb. All these egg cells which were examined contained but one egg and it is recorded in my notes that these eggs were very small. Egg laying continued at a surprising rate and on June 25 there were nearly fifty eggs in the numerous cells. At the time of this examination, the number of eggs in a cell varied between one and three. The egg cells were slightly smaller than those in which the queen laid her eggs. Undoubtedly these eggs were laid by a number of the workers, since on this day six of them were found acting in every way as if they were the mother queen.

During the last part of June, the workers continued to lay eggs and a few of them still foraged for pollen and nectar. The first male to emerge appeared on June 30 and others were eventually produced. Only one queen was produced by this colony and she emerged on July 7. This queen was reared from eggs laid previous to the disappearance of the old queen and such was also the case with the males which emerged on June 30 and July 3. The male which appeared on July 19 was the product of a worker egg, as was also the dead pupa of a male removed from a cocoon on July 24. On July 24, the nest contained but one live worker and the experiment naturally came to an end.

7. Experiment 2, 1919

Two queens of *B. bimaculatus* collected on April 12 in the Brownfield Woods were placed in an artificial nest on April 15. Both queens immediately took an interest in the nest and on the next day a couple of eggs were discovered in a cell on the pollen lump. As usual, I marked the queen which showed the greater interest in the egg cell by clipping a notch in the margin of one of her wings. In this particular experiment, I did not place a honey-pot in the nest and accordingly was greatly pleased to see the queens on April 17 constructing one of wax from bits of this material which were put into the nest the day before.

The nest was not examined in detail again until April 22, when several small larvae were found in the cells. During the following three weeks the queen with the entire wing margins manifested no interest in the incipient comb and so she was removed on May 12. I never saw the two queens fight during the time that they were in the nest together. This may be due to the fact that the queen which was removed held herself aloof from the comb on which the other queen was brooding. On May 10, the groove in which the queen rested when brooding over the comb was quite evident. On this same day, the queen with the clipped wings made another egg cell in which were laid four eggs, and one worker emerged. In Figure 6 is shown the queen brooding on the incipient comb, and the worker which had just emerged.

On May 12, there were four workers in the nest and during the next two days two more emerged, bringing the total of workers to six. Nothing more of particular interest transpired in this nest until on May 23. On this date, two workers accidentally escaped from a bottle in which they had been temporarily placed while examining the comb. As they had never been allowed to fly from their nest box, I was curious to see if they could find their way back into the nest, which was about one foot away from the bottle. On leaving the bottle they immediately flew around the bottle, and incidentally the nest box, in small circles. Finally they alighted on the side of the nest box and then crawled upon its top. When I lifted one of the glass sections on the top of the box, the workers immediately crawled down into the nest.

A couple of days after the escape and safe return of the workers, a small larva was accidentally dislodged from a cell containing several other small larvae. The moment the queen discovered that the cell was open she made haste to seal it over. Before she could accomplish her purpose I tried several times to replace the dislodged larva in its cell, but the queen repeatedly accidentally knocked it from the cell again in her hurried efforts to close the latter. Finally my efforts were successful. In order to close the breach made in the cell, the queen searched about over the comb for the necessary material. Besides using some of the wax-pollen matrix which was still clinging to an adjacent cocoon, she accepted a small bit of pollen offered to her, carried it bodily to the place where it was needed and worked it into the cell wall. Of particular interest to me was the fact that the queen showed no attachment or interest in a larva out of its cell, and returned directly to the open cell after finding the necessary material for closing its breach.

Additional workers began to emerge on May 26, and by the first of June there were twenty-two of them in the nest. On May 27, the queen was caught in the act of eating one of her own eggs. While examining an egg cell containing four eggs, the queen happened to come in contact with this opened cell and the exposed eggs. Instead of immediately closing the cell, she calmly proceeded to pick up one of the eggs and ate it. I immediately pushed her to one side and closed the cell as best I could. Returning almost immediately and finding the cell partially closed, she then proceeded to finish the job in the orthodox manner. At two in the afternoon of June 1, the bees were allowed their liberty and a study was made of the orientation flight of the first five workers to leave the nest. A discussion of these flights is given in another paper. It should be mentioned here, however, that one of the workers returned to the nest within seven minutes after leaving it and passing from my observation.

No further attention was paid to this colony until June 16, when the nest was closely examined and found to contain thirty-three cocoons containing immature forms, eight larvae, six egg masses, the old queen and fifteen workers. As this examination was made at four in the afternoon, other workers were probably away from the nest. When next examined on June 27, the colony contained four males. The first young queen was found in this nest on July 13. On this latter date, there were only a few egg cells on the cocoons and there was but one egg in each cell. The old queen was still alive on July 20, at which time the nest contained in addition eight workers, two males, seven young queens, and a few small larvae. Three of the small larvae were found in pollen stored in one of the pollen pots and I believe that they were the product of worker eggs. Though there was some storage of pollen in the nest, no honey was to be found.

During the remainder of July additional queens and males were produced. The last day of July, I found that the old queen had died. Not wishing to continue the experiment longer, the few remaining young queens were removed and the sole surviving worker killed.

8. Experiment 14, 1919

This colony of *B. bimaculatus* was found on May 11 in the University Woods and was brought to the laboratory on May 26. The colony was originally started in an old mouse nest under a decayed log. The nest contained at the time it was removed, six workers, eleven cocoons containing larvae or pupae, four egg cells, three groups of larvae in various stages of development and one live queen. The egg cells contained between three and four eggs each. Just outside of the nest proper the bodies of four dead queens of this same species of bumblebee were found; mute testimony of earlier struggles for the possession of this site or nest. There was no surplus of honey or pollen in the nest at this time.

The cocoons found in the nest began to produce workers on May 28 and on June 1 there were twelve of them in the nest. On June 2, the workers were allowed freedom of flight. The workers immediately took advantage of their liberty and soon began to gather pollen and nectar. Ten days after the colony was released a male emerged. During the latter part of June the colony plainly showed the effects of parasitism and on June 21 a large number of *Brachycoma sarcophagina* (Towns.) puparia were removed from the nest. A large number of larvae of *Vitula edmandsii* (Pack.) were also in the nest and on June 24, when the experiment was closed, the comb was completely overrun by them. Figure 7 shows the comb and nest as it appeared on May 26.

