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CONTENTS.

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ON THE LIFE-HISTORY OF *ALEOCHARA BILINEATA*, GYLL., A STAPHYLINID PARASITE OF *CHORTOPHILA BRASSICAE*, BOUCHÉ.

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(WITH PLATES I AND II AND 1 TEXT FIGURE).

CONTENTS.

I.—PREFACE.

The present paper is the first of a series dealing with the parasites of some common injurious insects which are found in the soil at some stage of their existence.

In addition to the Staphylinids *Aleochara bilineata* and *Aleochara nitida,* the following hymenopterous parasites have also been bred from puparia of *Chortophila brassicae,* the cabbage-root fly :—The Ichneumons *Atractodes tenebricosus,* Grav., and *Phygadeuon fumator,* Grav., and the Cynipid *Cothonaspis* (*Eucoila*) *rapae,* Westw. I hope to deal with some of these species in greater detail in a future paper.

The work has been carried out in the Department of Agricultural Entomology, of the Manchester University. I am greatly indebted to Dr. A. D. Imms for encouragement and advice during its progress.

The help of John G. Williams, laboratory assistant in the Department, has been much appreciated in the tedious task of collecting puparia. I wish also to express my thanks to Dr. C. Gordon Hewitt, Dominion Entomologist, Canada, for his kindness in supplying me with various references and extracts from journals not readily accessible here. Other assistance, especially that rendered by Dr. D. Sharp, is acknowledged further on in this paper.

II.—Historical and Introduction.

Although the cabbage-root maggot, or larva of *Chortophila brassicae*, has been the subject of numerous investigations since 1883, when Bouché described it as often destroying whole cabbage fields, comparatively little attention has hitherto been bestowed on the parasites of this destructive and widely distributed pest.

In 1894 Slingerland (16) collected together all the facts known at that time bearing on this branch of the subject, and discussed them very fully in his well-known bulletin, "The Cabbage Root Maggot." In this work he mentions the various parasites of the root maggot which were known up to that time (1894), and the paper contains an account of a Staphylinid beetle which was included in the list of natural enemies of that host. This insect was considered to be identical with *Aleochara nitida*, Grav., which has been known in Europe for more than a hundred years; it was also recognised in America in 1836, and described by Say as *Aleochara verna*.

According to Slingerland, nothing appears to have been recorded of the habits of *Aleochara nitida* until Sprague, in 1870 (17), first detected its association with the cabbage-root maggot. As Sprague's discovery is apparently unrecorded in British entomological literature, a summary of his papers may be of interest to those who are unacquainted with his work.

After describing the effects produced by the fly larvae on his cabbage plants, Sprague further relates that on June 20th he obtained twenty-six pupae from the soil near an infected plant, and these were placed in boxes containing soil. On July 12th he found flies therein, which he identified as *Anthomyia brassicae*, Bouché. A further examination on July 15th revealed a small black Rove-beetle new to his collection. He then presumed the beetle came from a Staphylinid pupa accidentally put in the box with the soil, but on July 17th he was greatly surprised to find six more of the same species of beetle, where he expected to find two-winged flies. Six of the fly puparia were found each with an irregularly-shaped hole gnawed through the side, and this observation led him to the obvious conclusion that the beetles had emerged therefrom. A careful examination of the remaining puparia was then made with the microscope, but Sprague could detect no break or orifice by which the beetles could have entered the puparia; each segment was entire. On opening the puparia which remained he obtained from them three imagines and one pupa of the Rove-beetle; the other puparia contained living fly pupae. Sprague concludes his first note as follows :—"thus proving beyond a doubt that either the eggs, or what seems more probable, the young larva of this *Staphylinus* entered the fly larvae long before they had arrived at maturity."

Sprague's account is interesting as it appears to be the first contribution to our knowledge of the life-history of any member of this genus (*Aleochara*). His final conclusion, however, is incorrect, being based upon erroneous observations.

As a matter of fact neither the eggs nor the young larvae of the Staphylinid enter the fly larvae. As will be shown subsequently, the young larvae bore their way into the *puparia,* and the apertures they make in so doing are not difficult to detect. In a later note on the same subject (18) Sprague expresses his opinion more guardedly. After restating his previous account, he writes :—"thus proving, so far as I can judge, that the fly larva was entered before its skin had hardened into the pupa case."

The genus to which the beetle belonged was determined by Dr. Horn, and Sprague, who believed it to be a new species, gave it the name *Aleochara anthomyiae.* American systematists, however, have subsequently regarded *A. verna* and *A. anthomyiae* as identical with *A. nitida,* although Heyden, Ritter, and Weise (1906), consider *A. verna* distinct from *A. nitida* (7). The latter authorities also regard *nitida* as a synonym of *bipustulata,* Linn., which they include in the genus *Coprochara.*

Barnard, in 1880 (1), made some observations on the same Staphylinid; he found the adult beetles attacking, and feeding upon the living, full-sized cabbage-root maggots.

In 1890, Fletcher (4), as the result of his observations on the same insect, considered it to be a true parasite; he says :—"Not only is it extremely active in preying upon the maggots, but it is also a true internal parasite, feeding inside them and completing its transformations inside the pupa case." From this statement it would appear that Fletcher also held the opinion that the larva of this beetle enters the maggot and feeds therein, completing its development within the puparium subsequently formed.

A short discussion on the habits of *Aleochara* was held at the

Third Annual Meeting of the American Association of Economic Entomologists in 1892 (8). Mr. Schwarz considered the larvae of these beetles not to be true parasites but simply predatory. Mr. Fletcher, from the results of his observations, considered them to be true parasites. Schwarz, in his reply, stated :—"that the beetle larva has no approach to the parasitic habitus"; he also quoted Coquillet as having noticed the larvae of *Aleochara* enter the puparia of *Anthomyia*. Coquillet, in 1891 (2), however, observed a larva of *Maseochara valida,* Leconte, gnawing its way into a puparium of *Copestylum marginatum,* a Syrphid. At the expiration of a month, this larva, having eaten up the dipterous pupa, emerged from the puparium and spun a cocoon, from which the adult beetle issued about eleven weeks later. This result was subsequently confirmed on more examples. The larvae of this Staphylinid are apparently predatory and not parasitic. Probably these observations by Coquillet led Schwarz to affirm that the larvae of *Aleochara* were not parasitic, although he appears to have misquoted Coquillet.

Finally, Fletcher, in 1901 (5), in his annual report, refers briefly to this beetle. Discussing various kinds of root maggots, he says :— "The small Staphylinid beetle, *Aleochara nitida,* Grav., which is certainly a true parasite on these maggots, occurred in large numbers on some sandy lands at Ottawa, and at the end of the season hardly any maggots or pupae could be found in a place where they are usually very numerous."

This is the latest reference that I have found concerning this insect. Both Sprague and Fletcher, apparently the only observers who made any attempts to investigate its life-history, believed that its larvae were parasitic. Apparently neither of these observers saw a fully grown larva; had they done so, any doubts they may have entertained as to its parasitic habits would have been dispelled. Judging from the evidence at his disposal Slingerland evidently also believed that the larvae were parasitic, although he never met with the beetle during the course of his investigations.

One of the most recent papers on the cabbage and onion flies by Paillot (13), contains no further information on the parasites of *C. brassicae* other than that given in Slingerland's bulletin published twenty years ago.

This beetle first attracted my attention in the summer of 1911. In that year cauliflowers and brussels-sprouts in my own and neighbouring gardens were severely attacked by cabbage-root maggots, and the opportunity was taken to collect a number of larvae and puparia for class purposes. Although ignorant then of Sprague's discovery, my experience was similar to his, and I was probably equally surprised to find beetles present in the breeding-jars shortly after flies commenced to emerge. On opening a few of the remaining puparia, pupae and imagines of the beetle were also found within them. Reference was then made to Slingerland's bulletin where Sprague's account of his discovery was found, and subsequently the beetles were identified as *Aleochara nitida*.

In view of the scanty information regarding the life-history of that and other allied species which had been recorded up to the date of Slingerland's paper, and indeed to the present time, it was recognised that a more detailed study of its life-history was desirable, and that such a study would probably yield interesting results. Various circumstances, however, prevented my giving any further attention to the subject until the latter end of 1913, when observations were renewed.

Before proceeding to describe the life-history of this beetle it will be necessary to explain why the specific name *Aleochara bilineata* is used in this paper instead of the name *Aleochara nitida* as used by previous writers on the subject. Of about two dozen beetles that were reared from puparia during the spring and the summer of 1914, only one agreed with the description given of *A. nitida*. One of the features exhibited by this species is the presence of red spots at the apex of the elytra. The single example referred to possessed the red spotted elytra, whereas all the other possessed black elytra, and also exhibited other small differences. These individuals were regarded as belonging to the variety *bilineata*, Gyll., of *A. nitida*. At the suggestion of Dr. Imms, living examples of this form were submitted to Dr. D. Sharp for examination, and he very kindly undertook to examine these specimens. Dissections of the male genitalia were made, and Dr. Sharp informs me that a comparison of these dissections with corresponding ones of *A. nitida* leaves no doubt as to *bilineata* being a distinct species from *nitida*. The same nomenclature has previously been used by Ganglbauer (Käf. Mitteleur. II, p. 41), but has not yet been generally accepted by the students of Coleoptera in this country.