9. Experiment 2, 1920

On May 3, two queens of *B. bimaculatus* were placed in an artificial nest. Both of these queens were collected in the Brownfield Woods near Urbana, one on April 21 and the other on May 1. The very next day one of them was seen fashioning an egg cell in the pollen lump. On the following day, May 5, there were three sealed egg cells and three empty egg cells on the pollen lump. On May 10, I found dead in the nest box the queen which displayed the least interest in the nest. There was no evidence to indicate that her death was caused by parasites and I believe that she was stung to death by the brooding queen.

A small honey-pot was made on May 11 adjacent to the artificial one originally placed in the nest. No examination was made to see when the eggs hatched, but some of the cells contained larvae on May 13. Some of these first larvae died before reaching maturity and were carried out of the nest by the queen. On May 25, the groove in which the queen rested while brooding over the cells was very conspicuous. On June 4, this experiment was terminated because I needed the box for other colonies and detailed studies of this species had already been made in 1917 and 1919.

10. Experiment 3, 1920

This experiment was started with two queens of *B. bimaculatus* sent me from Geneva, New York, by Dr. Hugh Glasgow. The queens were received on May 3 and both placed in the same artificial nest on May 5. No interest was taken in the nest until May 7, when a single egg cell was constructed on the pollen lump. When next examined on May 9, one queen seemed to be dominating the nest and the cells on which she was brooding contained eggs.

On May 10, both queens appeared to be interested in the nest and more egg cells were made and eggs laid. Five days later I found the queen, which was the last to take an interest in the pollen lump, brooding on a sealed egg cell which was constructed on the side of the honey-pot. Evidently, the queen which first took an interest in the nest still dominated the incipient comb. On June 5, I ended the experiment, after satisfying myself that the queens of this species could be shipped long distances without breaking up their nesting instincts.

C. Summary

1. Nesting habits

As far as I am aware only two authors previously have given us any information concerning the nesting habits of this species. The first of these is Franklin (1913), who records the finding of a single nest "located on the surface of the ground, among the bases of saplings, in a thicket of alders in Bernardston, Massachusetts. The nest was made up of dried grass in the usual way and contained six queens, ten workers and nine males, besides a considerable number of cells with partially developed larvae. The nest was taken on July 15, 1904. The workers of this species are very waspish and, next to those of *B. vagans* F. Sm., are the most ready to use their stings of all those with which I have had any experience." In two other recent articles by Plath (1922a and 1922b) there are several statements regarding the habits of this species. Plath mentions finding four nests of this species near the Arnold Arboretum in 1921 and 1922. All of these nests were subterranean and from "6 inches to 1 ft. below the surface of the ground." Tunnels leading to these nests varied from 9 inches to 4 feet in length. He further says that the "largest of the four nests contained (July 8, 1921) the old queen, 23 young queens, over 60 workers, and a considerable number of queen cells." According to this same author the queens of this species appear during the latter half of April, the colonies are probably started in May, and break up in August. In speaking of the appearance of *Psithyrus laboriosus* (Fabr.) in two colonies of *Bremus bimaculatus*, Plath says one of these colonies consisted "of the old queen and about 25 workers, and the other of the old queen, several young queens, and about fifty workers." These colonies of *bimaculatus* never objected to the presence of *Psithyrus* queens, which sometimes stayed in their nests for several days, but neither of them produced adults of this inquiline bee.

In a more recent article by Plath (1924) the statement is made that "the nests of *Bremus bimaculatus* . . . are almost always subterranean, and yet the majority of the queens of these two species (*B. terricola* is the other species referred to) take up their winter quarters in July." It is evident in this vicinity that *B. bimaculatus* shows a decided preference for nesting in woodlands (figure 8), and the queens in spring are almost exclusively found in or near such wooded areas. I have found the nests of this species in the woods under an old log and in an accumulation of old leaves in a brush pile. Domiciles both buried in the ground and placed in tree stumps in the woods were occupied by this species, but never a domicile in a meadow or pasture land. The adults, too, are rarely encountered near Urbana except in wooded areas. Franklin (1913) reports finding a nest on the surface of the ground among the bases of saplings, and Plath (1922) found four nests in subterranean situations. It is evident from these records that the queens of this species will select almost any protected situation for the site of their nest in the area they prefer to inhabit.

2. Anthophilous habits

There are fewer records in literature of the flowers frequented by this species of bumblebee than for the closely allied *B. impatiens* (Cresson). This is due in part to the smaller size of the colonies of *B. bimaculatus,* the character of the area in which the bees nest and the seasonal history of the species. The diversity of the flowers they are known to visit is sufficient, however, to establish the fact that they are polytropic. The reader is referred to Lutz and Cockerell (1920) for records of the flowers visited by this bee. In addition to those records the following should be added:

Jackson (1920): *Salix sericea, Pontederia cordata, Diospyros virginiana, Xolisma ligustrina, Azalea nudiflora* and *Brassica* sp.

In addition to the published records I have found this species on *Dicentra canadense, Monardia fistulosa* and *Geranium maculatum.*

3. Duration of the developmental stadia

a. *Egg stage*

As is the case with all other species of bumblebees that I have studied, the egg stage is the shortest of the developmental stadia. In tables 1, 2, 3, and 4 considerable data are presented concerning the duration of this stage. Because the males and queens are produced early in the season and at a time in the history of the colony most favorable for close observations, I have more data bearing on the duration of the egg stage in the males and queens than for the workers. Colonies found under natural conditions, and those removed from my domiciles for closer observation, had usually progressed to the point where additional eggs were destined to produce chiefly males and queens. In colonies started under controlled conditions, the fear of causing the queen to desert the nest was responsible for the lack of frequent examinations of the first cells.

There seems to be little if any difference in the duration of the egg stage of the various castes. Of course, data such as given in the tables are not sufficient to show differences of a few hours' extent in the duration of this stage in the various castes, even though such a difference does exist and is quite constant. In order to secure such data, studies with only this objective will be necessary. From the tables already cited I have extracted for analysis the records bearing upon this subject shown on the next page.

All of the records just given are not approximations, but represent a total known time passed in the egg stage. In all cases, there exists a period preceding when the egg was first noticed and before the larva was first found, where no data are available. Although this total period represents forty-eight hours, the hours which are not accounted for are certainly in most cases much less than this total number. The fact that the egg cells are constructed before the eggs are laid aids in computing the duration of the egg stage. It is a general rule that the eggs are laid within four or five hours after the egg cells are constructed. Exceptions occur, however, but need not be discussed here.

Eight of the ten above-listed groups of eggs which eventually produced males remained for a certainty over ninety-two hours in the egg stage. Only two groups fell below this hour-total and it is significant to note that the cells in which they were laid were observed on the preceding day. This indicates that these latter eggs were probably laid a considerable number of hours before they were found. Three groups of eggs gave a ninety-seven hour period. In consideration of the records as given, I believe that slightly over one hundred hours, or four and one-fourth days, is a fair estimation for ordinary purposes of the egg period of the male of *B. bimaculatus*.

The best record of the duration of the egg stage of the worker is shown in Group L of Experiment 5, 1917. In this instance an

TABLE 1

Exp.	1,	1917	Group	E,	June	25	(8 A. M.)	to	June	29	(7 A. M.)	= 97	hours	(2 ♂♂)
"	5,	"	"	P	"	12	(10 A. M.)	"	"	16	(9 A. M.)	= 95	"	(4 ♂♂)
"	"	"	"	Q	"	13	(9 A. M.)	"	"	17	(10 A. M.)	= 97	"	(2 ♂♂)
"	"	"	"	R	"	14	(")	"	"	18	(")	= 97	"	(1 ♂)
"	"	"	"	S	"	17	(10 A. M.)	"	"	21	(8 A. M.)	= 94	"	(1 ♂)
"	11	"	"	L	"	4	(4 P. M.)	"	"	7	(6 P. M.)	= 74	"	(3 ♂♂)
"	"	"	"	N	"	5	(6 P. M.)	"	"	9	(3 P. M.)	= 93	"	(1 ♂)
"	"	"	"	O	"	7	(")	"	"	11	(")	= 95	"	(1 ♂)
"	"	"	"	R	"	8	(")	"	"	12	(5 P. M.)	= 95	"	(3 ♂♂)
"	"	"	"	T	"	10	(")	"	"	13	(")	= 71	"	(2 ♂♂)
"	"	"	"	J	"	3	(9 A. M.)	"	"	7	(9 A. M.)	= 96	"	(2 ♀♀)
"	"	"	"	N	"	6	(")	"	"	10	(10 A. M.)	= 97	"	(6 ♀♀)
"	"	"	"	O	"	10	(10 A. M.)	"	"	16	(9 A. M.)	= 95	"	(3 ♀♀)
"	"	"	"	N	"	7	(6 P. M.)	"	"	10	(6 P. M.)	= 72	"	(1 ♀)
"	"	"	"	O	"	9	(3 P. M.)	"	"	12	(5 P. M.)	= 74	"	(1 ♀)
"	"	"	"	P	"	8	(6 P. M.)	"	"	"	"	= 95	"	(1 ♀)
"	"	"	"	T	"	10	"	"	"	13	"	= 71	"	(2 ♀♀)
"	"	"	"	L	"	5	(noon)	"	"	8	(10 A. M.)	= 70	"	(1 large ♀)

egg which produced a large worker had a period of seventy hours. In the case of this latter record, there is a leeway period of nearly fifty hours and I believe that the total egg period was about the same as for the queens. Further evidence that the worker has a longer egg stage than is indicated by this record lies in the development period of the first eggs laid by a queen. In none of my colonies did I find larvae in the artificial pollen lump so soon after the first eggs were laid. In four of the seven groups cited, which show the known duration of the eggs eventually producing queens, four of them (twelve of the sixteen queens) required over ninety-four hours. In all three groups with a smaller hour-total, the eggs were laid in cells found in the nest on the examination of the previous day. This indicates a time of laying almost sufficient to bring these eggs to the ninety-five hour total, without considering the time that they were in the egg stage after the time they were last recorded as such. Taking all things into consideration, it appears that the eggs from which queens were eventually produced, required somewhat over one hundred hours, or a fraction over four clock days, before hatching.

Summarizing all that has just been said in regard to the duration of the egg stage, it appears that all castes result from eggs which require approximately somewhat over a hundred-hour developmental period before hatching. It may be stated, also, that the data are not sufficient to demonstrate or refute that there exist slight differences in the duration of the egg stages of the various castes.

b. *Larva*

The record of larval development in the male and queen castes is more complete than that obtained for the workers. It should be mentioned here, perhaps, that the transitional period between the larva and the complete attainment of the pupa is considered for convenience as part of the larval cycle. The data concerning the duration of the larval period are given in tables 1, 2, 3, and 4. Some of the most complete of the worker records are considered for analysis in the tabulation on page 202 (Table 2).

All of the above records represent a total known durational period of larvae which eventually produced workers. It is evident from these records that all these larvae had a developmental period of two hundred and forty hours, or ten days, and one of them over fourteen days, or three hundred and forty hours. In order to get a good estimation of the larval period of the workers of this species, one must take into consideration the probable number of hours of larval development which the records do not show. At the most, this is usually not over forty-eight hours. Accordingly, it appears that worker larvae, as a rule, remain between eleven and thirteen days in the larval stage. That this may be exceeded is proved in Group B, Experiment 11, 1917, when one larva which produced a large worker required at least three hundred and forty-five hours for development. This same Group B produced both large and small workers, and though it was not definitely ascertained just when the various larvae producing them hatched, it seemed that the duration of the larval period was correlated with the size of the adult.

A large number of records are available which throw light on the duration of the larvae which eventually produced queens. A list of some of these—selected to show the extremes and average records—are presented for analysis on page 202 (Table 3).

A study of these figures for the durational period of the larvae which eventually produced queens, without taking into consideration the number of hours they were in the larval stage not shown by the record, shows that queen larvae require a longer period for development than do the larvae of workers. Almost half of the total number of records given in the detailed developmental tables for larvae which produced queens required with certainty over three hundred and ten developmental hours. The record of the queen larva with the least known hour total shows a larval duration period equivalent to that of the average worker. One larva of a queen in Group N, Experiment 5, 1917, required with certainty three hundred and eighty-one hours, or nearly sixteen days, before it pupated. All this goes to indicate, that when we take into consideration a fair estimate of the number of hours spent in the larval stage by queen larvae which is not shown by the record, we are dealing in the queens with a developmental cycle which requires between thirteen and seventeen days for completion. Group N, Experiment 5, 1917, the record of whose larvae is exceptionally comprehensive, shows that a variation does occur.

More data are available for the males of this species than for the queens. Of thirty-two fairly complete records of larvae that produced males, only five show a known total period of larval duration in excess of three hundred hours. A few of the records relating to the duration of the larval period in this sex are given on page 203 (Table 4).