My best thanks are tendered to Dr. Sharp for the interest he has manifested in this question, and for the trouble he has taken to establish the fact, from evidence based on anatomical data, that these two forms are specifically distinct. Ganglbauer's determinations were based apparently on external characters only.

In the following pages the life-history of the Staphylinid *Aleochara bilineata* only will be considered, and it has been assumed that the life-history of *A. nitida* is similar. During the course of this investigation, however, observations have been made on the hymenopterous and other parasites of the cabbage-root maggot. Material has been collected for a further paper on this subject, and this, it is hoped, will be ready for publication in the near future.

III.—Material and Methods.

Puparia of the cabbage-fly were collected from various market-gardens and allotments in the vicinity of Northenden, and Sale, Cheshire. They were collected every month in 1914, except during April and May, and also in the early months of 1915. It is noteworthy that puparia of this fly may be collected, wherever cabbages and related vegetables are grown, during every month in the year. Puparia from the first brood of flies produced in the year may be found in June and July. The puparia resulting from the second brood of flies may be collected during August and September. During the succeeding months, until May or June of the following year, they are also present in the soil; whether these are also the offspring of the second brood of flies, or the progeny of a subsequent one, is at present uncertain. It does not appear tc be proved that three generations of the cabbage-fly are produced in one year in this country, although statements to this effect are frequently made.

After collection the puparia were washed either with water or weak salt-solution to remove the adherent soil, and whilst still moist they were examined under a low power of a Zeiss binocular microscope. In most cases moisture renders the puparium semi-transparent. If it then be strongly illuminated, either by sunlight or artificial light concentrated by means of a condenser, the contents become visible, and those puparia which contain parasites may be detected with comparative ease. After the numbers of infected puparia had been determined, they were placed in glass-topped boxes containing moistened sterilised sand, wherc they remained until required, or until the adult beetles emerged. Very few puparia were lost by adopting this method; it is necessary, however, that the sand should be kept in a slightly moistened state and the box lids should be opened occasionally for ventilation.

The adult beetles live quite well in captivity—individuals having been kept alive for three months—and no difficulty was experienced in obtaining fertile females, ova, and larvae. Living larvae, and the extracted contents of puparia of the cabbage-fly, were given to the beetles for food. If puparia are placed within the breeding-boxes for the newly-hatched beetle larvae to enter, and if the proper conditions of moisture and ventilation are likewise maintained, the complete developmental cycle can be observed in the laboratory.

Experiments were also made with the object of hastening the course of development of the larvae during the winter months, by subjecting infected puparia to moist warm conditions. These attempts were completely successful; the normal rate of development being greatly increased. The parasitised puparia, containing beetle larvae in the first stage, were placed in deep glass-topped boxes. The latter were filled with moist sand to within a quarter of an inch of the top, and the puparia were placed about the same distance below the surface of the sand. The boxes were then placed in a warm room where the temperature varied, in one series of experiments, from 60.5° F. (16° C.) during the nights, to 74.5° F. (24° C.) during the daytime. These are the average temperatures obtained from daily readings of the thermometer from January 8th to February 8th, 1915. Under these conditions, which probably approximate to those occurring a few inches below the surface of the soil during the hot months of the year, adult beetles were obtained in one month from the time the infected puparia were placed in the warm room. Normally, these adults, which were obtained during the winter months, would have emerged in the months of May or June.

IV.—Life-History and Habits.

The ova of *A. bilineata* are deposited in the soil, probably near roots of cabbages, etc., which are attacked by larvae of *C. brassicae*. The exact number of ova laid or matured by the female beetle was not determined, although a few recently-emerged females were dissected, and the mature or nearly mature ova found within their bodies were counted. The number of such ova varied from ten to twelve in each individual; in addition to these, numerous immature ova were also present. Little value, however, can be attached to estimates formed by counting the number of mature ova contained in the bodies of insects, as the eggs in many instances do not all mature at the same time.

The larvae hatch out in ten to twelve days from the date of oviposition. The actual process of hatching was not observed; ova which were isolated with that object in view always failed to develop. They were placed in moist chambers, but evidently the requisite conditions were not present, and the experiments failed.

Recently hatched larvae (Pl. i, fig. 2) are active little creatures, measuring about 1.5 × 0.25 mm. If disturbed and brought to the surface of the soil or sand in which they may be present, they at once commence to burrow downwards, and soon disappear. Apparently they avoid the light. Their natural habitat is below the surface of the soil, at the level where puparia of the cabbage-fly are found. In order to complete their development it is essential that they should enter dipterous puparia; whether they are restricted to the puparia of *C. brassicae*, or whether they attack those of other species of diptera, is at present undetermined.

Three small Anthomyiid puparia containing Staphylinid larvae were found during the recent winter months. The development of one larva was hastened by means of warmth, and the adult beetle obtained. It was determined to be a very small *A. bilineata*, being about one-third to one-half the size of an ordinary individual of that species. Apparently the small Anthomyiid puparia belong to a species distinct from *C. brassicae*. Until the adult flies have been bred from similar puparia, it is uncertain, however, whether they do belong to a distinct species or not. If the flies are found to be distinct from *C. brassicae* it will follow that the larvae of *A. bilineata* parasitise dipterous hosts other than *C. brassicae*. This would also account for the frequent variability in size exhibited by indvidual Staphylinids of this species and also of *A. nitida*. Fletcher (3) once bred an *Aleochara* from a puparium of the onion-fly, but its specific name was not given.

Previous observers held the opinion that the beetle larva entered the larva of the fly. Lacking definite evidence, however, these opinions were expressed with reserve. Kolbe (11), in a recent paper on ecto- and endo-parasitic Coleoptera, is very emphatic on this point; he says: "Nach Slingerland schmarotzt *Aleochara nitida* eine kleine Staphylinide Nordamerikas, in den Larven und Puppen des Dipterons *Phorbia brassicae*. Die Larve des Käfers bohrt sich in die Larven diese Anthomyide ein und macht ihre Metamorphose in der Puppe derselben durch." The statement that the beetle larvae enter the larvae of the fly is here ascribed to Slingerland, although the latter writer makes no such statement in the bulletin to which Kelbe refers. Slingerland, after reviewing the evidence adduced both for and against the view that the larvae of *A. nitida* are parasitic, evidently regarded the question as being still unsettled and requiring further investigation. He favoured the views of Sprague and Fletcher, however, that the larvae are parasitic, but he expressed no opinion as to how they may enter their hosts.

Having found a suitable puparium, the larva proceeds to gnaw a hole in the hardened wall thereof. Attempts were made to determine the length of time occupied in this process. Two larvae that were engaged in this act were observed, at intervals, for six and eight hours respectively. At the expiration of those times neither had succeeded in effecting an entry; the time that elapses is apparently very considerable. Possibly in these two instances the walls of the puparia were very hard; it is also possible that in the depths of the soil, under moister conditions, the puparium wall would become softer, and the task be thereby rendered easier and shorter.

The entrance apertures made by the larvae measure 0.08 to 0.13 mm. in diameter. They are circular in outline and are usually filled up with a white opaque substance; in a few instances this plug is dark brown in colour. It is probably a clot, resulting from an ordinary wound reaction, consisting of a fluid or other substance from within the puparium, which coagulates and becomes opaque on exposure to the air. It is, however, most essential that the entrance aperture should be effectively sealed up. A small proportion of parasitised puparia were found, containing either Nematodes, or spores of a fungus (*Fusarium* sp.[1]). In nearly every case of this kind that was examined, a dead first stage Staphylinid larva was also present, and the host pupa destroyed. It is reasonable to assume that the Nematodes gain admission through the aperture either before it becomes sealed up, or if it is imperfectly sealed. In those examples which are attacked by Fungi the infection probably commences at the same place and under similar conditions. Another possibility is that of either ova or embryos of Nematodes, or spores of Fungi, being carried inside the puparia on the bodies of entering larvae. By either of these particular forms of secondary infection the host is destroyed and the parasitic larva dies.

A considerable number of infected puparia were examined in order to discover whether the entrance aperture was constant in position or not. It was found that in almost every case the apertures were either in the mid-dorsal line or were placed dorso-laterally. In very few instances were puparia found with apertures on the ventral surface. Possibly the puparia usually lie in the soil with their dorsal surfaces uppermost, and the beetle larvae may always attempt to enter them on the upper surface.

In a few instances two larvae were found within a single puparium, whilst from the breeding-boxes a single instance was recorded of three larvae entering one and the same puparium. In the latter case all the

[1] Identified by Mr. W. Robinson, Botanical Dept., Manchester University.

larvae died; in the former cases, where two larvae had originally entered one host, both larvae were usually dead. In two instances, however, one of the two larvae had survived.