TABLE 2

Exp. 5,	1917	Group E,	May 30 (8 A. M.)	to June 9 (10 A. M.)	= 242 hours	(3 ☿☿)
“ “	“	“ G	June 1 “	“ “ 10 “	= 218 “	(2 ☿☿)
“ “	“	“ G	“ 1 “	“ “ 11 (9 A. M.)	= 241 “	(2 ☿☿)
“ “	“	“ L	“ 9 “	“ “ 20 (8 A. M.)	= 262 “	(1 large ☿)
Exp. 11,	1917	Group A,	May 30 (8 A. M.)	to June 13 (5 P. M.)	= 345 hours	(1 large ☿)
“ “	“	“ B	“ “ “	“ “ 11 “	= 297 “	(3 large ☿☿)
“ “	“	“ B	“ “ “	“ “ 9 (3 P. M.)	= 247 “	(2 small ☿☿)

TABLE 3

Exp. 5,	1917	Group N,	June 10 (10 A. M.)	to June 23 (9 A. M.)	= 311 hours	(2 ♀♀)
“ “	“	“ “	“ “ “	“ “ 25 (5 P. M.)	= 344 “	(1 ♀)
“ “	“	“ “	“ “ “	“ “ 26 (7 P. M.)	= 370 “	(1 ♀)
“ “	“	“ “	“ “ “	“ “ “ “	= 381 “	(1 ♀)
“ 11	“	“ O	“ 13 (5 P. M.)	“ “ 23 (5 P. M.)	= 240 “	(1 ♀)
Exp. 11,	1917	Group R,	June 13 (5 P. M.)	to June 26 (5 P. M.)	= 312 hours	(1 ♀)
“ “	“	“ S	“ 14 (3 P. M.)	“ “ “ “	= 290 “	(1 ♀)

TABLE 4

Exp.	11, 1917	Group N,	June 10 (6 P. M.)	to June 18 (4 P. M.)	= 190	hours	(1 ♂)
“	“ “	“ O	“ 12 (5 P. M.)	“ “ 21 (5 P. M.)	= 216	“	(1 ♂)
“	“ “	“ R	“ 13 “	“ “ 23 “	= 240	“	(2 ♂♂)
“	“ “	“ S	“ 14 (3 P. M.)	“ “ 25 (4 P. M.)	= 263	“	(1 ♂)
“	1 “	“ E	“ 30 (7 A. M.)	“ July 14 (1 P. M.)	= 342	“	(2 ♂♂)
“	13 “	“ G	“ 20 (8 A. M.)	“ “ 3 (noon)	= 316	“	(1 ♂)
“	“ “	“ “	“ “ “	“ “ 4 (“)	= 291	“	(1 ♂)
“	“ “	“ “	“ “ “	“ “ “ “	= 340	“	(1 ♂)

TABLE 5

Exp.	5, 1917	Group E,	June 10 (10 A. M.)	to June 14 (9 A. M.)	= 95	hours	(1 ☿)
“	“ “	“ G	“ 12 “	“ “ 17 (10 A. M.)	= 120	“	(2 ☿☿)
“	11 “	“ D	“ 5 (6 P. M.)	“ “ 11 (5 P. M.)	= 145	“	(1 ☿)
Exp.	11, 1917	Group G,	June 11 (5 P. M.)	to June 18 (4 P. M.)	= 167	hours	(1 large ♀)
“	“ “	“ D	“ 10 (6 P. M.)	“ “ “ “	= 190	“	(5 “ ☿☿)

Considering these records in the same manner as for the other castes, it is evident that there exists a variation in the duration of the larval stage of larvae destined to males, and that between ten and thirteen days is a fair approximation of the larval stage of larvae which eventually produce normal males. It is interesting to note that all the records selected from Experiment 13, 1917, which showed a fairly long developmental period, were the progeny of workers. Furthermore, these same larvae were reared under conditions not very favorable for normal development. Whether this has any significance other than nutritional I can not say. A discussion of the production of males by workers of this species has been mentioned in a previous paper (Frison, 1927c).

c. *Pupa*

The pupal stage is longer than the egg stage and shorter than the larval stage. Many records are available in tables 1, 2, 3, and 4 to give a good idea of the duration of the pupal period. In recording the data, the cocoon has been considered as containing a pupa up until the time that the adult emerges. This of course is not strictly correct because the pupal skin is cast before the adult emerges. The following records have been selected to show the extremes and average developmental periods of the worker pupae (Table 4, p. 203).

With proper allowance for the time spent in the pupal stage, which is not shown in these figures, it is clearly evident that some pupae which produce workers require a longer developmental period than do others. Furthermore, in the tables it is evident that large workers had a longer pupal period than small workers. A pupal period of from five to eight days is a fair approximation of the length of the pupal stage in the workers.

In the queens the pupal period is much longer than in the workers and under equal conditions it is longer than in the males. This is quite evident from the following records, which show both extremes as well as intermediate total known time requirements (Table 6, p. 205).

These records show that the duration of the pupal period of the queens varies. With allowance for the time spent in the pupal stage, which the records do not show, it is fairly evident that the pupal period of the queen is between eight and eleven days.

Most males of this species have a pupal period which varies between seven and nine days. My records show that one male remained over eleven days in the pupal stage, but this male was very diminutive and produced under exceedingly unfavorable conditions.

TABLE 6

Exp.	5,	1917	Group	O,	June	27	(7 A. M.)	to	July	5	(noon)	= 197	hours	(3 ♀♀)
"	"	"	"	N	"	26	"	"	"	6	(7 A. M.)	= 240	"	(1 ♀)
"	11	"	"	N	"	22	(3 P. M.)	"	June	29	(5 P. M.)	= 170	"	(1 ♀)
"	"	"	"	J	"	10	(6 P. M.)	"	"	19	(4 P. M.)	= 214	"	(1 ♀)
"	"	"	"	D	"	"	" "	"	"	20	(6 P. M.)	= 240	"	(1 ♀)

TABLE 7

Exp.	1,	1917	Group	D,	July	11	(8 A. M.)	to	July	18	(1 P. M.)	= 173	hours	(1 ♂)
"	5	"	"	F	"	12	(10 A. M.)	"	"	"	(10 A. M.)	= 144	"	(1 ♂)
"	"	"	"	P	June	25	(5 P. M.)	"	"	3	(4 P. M.)	= 191	"	(2 ♂♂)
"	"	"	"	L	"	10	(6 P. M.)	"	June	27	(6 P. M.)	= 168	"	(3 ♂♂)
"	13	"	"	G	July	3	(noon)	"	July	12	(noon)	= 216	"	(1 ♂)
"	"	"	"	G	"	5	(8 A. M.)	"	"	16	(1 P. M.)	= 269	"	(1 small ♂)

The following records have been selected to give a general idea of the known duration of this period in the males (Table 7, page 205).

d. *Summary of facts concerning duration of the developmental stadia*

The developmental records for the immature stages of this species are about as complete as daily records permit. All castes were reared and usually in several or more colonies. In all castes the egg stage is the shortest of the developmental stadia, the pupal stage intermediate and the larval stage the longest. No appreciable difference was found in the length of the egg stage in the three castes, and the time required for them to produce free larvae was a fraction over four days. The larval period varies according to the caste. In the worker caste this latter stage required between eleven and thirteen days, in the queens between thirteen and seventeen days, and in the males between ten and thirteen days. The pupal period of the workers varied between five and eight days, of the queens between thirteen and seventeen days, and the males between ten and twelve days. Ample evidence was obtained to prove that there exists a considerable variation in the rate of development of larvae and pupae of the same caste. Abnormal specimens often exceed the approximations just given and some of the factors which cause this variation will be discussed in another paper.

e. *Complete developmental cycle*

Because there exists a variation in the time required by the developmental stages of all castes, we find a corresponding variation in the sum total time of all developmental stages of all castes. In the case of this species, the queens required the longest time to complete their development. Not a great deal of difference seems to exist between the workers and males in this respect, but I am inclined to believe that the males usually require a slightly longer developmental period than do the workers. According to the figures presented separately for each immature stadium and from a study of the various tables, the workers require from twenty to twenty-five days, the queens from twenty-five to thirty-three days, and the males from twenty-one to twenty-six days to complete their developmental cycles.

4. Seasonal appearance of the castes

In Champaign County, Illinois, *Bremus bimaculatus* is the first species of bumblebee to appear in spring. The earliest records that I have for the queens of this species in the University Woods during the following years are:

April 20, 1915	University Woods
April 12, 1917	" "
March 21, 1918	" "
March 28, 1919	" "
April 20, 1920	" "

In 1917, a close watch was kept on the advance of spring in the University Woods. The first flowers which I saw in bloom were those of *Claytonia virginica* on April 8. Four days later I observed *Dicentra cucullaria* in bloom and on this same date I saw and captured the first bumblebee queen of the season; a queen of *B. bimaculatus.* Shortly after this date, the flowers of *Collinsia verna* appeared. During this early or prevernal season the queens of this species of bumblebee fed mostly at the flowers of *Dicentra cucullaria,* and such was also the case in other years. In fact, the appearance of the flowers of the Dutchman's-breeches is a good indication that the queens of this species are on or about to appear on the wing. The queens are also among the first to disappear again. In 1917, none of them were seen in the field after the end of May. The dates just given for certain years when the first queens were taken, clearly shows that the "appearance-time" of the queens is correlated with the climatic factors which hasten or retard prevernal conditions.

Because the queens are the first to appear in spring, it is not surprising that the workers make their appearance before those of other species. In 1917, I collected workers feeding on the flowers of *Collinsia verna* in the University Woods on May 14. This was a little more than a month after seeing the first queens. After this date I frequently saw them, and on May 25 they were very common on the flowers of *Hydrophyllum appendiculatum.* Workers always resulted from the eggs first laid by the queens in colonies under observation. Their production reached its maximum during the early part of June and none were produced in my colonies after June 30. The workers which emerged after the middle of June were much larger than those produced earlier in the season.

The males of *bimaculatus* are the first males of any species of bumblebee to appear in Central Illinois. This is evident not only from the early appearance of males in colonies under controlled conditions, but also from captures of males under natural conditions. Their early appearance, too, is not due to abnormal conditions, such as frequently cause males of various species to be produced much earlier than the majority of their kind, but to the peculiar seasonal adjustment of this species of bumblebee. Males were produced in two of my colonies, in 1917, as early as June 18. The majority of the males appear in July, but males emerged as late as September 6. It should be stated though, that these latter males were produced under unfavorable conditions and from eggs laid by workers at a late period of the season. The early appearance of the males under natural conditions is substantiated by the capture of numerous males flying about in the University Woods on July 19 and 20, 1917.

The young queens appear about or shortly after the majority of the males have emerged. Because of their reticent habits, however, very few of these young queens are encountered out-of-doors. Queens of *B. bimaculatus* are also one of the first, if not the first, bumblebees to appear in other parts of their range. This is evident from the study of a large series of pinned specimens in various collections throughout the country. What has been said, also, regarding the appearance of the males in July, in Illinois, holds true for other localities, such as Kansas, New Jersey, Pennsylvania, New York and Maryland. Plath (1922) has shown that the same condition prevails in Massachusetts and the data given by Jackson (1920) show that such is the case in the vicinity of Washington, D. C.

5. Caste ratio

In only one colony did the total number of males and queens produced exceed the number of worker progeny. Experiment 11, 1917, produced fifty-five workers, forty-two queens, and thirty-two males. In Experiment 15, 1917, there were produced fifty-six workers, thirteen queens, and twenty-one males. As a rule, in all my colonies two workers were produced for every male and nearly three workers for every queen. In some experiments more males were produced than queens, but in strong colonies as many or more queens were produced than males. Weak colonies are responsible for the production of more males than queens, due in the cases under my observation to the prominent part that the workers take in egg-laying in such colonies. In the colony of this species which Franklin found, the worker caste was numerically the strongest of the three, but the other castes were nearly as abundant. The largest colony studied by Plath (1922) contained about three times as many workers as young queens, but there were some queen cells still in the nest.

6. Size of colonies

Judging by the size of the colonies produced in my boxes, those I have found in the field and the records of Plath and Franklin, the colonies of this species never attain large size. The largest colony that I have studied, Experiment 11, 1917, produced one hundred and twenty-nine bees. Most of the other colonies were much smaller than this. The production of males and queens in midsummer, is without doubt the cause of the small colonies produced by this species.

7. Color Variation of Adults

The colors of the pubescence and their arrangement are usually the same with the workers and queens of *B. bimaculatus*. The colors exhibited by the males, however, are more variable. Some males present the same color pattern of the females; namely, with dorsal abdominal segments black, except for the first and basal middle portions of the second segments, which are yellow. Others found in the same nests with typical forms deviate from this by having a varying amount of yellow pubescence on the areas which are normally black. For these latter forms the varietal name of *ridingsii* Cresson may be used. A tendency for rufous pubescence to replace black on certain dorsal abdominal segments of specimens from Massachusetts has led to the recent description by Bequaert and Plath (1925) of the variety *ahenus*. Another variety, based upon black occiput and broad, black, interalar band, has been named by the same authors as *arboreti*. Judging by a study of a large series of specimens, var. *ridingsii* Cresson is of common occurrence and widely distributed, whereas varieties *ahenus* and *arboreti* are rare and of local distribution.