Since the puparia, required by the beetle larvae in order to complete their development, are present below the soil level at a depth varying from one to six inches, they are therefore in complete darkness, and invisible to ordinary sight. The question arises, how do the young larvae find their hosts? Their eyes appear to be but feebly developed. An account is given by Sharp (Insects, pt. ii, p. 205) of a number of blind Carabidae; some of them dwell in caves, and in these forms all the internal and external organs of vision are wanting. The tactile setae have, however, a larger development than usual, and the insects are as skilful in running as if they possessed eyes. In the recently hatched *Aleochara* larva the outer terminal lobe of each antenna bears three exceedingly long setae (Pl. ii, fig. 8), which probably function as tactile organs. Possibly by means of these sensory structures the young larvae are enabled to find their hosts in the soil.

After entering the puparium the larva may be observed moving very slowly over the pupa. They appear to confine themselves to the anterior dorsal region of their hosts, and were never found on the ventral surface.

The methods whereby the young larvae obtain ther food are not easy to determine; the larvae are so very small. Probably they make minute punctures in the pupal cuticle with their mandibles, and the larvae then ingest the semi-fluid contents which thereby escape. From indications observed on the cuticle of dead parasitised pupae, it appears probable that the young larvae obtain their food from the pupal head and thorax, and occasionally from the anterior region of the abdomen. Numerous black spots, frequently in pairs, were visible on the dorsal surface of the cuticle of these parasitised individuals. The black spots had the appearance of punctures which were closed up and by some chemical change had acquired a dark coloration. By means of forceps, pressure was also applied to the head region of infected pupae which were removed from the puparia; tiny droplets of fluid exuded as a result of this procedure, thus lending support to the above view of the process.

As growth proceeds the larva becomes very much swollen, and presents a remarkable appearance; the head, limbs, and two posterior body segments remain the same size as when the larva enters the puparium. The remaining segments of the thorax and abdomen become very much distended, owing to the stretching, or possible growth, of the intersegmental, non-chitinised cuticle. The body of the larva becomes cylindrical in shape, whereas it was flattened dorso-ventrally when the process of feeding commenced. When this stage has been attained the larva is ready to moult, and measures about 2×0.35 mm. During the process of moulting the larval cuticle splits dorsally in a longitudinal direction. The fissure extends from the anterior border of the pro-thoracic segment to the posterior border of the mesothoracic segment. Two further ecdyses occur before the pupal condition is assumed; there are therefore three larval stadia in all.

The larva of the second stadium is totally different from that of the first. It is glistening white in appearance, the cuticle of the body is soft and flexible, and is very slightly, if at all, chitinised. The antennae and mouth parts are considerably altered in form, whilst the limbs have lost their claws, are indistinctly segmented, and appear quite rudimentary in character. The anal cerci also disappear, and the larva exhibits all the characters of a parasite, which it undoubtedly is. A comparison of Figs. 2 and 4 will indicate the striking change which occurs at this moult. The larva figure (4) was fully grown; in all essential characters, however, the young larva of the second stadium resembles the fully grown one, so far as I can judge, excepting of course as regards size. In the subsequent ecdysis which occurs between this stage and the fully grown one the same characte s are retained.

At this stage of development the larva takes up a definite position in relation to the host, and is always found in approximately the same position until the process of feeding is nearly completed. A larva is figured in position on Pl. i, fig. 3. It is always present on the dorsal surface of the host with its head near the junction of the head and thorax of the pupa, and with its body lying parallel to the long axis of the puparium. Almost all its food is absorbed whilst it remains in this position. After the absorption of the anterior portion of the host's body, the larva commences to bend the anterior part of its own body in order to feed, firstly on the thorax, and finally on the abdomen of the host. When the latter stage has been reached, the anterior ventral surface of the parasite's body is parallel with and touching its posterior ventral surface, the body being thus bent on itself and forming at the bend an angle of approximately 180°. Having absorbed all the body contents of the host, the larva straightens itself out again.

The larvae feed very rapidly after entering the second stadium, especially during the summer months, or under warm conditions. In some laboratory experiments conducted in a heated room (see page 7) the larvae finished feeding and were fully fed in five to six days from the first ecdysis. In this stage they appear to obtain their food by suction. The cuticle is apparently pierced by the mandibles of the larva, and the semi-fluid contents of the host are then sucked or pumped out. If a larva that has not finished feeding be removed from the puparium and placed in a small glass vessel, its method of feeding may be observed. Its head should be placed in the teased out contents of a pupa, and it is also instructive if a little carmine be mixed with the food. The labium acts like a tongue; it is alternately fairly rapidly protruded slightly and then retracted, and appears to lap up the food in a tongue-like manner. The maxillae move outwards and inwards, and probably assist in pressing the contents of the pupa through the punctured cuticle. At the same time the pharynx and oesophagus expand and contract rhythmically in a pump-like fashion, and the coloured food can be seen through the transparent cuticle of the head and thorax passing along the anterior portion of the alimentary canal in an intermittent stream. The pupal cuticle is not eaten, and may be found lying within the puparium.

Kolbe (*l.c.*) places *A. nitida* among the endo-parasitic forms. Strictly speaking, however, the larvae are ecto-parasitic, since they feed outside the living bodies of their hosts.

During the feeding period no excretory matter appears to be passed from the anus, with the exception of an occasional minute drop of a clear fluid substance. Two days after feeding has ceased an opaque semi-fluid white substance is first got rid of; afterwards the excretory matter becomes dark brown in colour. The excretory substance is plastered all over the inner surface of the puparium, so that apparently the larva is fairly active during this phase. This excretion causes the puparium to become opaque, and consequently the activities of the larva at this stage are no longer observable. A process of deferred excretion is probably common to all insects with parasitic larvae. When all the excretory matter has been expelled the larva becomes quiescent, contracts in length, and the changes leading to the pupal state commence. In summer about twelve to eighteen days elapse from the completion of feeding to the last larval ecydis and appearance of the pupa. The pupal state lasts about the same length of time, and at the end of this period the beetle gnaws a hole in the puparium and emerges.

The actual times recorded in one of the experiments previously referred to are as follows :—

Jan. 7th. Puparia—collected on Dec. 7th and 11th—containing first stage larvae placed in warm room.

Jan. 11th. Larvae moulted and in second larval stadium.

Jan. 15th to 16th. Several larvae fully fed.

Jan. 27th to 29th. Larvae entered pupal state.

Feb. 7th to 9th. Adult beetles emerged.

The adults are very active and very ravenous. Barnard's observations as to their feedings habits were frequently confirmed; they rapidly attack the living cabbage-root maggots and soon dispose of them. It a few instances where puparia only were present in the breeding-boxes, the beetles occasionally attacked and destroyed some of them gnawing through the puparium and feeding on the contained pupa. Whether they feed on pupae under natural conditions where other food is obtainable is uncertain. It seems unusual that the adult beetles should feed on pupae which are essential for the further development of their larvae.

Very soon after emergence, the beetles copulate; at times almost immediately afterwards, and always within two or three days of that event. No fertile ova were obtained from pairs that were left together for 24 hours or less. From beetles, however, which remained together for 48 hours, fertile ova were obtained, and larvae hatched out from these ova in ten to twelve days.

The beetles excavate passages or galleries below the surface of the soil or sand in which they may be placed. At intervals these passages are enlarged, and in the chambers so produced the male and female insects are frequently to be found together. At times three, four, or more beetles were observed congregated together in one chamber. Some slight indication of social life appears to be manifested by these insects; this aspect of their lives was not, however, considered further.

At least two generations of *A. bilineata* are produced each year, corresponding with those of the host. During May and June the adults of the first generation emerge from the dipterous puparia, and their metamorphoses occupy a considerable portion of the year. The larvae, which enter the puparia in September, and possibly also in October and early November, remain in the first larval stadium during the winter months until April or May the following year. As the weather becomes warmer the process of development is hastened, and the final changes are effected in much shorter time.

From a number of infected puparia collected at the end of March, 1914, the first beetle emerged on May 20th and the last one on June 23rd. The puparia were kept in the laboratory; outside in the soil adults would, no doubt, emerge somewhat later. Cabbage-fly puparia, resulting from the first brood of flies, were collected in gardens at the end of June and early in July; of these some contained first stage Staphylinid larvae. As the incubation period for the ova of *A. bilineata* is about twelve days, it is evident that the parents of these larvae emerged somewhere near the dates given for those adults obtained in the laboratory.

It is worthy of note that the larvae remain in the first stadium for a very long period during the winter months. In most cases apparently six or seven months elapse before the first ecdysis occurs. None of the parasitised puparia, which were obtained at the end of September, 1914, and during each succeeding month until March 31st, 1915, contained parasitic larvae in the second stadium. The adult beetles of the second generation appear during August and September. Six or seven weeks elapse from the deposition of ova to the attainment of the adult condition of this summer brood.

The possibility was considered of three generations of this species being produced in a year; no definite evidence has, however, been obtained showing that three generations are normally produced in one year under the conditions prevailing in this district. Judging from the results obtained by subjecting developing larvae to warm conditions (see page 7), and judging also from the time occupied by individuals of the summer brood in completing their development, it seems quite probable that three or more generations might readily be produced under warmer climatic conditions than those prevailing near Manchester.