As is the case with all bumblebees, there exists a variation in the size of all castes. The greatest, or rather the most consistent variation in size, occurs in the worker caste. Franklin gives the length of the workers as "8 mm. to 15 mm." and I have seen workers in some of my colonies which presented even a greater range in size. Workers are frequently produced which are almost the size of queens, and I have frequently been in doubt whether to class a particular female as a large worker or a small queen. The fact that workers attain large size is of particular interest and has been discussed in another paper (Frison, 1927c). There is also considerable variation in the size of the males and I have seen specimens varying in length from ten to nineteen millimeters.

I have never observed any significant variation in the form of the male genitalia of males reared from the same nest, but the size of the claspers varies in correlation with the size of the bee. The same may be said of other structures of taxonomic importance, such as the malar space. Abnormal or freak specimens are sometimes found in the nests, but their condition is due to malnutrition, injury, etc.

8. Cocoons and food storage

The larvae ordinarily spin their cocoons about two days before they pupate. Some silk, however, is spun by the larvae earlier in the course of their development and serves to hold together the walls of their cells. In correlation with the variation in the size of the adults of all castes, there is a variation in the size of the cocoons. During the course of my studies on this species I measured several cocoons with the following results:

Experiment Number	Year	Sex	Greatest Height	Greatest Diameter
11	1917	worker	18 mm.	11 mm.
11	1917	"	18 mm.	10 mm.
11	1917	"	17 mm.	12 mm.
11	1917	"	18 mm.	12 mm.
11	1917	queen	21 mm.	13½ mm.
11	1917	"	21½ mm.	13 mm.
11	1917	male	15½ mm.	18½ mm.
11	1917	"	15 mm.	8 mm.
11	1917	"	15 mm.	8½ mm.
2	1919	"	11 mm.	9 mm.
2	1919	queen	17 mm.	12 mm.
2	1919	"	15 mm.	12 mm.

Soon after the cocoons were spun they were cleared of the wax-pollen material which surrounded them by the bees in the nest.

When thus exposed, the cocoons were bright lemon-yellow in color. The adults emerged by partially cutting the tops off their cocoons, and shortly afterwards the empty cocoons were speedily renovated and adapted for the storage of both pollen and honey. Storage pots of wax and pollen were constructed from time to time and usually constructed on the side of the comb. These pots were utilized for the storage of both honey and pollen, but honey was more commonly found in them in the earlier part of the season. Since this species does not have the habit of making waxen pouches on the sides of growing larvae, it would be classified by Sladen (1912) as a ''Pollen-storer.'' Plath (1927) has given us the term ''Amarsipoea'' as a substitute for ''Pollen-storers.'' It seems, however, that the sectional name *Anodontobombus* Krüger (1917 and 1920) (recognized as applicable to North American species by Frison, 1927d) can probably be used both for biological or morphological classifications.

9. Mating

I have never seen males and females of this species copulating in my nest boxes or under natural conditions. Copulation under controlled conditions, however, was secured, details of which have been given in a previous paper (Frison, 1927b). In the University Woods on July 19 and 20, 1917, numerous males of this species were observed which were following a definite course in their flight. Each male as it flew past, followed almost the same path as its predecessor, encircling the same bushes and small trees. So pronounced was this ''stream'' of male bumblebees and so simliar the course followed by all of them, that by placing myself at a certain point between two bushes I could catch many of the males as they flew past. There were so many other similar bushes and young trees within a few feet distance of those which the males always encircled, that I was convinced that these males were following a scent left by some young queen which had recently followed this course in her flight. The production of males and queens at this time, and the results of my experiments with controlled matings of this species, clearly prove that copulation as a rule takes place in the case of this species during midsummer.

10. Miscellaneous

It is interesting to know that this species apparently has its counterpart in Europe in *Bremus pratorum* (Linn). The latter, according to Sladen (1912), Hoffer (1883), and other authors, produces small colonies, the old queens appear very early in spring and commence nesting earlier than those of any or most other species, the males and new queens are produced in June and July, and the colonies break up in July or shortly afterwards. Likewise, the nests of *pratorum* are generally found in woods or under brush or trees.

11. Domestication

This species readily lends itself to domestication, or, if preferred, a less pretentious term, semi-domestication. Frison (1927a) reports in more or less detail the results of his experiments in 1917, 1919, and 1920 in rearing colonies of *B. bimaculatus* in artificial nests. Normal colonies of this species were produced from queens placed in artificial nests with or without the aid of workers. Other evidence of the suitability of this species for semi-domestication has been published by Plath (1923). In other papers by Frison (1926a, 1927b) it has been demonstrated that the queens of this species can be attracted to artificial domiciles in spring, that males and females will readily mate under controlled conditions, and that queens produced and mated in fall will hibernate in artificial hibernacula.

Thus, from the standpoint of purely biological studies, *B. bimaculatus* offers exceptional advantages to the laboratory worker. To those interested in the economic exploitation of bumblebees, the small size of the colonies and the early seasonal adjustment of the species make this species less valuable than certain others.

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PLATE VI

Fig. 1. Comb of *Bremus bimaculatus,* showing: *a,* worker which has just emerged; *b,* wax-pollen honey-pots; *c,* larval cells. May 31.

Fig. 2. Comb of *Bremus bimaculatus,* showing: *a,* cocoon used for the storage of honey; *b,* cocoon; *c,* larval cells; *d,* wax-pollen pots for the storage of honey. May 31.

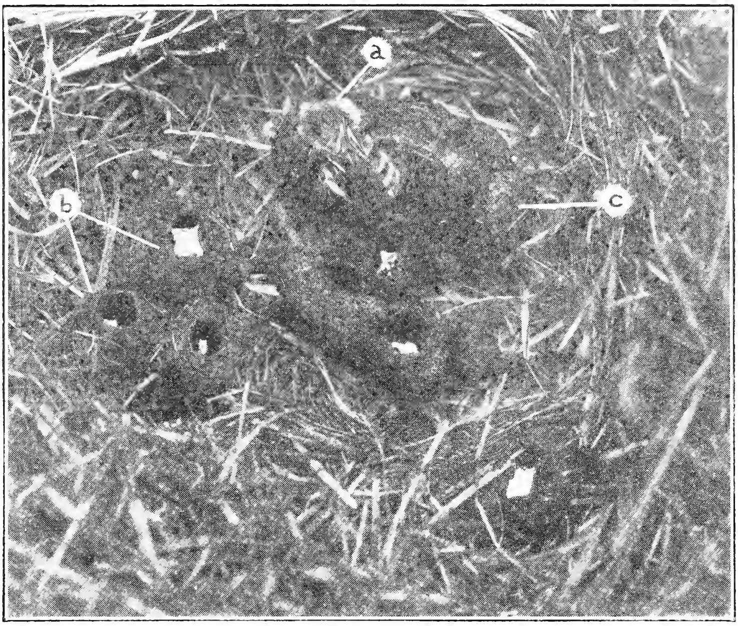

Figure 1.

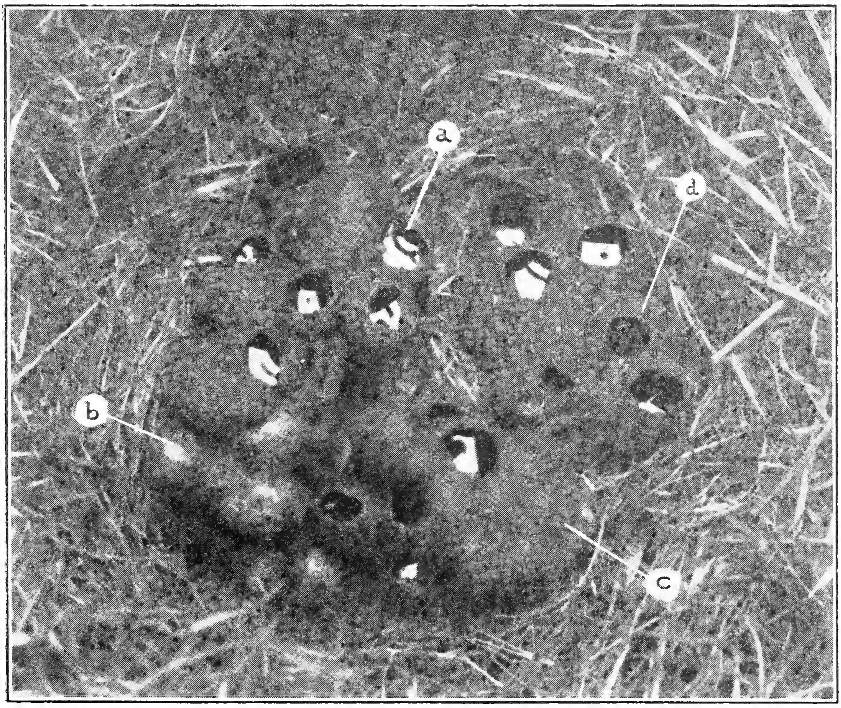

Figure 2.

PLATE VII

Fig. 3. Comb of *Bremus bimaculatus,* showing: *a,* wax-pollen pots used for the storage of honey; *b,* cocoon used for the storage of pollen; *c,* egg cell; *d,* larval cells. June **14**.

Fig. 4. Top view of the comb of *Bremus bimaculatus* which has passed climax development. August 6.

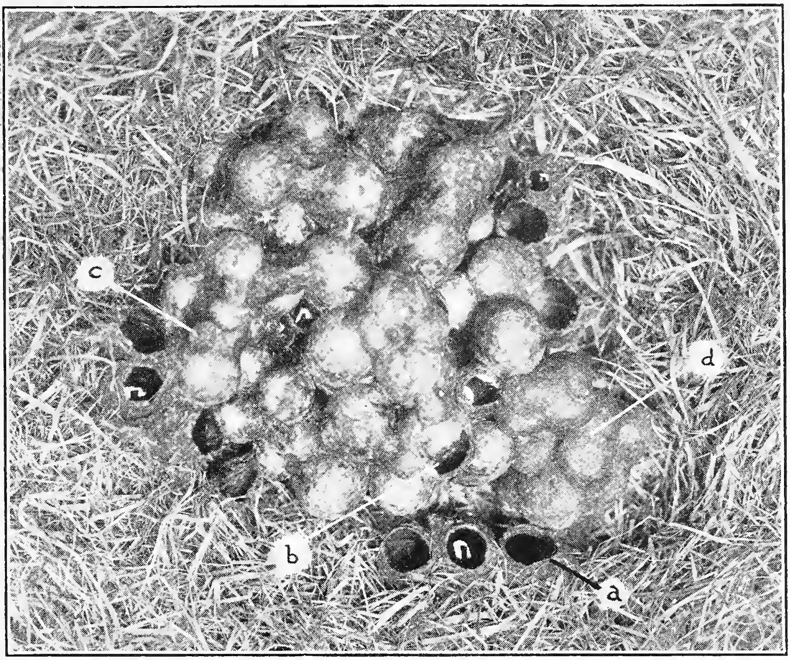

Figure 3.

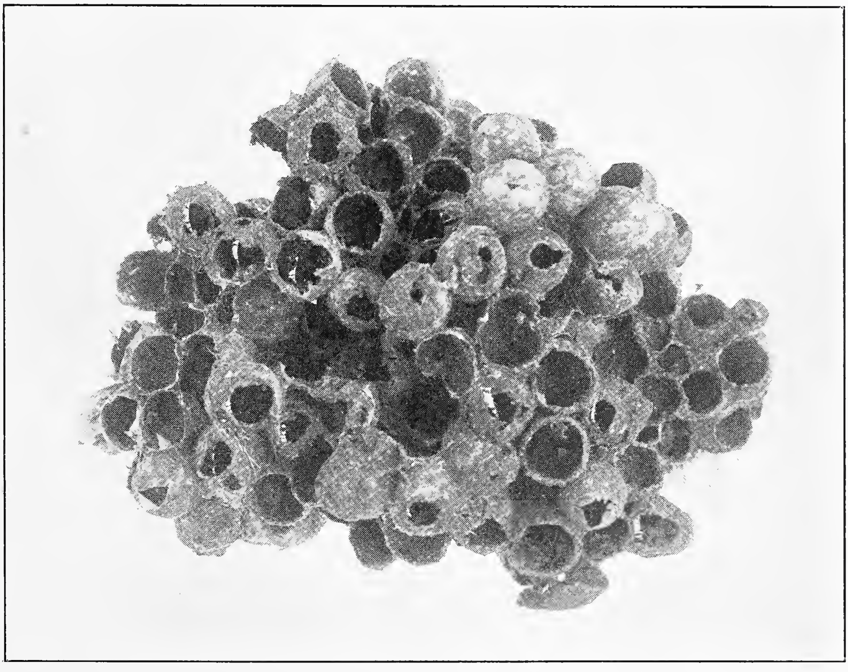

Figure 4.