It will be seen from the foregoing description, and from a comparison of Figs. 2 and 4 that the life-history of this species exhibits a simple form of hypermetamorphosis, of the type in which there are only two distinctly different larval stadia. In the first stage the larva is campodeiform (Pl. i, fig. 2), and in the succeeding stages it is eruciform (Pl. i, figs. 3 and 4). The hypermetamorphosis is not so complex, however, as that occurring, for example, in the development of the Meloid beetles, *Epicauta vittata, Sitaris humeralis,* and others. In these forms there are, in addition to the above two types of larvae, one or more supernumerary larval stadia, and in the case of *Sitaris,* in those individuals which pass through the winter a pseudo-pupal stage is additionally interposed.

On Plates i and ii the appendages of the two types of larvae are contrasted; Pl. ii, figs. 14-18 exhibit the modifications undergone by the appendages of the fully grown larva as the result of its parasitic mode of life.

As Fletcher remarked, probably other species of the genus are also parasites, although nothing definite was then known of their habits and nothing further appears to have been recorded since. In the same report Fletcher states that Mr. W. H. Harrington showed him specimens of *Aleochara lata,* which were found in a breeding-jar containing cocoons of saw-flies. The possibility that they might be parasites was not realised at the time, and the fact was recorded without an examination being made of the cocoons. This observation by Harrington lends support to Fletcher's view. It is probable that the members of this genus of beetles play a hitherto unsuspected rôle in nature, feeding parasitically, as larvae, upon the pupae of Diptera, Hymenoptera, etc. The following habitats of various species of *Aleochara* are given by Fowler (6) :—Carcasses, carrion, dung, dead animals, decomposing vegetable matter, sea-weed, decaying fungi, etc. : that is to say, they are found in exactly those places where dipterous puparia are likely to be abundant. Although some of the species are very common, nothing whatever appears to be known of their life histories.[1] Westwood (21) described and figured a larva which he thought was that of *Aleochara fusipes.* Kirby, however, who saw the figure before Westwood published his description, informed the latter that he did not consider it to be the larva of any of the Brachelytra, but rather to belong to one of the Nitidulidae. Judging from the figure, Kirby apparently was correct in regarding the larva not to be that of a Staphylinid. Ganglbauer regarded the so-called *Aleochara* larva described by Westwood as a young Silphid larva. As Westwood did not rear adult beetles from the larvae, he was probably mistaken in his identification. Apart from Westwood's figure and description, which are probably erroneous as applied to an *Aleochara,* there appear to be no others extant. Further investigations of the life-histories of other species of *Aleochara* are therefore desirable, and they would in all probability yield interesting results.

V.—Description of Ova, Larvae, Pupa, and Imago.

Ova.—The ova are elliptical in shape (Pl. i, fig. 1); the average measurements of six were 0.38 × 0.32 mm. They are enveloped in a thin, transparent chorion, through which the yolky contents may be observed. When recently deposited the ova are pale greenish white in colour, but become darker as development proceeds. A few days before the larvae hatch, the brown coloured mandibles and dark

[1] I have not been able to obtain, in this country, a copy of a paper by H. Bickhardt, entitled, Parasitische Staphyliniden, Entom. Blätter, Berlin, 1912, pp. 187, 188.

eye-spots of the young larva may be seen through the chorion; the latter also becomes slightly darker in colour.

Larvae.—The newly-hatched larvae (Pl. i, fig. 2) measure about 1.5 × 0.25 mm.; they are very pale yellowish brown in colour, with the intersegmental areas creamy white. The head and the last two segments of the abdomen are darker in colour than the rest of the body. A pigmented *eye-spot* (*e*), which measures 0.015 mm. in diameter, is conspicuous on each side of the head. Attempts were made to discover whether the eye consists of several ocelli, but there appears to be nothing more than a few dark pigment granules situated just beneath the surface of the head. The *antennae* (*ant.*) are well developed; each consists of three segments, together with a terminal outer and an inner lobe, which are borne on the third segment; the later bears two prominent setae (*vide* Pl. ii, fig. 8). The outer lobe of the antenna is much darker in colour than the inner lobe, and bears four or five short setae. Of these one is curved, is slightly larger than the others, and terminates bluntly; in addition to the shorter setae there are three—proportionately—much longer setae. The inner lobe bears no setae.

The *upper lip* bears two inner short setae, and two outer and longer ones; almost in a line with the latter setae, and posterior to them, are two much longer setae (Pl. ii, fig. 11). The homologies of this setae-bearing area are somewhat doubtful. Sharp (15) states that there is no distinct labrum in the larvae of Staphylinidae. Schiödte (14) gives to this area the name epistoma. Kemner (10) calls the corresponding part "frontale und clypeus," evidently regarding it as being composed of these elements fused together. The non-committal term "upper lip" is here adopted. The *mandibles* (Pl. ii, fig. 13) are brown in colour; they are somewhat flattened dorso-ventrally and sickle-shaped, as is usually the case in many Staphylinid larvae. A prominent notch is present on the outer border of each mandible near the apex, and two setae are borne on the same border nearer the base (Pl. ii, fig 13). The *1st maxillae* (Pl. ii, fig. 9) each possess a well defined cardo (*c*), which bears a single seta. On the next segment there appears to be no suture differentiating the stipes from the terminal lobe of the maxilla; probably the lower portion of this segment corresponds to the stipes; and the terminal portion to the *mala* of Schiödte. Mangan (12) in his description of the larval first maxilla of *Syagrius intrudens,* Waterh., which in some features resembles that in the larva of *A. bilineata,* regards this inner terminal portion as a lacinia. The corresponding appendage in various

Staphylinid larvae described by Kemner (*l.c.*) is named by him "mala exterior." Kellog (9) has shown, however, that during the development of *Anatis 15-punctata* the galea and lacinia of the adult arise within the single inner lobe of the larval maxilla. It would appear therefore to be more in accord with the evidence derived from a study of the development of these structures in that species, to regard this element of the larval maxilla as representing an undifferentiated galea and lacinia combined. This course is here adopted and the term "mala" as used by Schiödte is applied to this portion of the maxilla. In the larva here described it exhibits the characters of a lacinia, and probably subserves a similar function. Two elongate setae are present on the lower half of this segment, and a similar seta is present on the upper half.

The inner border of the mala carries about six broad tooth-like setae (Pl. ii, 9) and three more slender setae; two of the latter being situated on the anterior border. The *maxillary palp* (*m.p.*) is four-jointed; its basal joint bears a single seta, and a more elongate one arises on the outer anterior edge of the third joint. The terminal joint is elongate and cylindrical; lying alongside its outer border and closely adpressed to it there appears to be either another shorter and very narrow segment, or, a seta with rounded apex.

The *labium* (Pl. ii, fig. 10) consists of the usual parts. There is a pair of short *labial palpi* (*l.p.*), a median *ligula* (*l.*), and the *palpiger* (*pg.*) bears two long, curved setae, which arise near its mid-lateral borders. The *mentum* (*m.*), which is slightly broader than the palpiger, carries two pairs of setae which are situated near the median line; those of the anterior pair are about three times as long as the posterior pair; the latter arise almost immediately behind the former. The *sub-mentum* (*s.m.*) also bears a pair of setae. Numerous hairs are borne on the various body sclerites and appendages; those on the first eight abdominal terga are all arranged on a common plan. The distribution of the hairs on the body of this small larva has not been studied in sufficient detail, however, to admit of an accurate description of them being made. The three pairs of limbs are of the type usually possessed by active free-living Staphylinid larvae and require no special mention; one of the third pair of limbs is figured in Pl. ii, fig. 7. The *anal cerci* are shorter than is usual in Staphylinid larvae of this type; they each consist of a single joint which carries a long terminal seta (Pl. ii, fig. 12); during the growth of the 1st. stage larva these setae frequently disappear; apparently they either atrophy or become broken off. The respiratory system is well developed. Externally there is a single pair of thoracic spiracles situated laterally between the pro- and meso-thorax, and eight pairs of abdominal spiracles are placed laterally on the first eight abdominal segments.

The fully grown larva (Pl. i, fig. 4) is creamy white in colour, with the head slightly darker than the rest of the body. An extended example measures about 7 × 1.8 mm.; contracted specimens measure 5 to 6 mm. long by 2 mm. across; the width is measured across the fifth or sixth abdominal segments where the body is broadest. In living individuals the greater portion of the alimentary canal is clearly visible through the semi-transparent cuticle, and at the sides of the body a pair of white opaque malpighian tubes are very conspicuous. The eyes stand out clearly as small black spots on the sides of the head; they are only slightly larger than those of the primary larva, and are apparently of no use to the larva in this stage. Short hairs are sparsely distributed over the surface of the body; they probably occupy positions corresponding to those on the body of the first instar; on the head appendages, where they have been carefully studied, they certainly do so. Each of the first eight abdominal segments bears a pair of dorso-lateral papillae; these are the lateral terminations of a dorsal transverse ridge present on each of these segments. The ridges are very prominent when the larva is in a state of contraction, but they flatten out when the larva is extended. Indications of corresponding lateral papillae are present on the meso- and metathorax. Immediately beneath the dorso-lateral papillae of the abdominal segments, and on the meso- and metathoracic segments also, there is a small papilla present on each side along the mid-lateral line.