PLATE VIII

Fig. 5. Side view of the comb of *Bremus bimaculatus* which has passed climax development, showing the layer-like arrangement of the comb. September 6.

Fig. 6. Queen and young worker of *Bremus bimaculatus* brooding on comb: *a*, queen; *b*, worker; *c*, larval cells; *d*, artificial honey-pot. May 10.

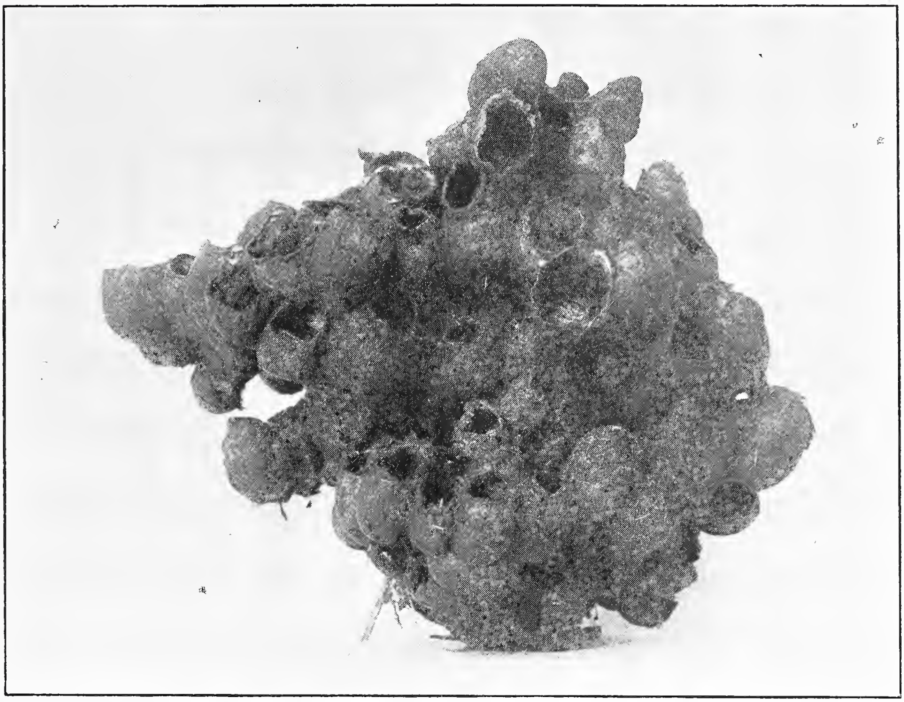

Figure 5.

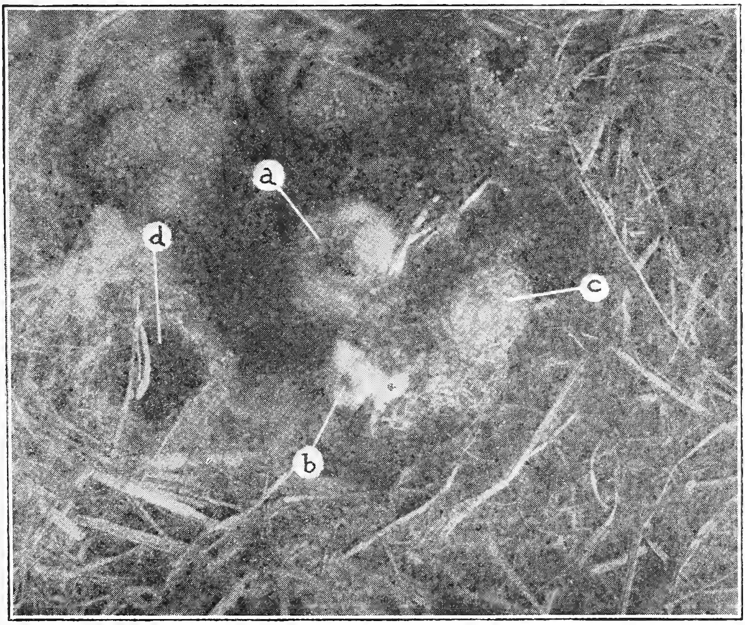

Figure 6.

PLATE IX

Fig. 7.—Nest of *Bremus bimaculatus* found under log, showing: *a,* recently emerged worker; *b,* one of four dead queens found in nest débris; *c,* cocoons. May 26.

Fig. 8. University Woods the last of May, 1919. The type of community in which colonies of *Bremus bimaculatus* are most frequently found in the vicinity of Urbana, Illinois. Nest found under log.

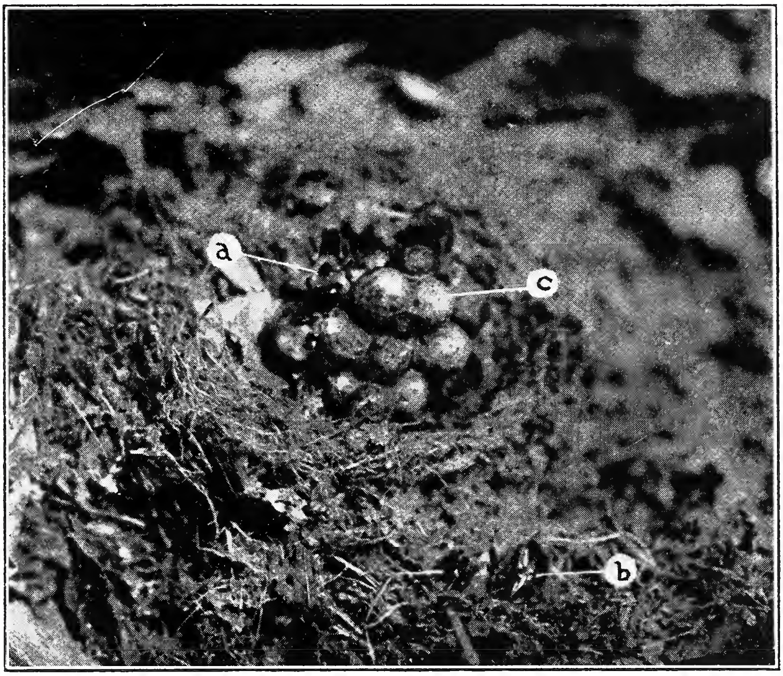

Figure 7.

Figure 8.

Hillebrand