Compared with the limbs of the primary larva, those of the later larvae are much reduced and modified (Pl. ii, fig. 14). They appear as thick, fleshy, conical papillae. The joints of the limbs are indistinct. A careful study and comparison of the chaetotaxy of these limbs, however, with that of the limbs of the primary larva would, I am convinced, enable one to homologise the segments of these degenerate limbs with those of the well-developed limbs of the 1st stage larva. The *claw* is reduced to a very minute segment (Pl. ii, fig. 14).

The *antennae* (fig. 15) possess the same number of points as those of the primary larva; they are, however, relatively much broader and thicker, and the hairs, which correspond exactly with those on the antennae of the 1st. stage larva, are very short. The *upper lip* (Pl. ii fig. 17) and mouth appendages (fig. 16) also differ greatly from those of the primary larva in that they are much thicker and broader proportionately, and have a rounded, fleshy appearance.

The *mandibles* (Pl. ii, fig. 18) differ greatly from those of the primary larva; compared with the latter they are much shorter, broader, and stouter in build. The basal half of each mandible is broadly conical in shape, whilst the apical half is flattened. One noteworthy difference is that the inner border of the mandible is notched, whereas in the mandible of the 1st. stage larva it is the outer border that is notched. Probably one of the functions of the notched mandibles, in addition to that of piercing the host's cuticle for the obtainment of food, is to enable the larvae to fix themselves on the host when feeding, by interlocking together. On the outer border two hairs, which correspond to those on the mandible of the primary larva, are present. The *anal cerci* have disappeared.

The respiratory system corresponds externally to that of the 1st instar; there is a single pair of thoracic spiracles, and eight pairs of abdominal spiracles. Each thoracic spiracle is borne on a prominent papilla (*pa.* fig. 4) which is situated laterally between the pro- and mesothorax. A smaller papilla occupies a similar position between the meso- and metathorax; apparently, however, it does not bear a spiracle. The abdominal spiracles are nearer the dorsal surface than the thoracic ones are; each spiracle is situated on the basal anterior surface of the dorso-lateral papillae.

The cuticle of the later larvae is very soft and flexible, and is but slightly chitinised. The mandibles and the head capsule, however, are more strongly chitinised than the rest of the body. At the commencement of pupation the larva contracts in length and broadens slightly. The average measurements at this stage are about 4 × 2 mm.

The Pupa.—A detailed description of the pupa is not attempted; the general features are exhibited in figs. 5 and 6. The example from which the drawings were made was light brown in colour, and apparently very near the adult condition. It measured 4.25 mm. long × 1.85 mm. wide, measured across the wings.

Viewed from the dorsal surface, the posterior border of the head is just visible. Emerging from beneath the latero-posterior borders of the thorax are the antennae. They appear from about the middle of their length to the apex, and are seen lying parallel to the sides of the elytra; the latter are widely extended. The basal portions of the wings cover the femora of the third pair of limbs, and lie immediately behind the elytra; here the articulation of the femur with the tibia is exposed.

On the ventral surface a full view of the head, which is strongly flexed ventrally, is obtained. The eyes are conspicuous, and their lower borders are covered by the basal joints of the antennae and their sheaths. The mandibles, with their dark coloured borders and apices, stand out prominently, whilst posterior to them lie the labial and maxillary palpi. The edges of the elytra are seen on each side behind the apices of the antennae and slightly nearer the middle line. The wing sheaths containing the folded wings are very noticeable; they extend posteriorly from the hind border of the second pair of tibiae to the posterior border of the first visible abdominal segment. The sheaths of the third pair of limbs extend almost to the hind border of the third visible abdominal segment. The pupal sheath consists of a very thin transparent membrane, and bears a few hairs. The pupa of *A. bilineata* is not obtected; obtected pupae are frequently met with in Staphylinidae: in this case, however, the pupa is a "pupa libera."

Imago.—The description given by Ganglbauer (l.c.) of *A. bilineata* is very short; the points in which it differs from *A. nitida* being principally referred to. The same course is adopted by Fowler (Brit. Coleopt. II) who regards *bilineata* as a var. of *nitida*.

Fowler's description of *A. nitida* is here given, followed by his description of *bilineata*, with one or two additions from Ganglbauer.

"*A nitida*, Grav. (*Baryodma* (*Coprochara*) *nitida*, Muls. et Rey). An exceedingly variable species both as regards length and breadth; black, shining, with a sharply defined red spot at the apex of each elytron; pubescence rather long, but somewhat scanty; head sparingly punctured, disc sometimes almost smooth, antennae short, thickened towards apex, black with the base obscurely pitchy, joints 4-10 plainly transverse; thorax broader than long, narrowed in front, as broad at base as base of elytra, diffusely and distinctly punctured at sides, with a smooth, longitudinal space on centre of disc, bounded by two somewhat irregular but plainly traceable rows of strong punctures (this character at once separates the species from all others); elytra about as long as thorax, strongly and thickly punctured; hind body almost parallel-sided, thickly and evenly punctured, sixth segment a little more sparingly than the others, legs pitchy black, knees and tarsi lighter. L. 3—5 mm.

Male with the dorsal plate of seventh segment of hind body finely crenulate on apical border, ventral plate distinctly prolonged and ciliate.

V. *bilineata*, Gyll. The variety differs from the type form in having no red spots at the apex of the elytra, which are unicolorous shining black; some authors consider it a separate species, on the ground that the size is a little larger, and the antennae less thickened.

with the fourth joint slightly longer; the punctuation also of the head and thorax is said to be more diffuse." According to Ganglbauer the hinder edges of the elytra may exhibit a red colouration.

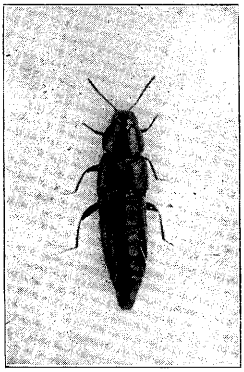

Fig. A.—*Aleochara bilineata*, ♂, × 5.

Sprague (*l.c.*) in his description of *A. anthomyiae* (*A. nitida?*) refers to the elytra as being "wholly black." Possibly the American species will be found to correspond to *A. bilineata* rather than to *A. nitida*. Comparison of the American forms with European specimens would be desirable and necessary in order to settle this point.[1]

VI.—Numerical Results, and Discussion of the Parasites of *C. brassicae* from the Economic Standpoint.

A considerable number of puparia of *C. brassicae* have been examined from November, 1913, to March 31st., 1915. The results obtained are given in the following table. No puparia were examined in the months of April and May. In these months the flies emerge, and as they emerge earlier than the beetles, the results would be untrustworthy, showing too great a proportion of parasitised to unparasitised puparia.

	No. of puparia collected and examined.	With Staphylinid larvae.
Jan., 1915.	128	6
Feb., 1915.	113	15

[1] Since writing the above I have received from Canada, through the kindness of Dr. C. G. Hewitt, six examples of the species hitherto regarded in America as *Aleochara nitida;* these specimens were bred from puparia of the cabbage-fly. Three of them have been examined by Dr. D. Sharp who reports that they are not *A. nitida* but closely resemble *A. bilineata*. The male reproductive apparatus, however, differs slightly from that latter species, and an examination of fresh undried specimens might prove it to be a species distinct from *A. bilineata*.

	No. of puparia collected and examined.	With Staphylinid larvae.
March, 1914 & 1915.	953	78
June, 1914.	24	7
July, 1914.	151	35
Aug., 1914.	49	21
Sept., 1914.	84	20
Oct., 1914.	100	13
Nov., 1913 & 1914.	264	21
Dec., 1914.	323	23
	2,189	239

Percentage of parasitised puparia, 10.9.

As may be seen, the number of puparia parasitised in the summer months is much higher than in those collected in the winter and spring. Of 308 puparia collected from late June to end of September, 1914, 83 were infected by Staphylinid larvae, or 26.9 per cent. Of the twenty-six puparia examined by Sprague, nine were parasitised by the Staphylinids, equivalent to 34.6 per cent. Fletcher obtained nine beetles from sixteen larvae and puparia of the cabbage-fly, in addition to some which failed to emerge; a much higher percentage than is shown either by Sprague's results or my own.

From the above table it will be seen that 10.9 per cent. of the puparia examined were parasitised by larvae of *Aleochara bilineata* and *A. nitida.* In addition to the pupae which are thus destroyed we may also add a percentage—as yet undetermined—of larvae which are eaten by the adult beetles; that the latter also destroy a certain number of the puparia is probable. It is evident, therefore, that these Staphylinids play an important part in checking the increase in numbers of the Cabbage-fly. Their potentialities in this respect were recognised by all previous observers of their habits. Thus, Barnard (*l.c.*), referring to the beetles feeding on the maggots, says :—"They are wonderfully active, and promise to be the best enemy against the fly, which has ruined so many crops here." Fletcher (1891) remarks :—"In addition to all that man can do to keep down the numbers of this troublesome insect, he has a most potent ally in the shape of a small beetle belonging to the Staphylinidea or Rove-Beetles." This statement is endorsed by Slingerland.

Of the hymenopterous parasites of *C. brassicae*—which will be more fully discussed in a future paper— the Cynipid *Cothonaspis rapae* is by far the most abundant. The two others occurred very rarely, and would appear to have but little effect in reducing the numbers of the pest in question.

About ten per cent. of the puparia examined were parasitised by Hymenoptera. At least twenty per cent. of the pupae and larvae of *C. brassicae* are destroyed by these Coleopterous and Hymenopterous parasites, in the district where the puparia were obtained.

If the numbers of these parasites could be increased, either by breeding them specially, or by rearing them from collected puparia, and then liberated in badly infected areas, it is likely that good results might follow.

As bearing on this point, Fletcher's remarks previously quoted are of interest; he said :—" the beetles occurred in large numbers on some sandy lands at Ottawa, and at the end of the season hardly any maggots or pupae could be found in a place where they are usually very numerous."

Evidently, if this condition of affairs could be brought about generally, the results would be very desirable from the cabbage-grower's point of view.

It is a well-known fact that the ravages of the cabbage-root maggot are very extensive. Thus, for example, Theobald (19) remarks that "The Cabbage Root Fly seems to have become an annual pest, and communications from fresh localities are always arriving"; he further reports (20) that around Newark acres of cabbages were stated to have been destroyed by the same pest.

In America the losses incurred by the depredations of the Cabbage-fly appear to be even more serious than in this country; tens of thousands of acres of cabbages and cauliflowers are said to have been utterly ruined there in a single season by this insect.

There can be no doubt of the serious destruction and loss annually effected by the larvae of this fly. Apparently no practical remedy that has been suggested up to the present time appears to reduce successfully the numbers of the pest in this country.

The various insecticides which have been proposed for the purpose of combatting the pest are either too expensive or in other ways commercially impracticable; others, either check the growth of the plant, or kill it—if used in sufficient strength to kill the maggots. The tarred discs, which are used for the purpose of protecting the cabbage-plants from the female flies, appear to drive the females to unprotected plants where eggs can be deposited with the certainty of larvae hatching therefrom; the numbers of the pest would therefore appear not to be reduced by this method.

In view of the marked destructiveness of the Cabbage Root Maggot, and of the fact that no practical remedy appears yet to have been devised that will reduce it in numbers on a large scale, the question of increasing the numbers of its natural enemies may be worthy of consideration by the Economic Entomologist.

VII.—Summary.

1. This paper contains an account of the life-history of *Aleochara bilineata,* Gyll., whose larvae parasitise the pupae of the Cabbage Root Fly, *Chortophila brassicae,* Bouché. Detailed descriptions are given of the ova, larvae, pupa and imago.

2. It is shown that the larvae of this insect hatch from the ova in the form of typical, free-living, campodeiform, Staphylinid larvae. They enter the puparia of the Cabbage-Fly, feed on the pupae contained therein, and at the first ecdysis emerge as eruciform larvae. They thus undergo a simple form of hypermetamorphosis as the result of their parasitic mode of life. Three ecdyses occur during larval life.

3. Previous observers believed that ova or larvae of the beetle enter the fly larvae; this view, however, is shown to be erroneous. After the first ecdysis the larvae feed rapidly; pupation takes place within the puparium of the host, and the adult beetle, after gnawing a hole in the wall of the puparium, emerges therefrom.

4. Two generations of these Staphylinids are produced annually —in the Manchester district—and it is suggested that in warmer climates three or more generations may be produced in a year. Adults of the first generation emerge in May and June; as larvae, they entered the host puparia in late autumn of the previous year. Apparently eight or nine months elapse whilst the individuals of this generation undergo their metamorphoses. Adults of the second generation emerge from the host puparia in August and September. Six or seven weeks only are occupied by this generation in completing the developmental cycle. The rate of development of larvae obtained in winter may be greatly increased by placing them in warm surroundings. Adults—which would normally emerge in May or June—may be thus obtained in mid-winter.

5. It is suggested that other members of the genus *Aleochara* will be found to have similar life-histories, possibly with modifications. It is also probable that the larvae of *A. bilineata* parasitise other dipterous hosts than *C. brassicae.*

6. 239 Cabbage-Fly puparia infested by Staphylinid larvae were obtained from 2,189 puparia examined, equivalent to 10.9 per cent.

The puparia collected during the summer months showed a higher percentage of parasites, viz. : 26.9 per cent. It is estimated that at least twenty per cent. of the larvae and pupae of *C. brassicae* are destroyed by Coleopterous and Hymenopterous parasites, in the district where the material for this investigation was obtained.

7. In view of the marked destructiveness of the Cabbage-Fly, and of the fact that practical methods of reducing it in numbers do not appear yet to have been devised, it is suggested that the increase in numbers and utilisation of its natural enemies is worthy of consideration.

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EXPLANATION OF PLATES I AND II.

Illustrating Mr. J. T. Wadsworth's paper on "The Life-History of *Aleochara bilineata*, Gyll."

PLATE I.

Fig. 1. Ovum of *Aleochara bilineata*. × 50.

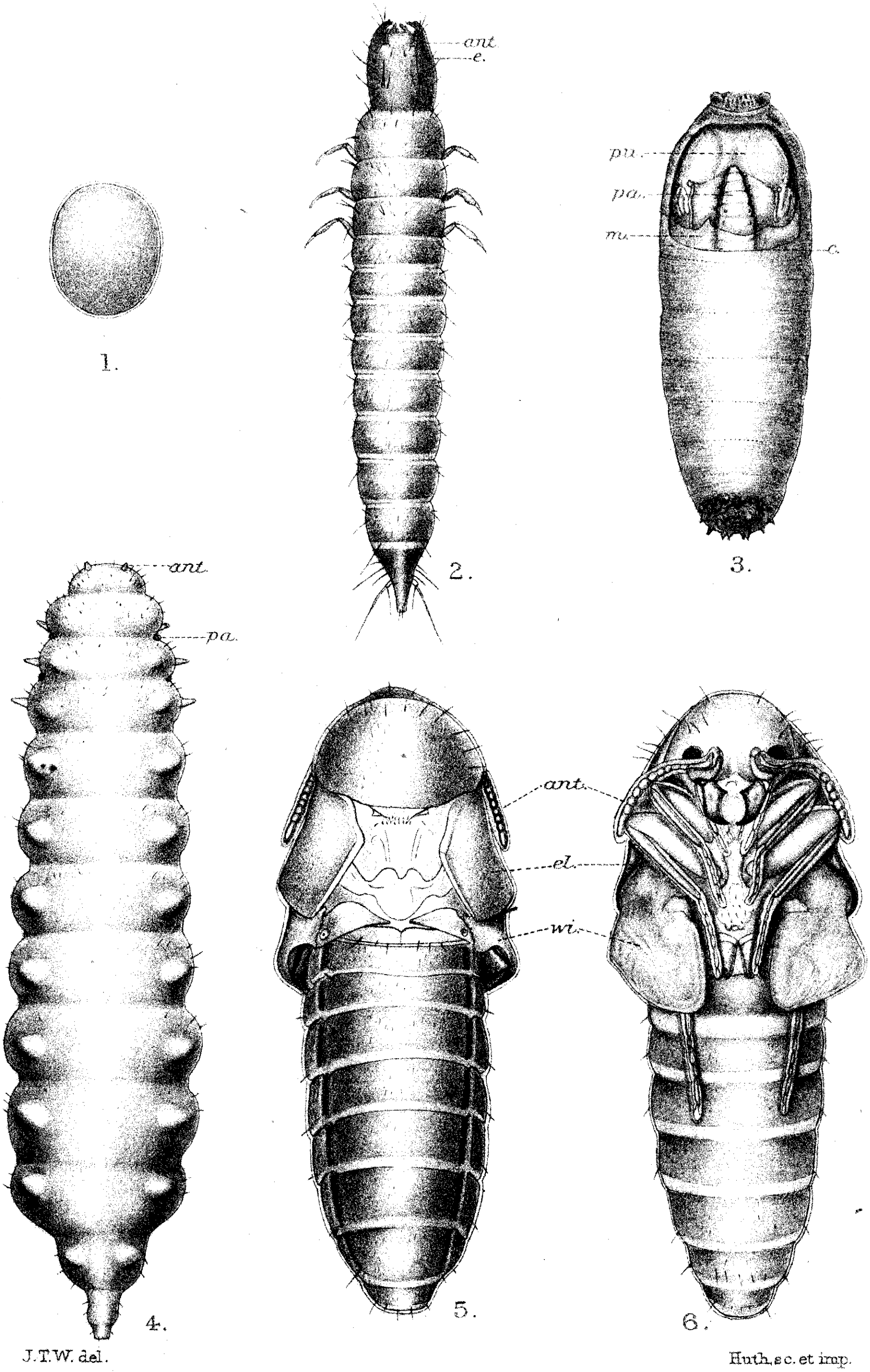
Fig. 2. First stage larva, dorsal view. *ant.* antennae; *e.* eye. × 55.

Fig. 3. Second stage larva, within puparium of host. A portion of the anterior dorsal wall of the puparium, together with the inner lining membrane of the latter, have been cut away to show the position of the larva in relation to the host. *pu.* pupa of *C. brassicae* (the host); *pa.* parasitic Staphylinid larva on dorsal surface of the host; *m.* membrane lining inner surface of puparium; *c.* cut edge of opening in wall of puparium. × 10.

Fig. 4. Mature third stage larva, dorsal view, drawn from an extended spirit specimen. *ant.* antenna; *pa.* papilla which bears anterior spiracle. × 15.

Fig. 5. Pupa, dorsal view. *ant.* antennae; *el.* elytra; *wi.* wings. × 20.

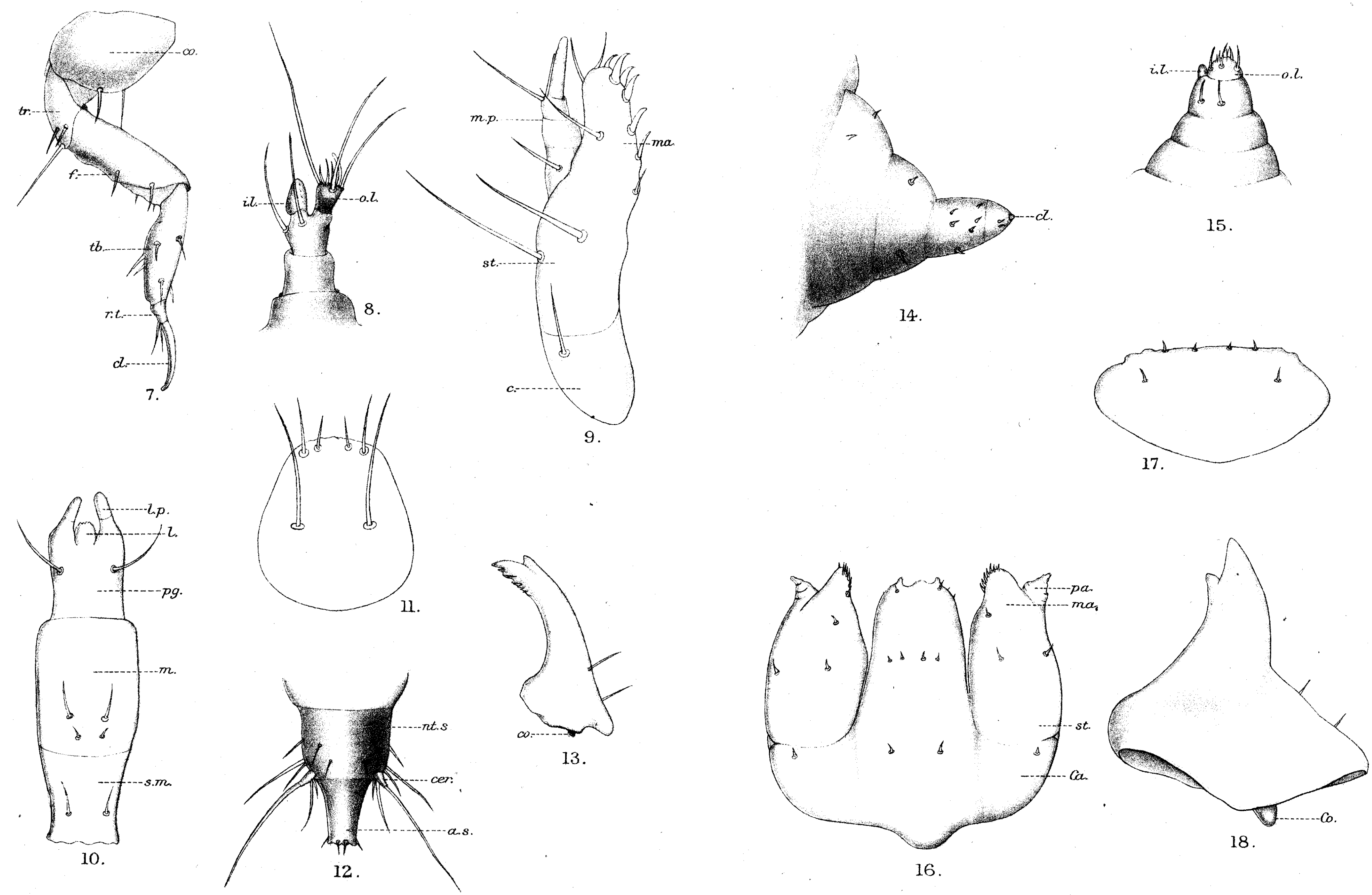
Fig. 6. Pupa, ventral view. Lettering as for fig. 5. × 20.



J. T. W. del.

Huth, sc. et imp.

ALEOCHARA BILINEATA, *Gyll.*



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ALEOCHARA BILINEATA, *Gyll.*

Plate II.

Fig. 7. Right leg of third pair, first stage larva of *A. bilineata; co.* coxa; *tr.* trochanter; *f.* femur; *tb.* tibia; *r.t.* rudimentary tarsus; *cl.* claw. × 340.

Fig. 8. Right antenna, *do.* viewed from above; *o.l.* outer lobe; *i.l.* inner lobe. × 430.

Fig. 9. Right first maxilla, *do.* viewed from below; *m.p.* maxillary palp; *ma.* mala; *st.* stipes; *c.* cardo. × 540.

Fig. 10. Labium, *do.* viewed from below; *l.p.* labial palp; *l.* ligula; *pg.* palpiger; *m.* mentum; *sb.* submentum. × 540.

Fig. 11. Upper lip, *do.* viewed from above. × 540.

Fig. 12. Terminal segments, *do.* viewed from above; *nt. s.* ninth abdominal segment; *cer.* anal cercus; *a.s.* anal segment. × 170.

Fig. 13. Right mandible, *do.* viewed from above. *co.* condyle. × 340.

Fig. 14. Right leg of third pair, fully grown larva of *A. bilineata,* posterior aspect; *cl.* claw. × 110.

Fig. 15. Right antenna, viewed from above. *o.l.* outer lobe; *i.l.* inner lobe. × 430.

Fig. 16. Labium and first maxillae, viewed from below. *pa.* palp; *ma.* mala; *st.* stipes; *ca.* cardo. × 180.

Fig. 17. Upper lip, viewed from above. × 270.

Fig. 18. Right mandible, viewed from above. *co.* condyle. × 340.

NOTE.—Fig. 14 is one-third the magnification of Fig. 7.
Fig. 16 ,, ,, ,, ,, ,, Figs. 9 and 10.
Fig. 17 ,, one-half ,, ,, ,, Fig. 11.
Fig. 15 is the same magnification as Fig. 8.
Fig. 18 ,, ,, ,, ,, ,, Fig. 13.

SOME OBSERVATIONS ON THE STUDY OF PLANT PATHOLOGY.

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1. Diseases of Plants.

Plant pathology is a very comprehensive term, embracing all the ills that plants are heir to. Omitting entomology, which is outside my sphere, such ills are mainly caused by one or more of the following factors: fungi, bacteria, weather and unsuitable environment, and cultivation. If the injury were caused by any one of the factors enumerated, the plant pathologist's work would be comparatively easy, but unfortunately such is rarely the case. Two members belonging respectively to any of the different factors enumerated may be agents in causing a disease, or in some instances insects, fungi and weather conditions each play a part in promoting a disease, and in such cases it is often difficult, without close and prolonged observation to determine with certainty the primary cause of injury, and unless this is done preventive measures cannot be adopted with any hope of success.

Owing to the difficulties in the way of determining the primary cause of a disease, some secondary agent is often credited with being the primary cause, because, curiously enough, the effects of a secondary agent are usually much more obvious than are those of the primary one, yet without the preliminary work done by the primary agent, the secondary one could not have gained a foothold. This naturally has led to many mistakes in the past, and the present craze to attribute the evil to a fungus on every possible occasion, has unnecessarily augmented the list of so-called fungus parasites injurious to plant life. It is perfectly true that in many instances where a fungus is concerned as a secondary agent even, the fungus is the sole cause of injury from the cultivator's point of view, but this fact does not exonerate those plant pathologists who have never learned to see beyond what a fungus can do given the opportunity. As a very simple illustration, take the case of *Nectria cinnabarina,* Fries., which can pass its whole life as a saprophyte on dead wood, twigs, etc., but given the opportunity, if a spore of this fungus alights on a minute

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wound on a living branch, it germinates, commences growth as a saprophyte on the injured tissue of the wound, and from thence proceeds as a rampant parasite. Now in this case the fungus may perhaps be fairly set down as the sole cause of injury to the plant, and if every so-called wound-parasite gained an entrance to the plant that it eventually kills, through an infinitesimal wound, then it would be practically impossible to detect on the part of the plant pathologist, and there would be ample excuse for attributing the disease caused by wound-parasites to the sole action of fungi, or at all events to circumstances over which he could not possibly exercise control. This, however, is by no means the case, in numerous instances where wound-parasites prove destructive, and are too frequently looked upon as the sole cause of injury, the true primary cause of the disease is sufficiently obvious, and the injury in many instances could be prevented.

Hundreds, probably thousands of young trees are killed annually, or eventually die, due to injury caused by a fungus, owing to the method of planting known as "heeling in." A hole is made, the root of the tree inserted, and the earth trodden down, and in too many instances the heel of a boot bruises the trunk at the collar. Such wounds are taken advantage of by the mycelium or spores of fungi, and in due course *Fomes annosus*, Fries. (= *Trametes radiciperda*, Hartig), *Dasycypha calycina*, Fr. (= *Peziza wilkommii*, Hartig), or other fungi gain an entrance, and the work of destruction commences, but the mode of entrance of the fungus has in the meantime been obliterated.

The minute cracks in the bark of young shoots caused by a frost late in the spring, bruises due to hail, and punctures made by insects, may be enumerated amongst other primary causes of disease which are apt to be overlooked, yet the frequent girdling and consequent death of shoots put down to *Botrytis*, are primarily due to one or other of the injuries enumerated and not to the fungus which completes the injury. The breaking of branches by wind or snow, or the too frequent practice of removing a branch and leaving a "snag" which cannot possibly be protected by a growth of callus, are probably too obvious to allow of the wound-fungus, which appears in due course, to be considered as the primary cause of injury.

Most of the preceding remarks apply equally to wild or cultivated plants, but when we came to consider the many diseases practically confined to cultivated plants, a new factor is introduced, and that factor is mainly expressed by the term *cultivation*.

It is a well known fact that plants grown under glass are much more susceptible to disease than are the same kinds of plants when grown out of doors, in fact, many of the epidemics that indoor plants suffer from are unknown out of doors. Under the best of treatment a cultivated plant is placed under conditions which prevent it from exercising those subtle powers, the outcome of probably centuries of experience, in combating its enemies successfully, as proved by the fact that epidemics of disease, as we know them in connection with cultivated plants, are unknown amongst wild plants. This is probably owing to some physiological change due to cultivation, a problem which should be undertaken by a physiologist. It is certainly outside the range of the mycologist. The above statement is true of all cultivated plants, but applies more especially to plants grown under glass.

In the case of practically every cultivated plant the leading idea is to intensify or develop to an abnormal extent some one feature. Larger and more numerous tubers are required of the potato; larger and more numerous flowers or leaves are required in the case of decorative plants, while improved fruits in turn are sought after. All these desirable ends are obtained, but I think it must be admitted that such radical changes are not effected without disturbing to a very serious extent the physiological balance that the wild plant has evolved, and that this disturbance is evidenced in the much greater predisposition to disease on the part of cultivated plants, as compared with the same kinds of plants in a wild state.

In a state of nature, practically every plant has one or more fungal parasites, but you rarely meet with a wild plant that is completely swamped, or killed outright, by its parasite, as is unfortunately too frequent an occurrence with cultivated plants.

A hint as to why wild plants are not subject to severe epidemics due to parasitic fungi may be gleaned from observation as to the behaviour of cultivated plants when attacked by fungi. Soon after the middle of last century, cultivation of the hollyhock had been carried to such an extent that practically all resemblance to the wild plant from which it originated was wanting. Could it be possible that such very marked morphological changes could take place without corresponding physiological changes? I think not. The hollyhock is a native of the New World, and in common with other wild plants had its fungus parasite, known as *Puccinia malvacearum*, Mont. There is no evidence to show that the wild hollyhock suffered in any marked degree from the presence of its parasite, in fact, there are very few records of the occurrence of the fungus on the wild plant, and specimens are rare in herbaria.

By some unknown means *P. malvacearum* found its way into this country in the year 1873, and at once attacked our cultivated hollyhocks with such virulence that for several years they almost disappeared from our gardens. The cultivated plant had lost the power possessed by the wild plant of resisting the wholesale onslaught of the fungus, and the lost power could not be attributed to morphological changes alone, if at all. At the present day the hollyhock is still cultivated, and suffers but little inconvenience from its parasite, which is still present. In addition to this the hollyhock fungus attacked our wild mallows, where it can still be found, but not in the form of an epidemic, but in the proportion in which normal wild plants suffer from their fungal parasites. How is this to be accounted for? My opinion is as follows. The production of new varieties and intensive cultivation of the hollyhock waned many years ago, since which this plant has been at a standstill or stationary condition, hence its physiological balance has had an opportunity of becoming restored to a condition that enables it to resist to a very great extent the attacks of its fungus parasite. As to what this power exactly turns on is the business of the physiologist to determine. It may be due to the stock explanation, that is, that gradual elimination of those individuals least capable of resisting their enemy, which in reality does not explain anything, or as Brooks has intimated, it may come under Mendel's law. However, one fact in connection with the disease-resisting power of cultivated plants is very obvious, and that is, that those species that have not had their physiological equilibrium upset by repeated crossing, hybridisation, etc., are much more resistant to injury from fungi than are those kinds of plants subject to constant hybridisation, and subjected to all the methods known for the purpose of obtaining new varieties.

As an illustration of the last state of affairs, take the potato, which is quite as subject to "potato disease" caused by *Phytophthora infestans,* De Bary, as it was half a century ago; the reason is not far to seek. In the case of a plant of such supreme economic importance as the potato, the endeavour to improve the quality of the tuber has resulted in the production of many hundreds of varieties, the outcome of hybridisation. The majority of these varieties, for various known and unknown reasons, are ephemeral in their existence, and many are highly susceptible to the disease. There are yet to be met with, in certain parts of the country, some of the older varieties of potatoes, such as "Ash-Leaves," "Lapstones," etc., that have not been tampered with, and which in consequence are fairly resistant to the disease, but the tubers of these varieties do not come up to the standard required at the present day.

From the cultivator's standpoint the tubers of potatoes have been very materially modified, both from a morphological, nutritive, and physiological standpoint respectively. The old deep-eyed tuber has disappeared, and the general contour approaches that of an egg, the result being that "sprouting" is rendered almost impossible, and a very large percentage of tubers that have attained to this standard rarely form more than one or two "sprouts," whilst large numbers develop none at all.

The physiological modifications of modern tubers are even more pronounced, and it has been shown (1) that the enzyme, whose function it is to convert the starch into sugar, so as to be directly available for growth, has to a great extent ceased to exist, hence growth or "sprouting" is checked. In olden times tubers were practically unfit for food in the spring, because they became sweet and watery, due to the change indicated above. This change is not so marked nowadays. If such marked physiological changes have been proved to have taken place, may not corresponding changes have occurred, thus favouring the hybernation of fungus mycelium in the tuber, as such is now known to exist, and is to a great extent the means of continuing the disease.

The tomato is perhaps a still better example of the effect of hybridisation, in the production of numerous varieties, all of which are highly susceptible to the attacks of parasitic fungi, whereas the old form with fluted fruit is comparatively immune. So highly susceptible are many of the modern varieties of tomato to disease, that whenever opportunity is afforded, the many fungi hovering between saprophytism and parasitism find a congenial pabulum for furthering their parasitic tendencies. Modern research has shown that many more kinds of fungi, previously considered as pure saprophytes, are capable of becoming parasites when opportunity offers than was suspected, and it is highly probable that the enormous number of hybrids created annually afford the opportunity required by saprophytic fungi to become parasitic, or to be classed in the group designated facultative parasites by De Bary. The fact that many modern hybrid plants have their own special diseases supports this view, such special diseases often being due to fungi that under ordinary conditions are saprophytes. Such modern parasites have nothing in common with the parasites commonly known as biological species, which are confined to one or a few closely allied species.

A very interesting instance illustrating the advantage of mere opportunity, in enabling a saprophytic fungus to acquire a parasitic habit, was observed at Kew recently. My attention was called to a batch of *Clerodendron fallax,* the under surface of the leaves of which showed scattered, minute glistening drops, a feature considered unusual by the gardener in charge. Microscopic examination showed that the under-surface of the leaf was studded with glands, and that each gland, under the special conditions of cultivation, emitted a minute drop of sweet liquid. In due course each of these minute drops was covered with a tuft of brown mould, which on examination proved to be *Cladosporium epiphyllum,* Link. For some time the fungus was strictly confined to the sugary drops, living as a pure saprophyte, no trace of mycelium being present in the tissue of the gland. A fortnight later the fungus had extended beyond the area of the gland, and mycelium was present in the tissues of the leaf, and finally patches of the fungus developed on portions of the leaf devoid of glands, and formed brown, dead patches on the upper surface of the leaf, and infection experiments with the spores of the last formed generation of the fungus showed that they were capable of infecting any portion of the leaf as a true parasite. In the present instance a saprophytic condition of *Cladosporium epiphyllum,* due to favourable circumstances, became a true parasite. At this stage its career was arrested by the destruction of the plants, but it is not difficult to realise that had the *Clerodendron* been a cultivated crop on a large scale, the fungus might have become a new and injurious parasite.

Somewhat similar instances must be of frequent occurrence amongst cultivated plants, and probably accounts to some extent for the very numerous records of new diseases caused by fungi, or in other words, first records of fungi that have betrayed a parasitic tendency. Fortunately, in many instances, owing to lack of opportunity of continuing their career as parasites, as in the case of *Clerodendron* parasite mentioned above, the disease is of short duration; yet, on the other hand, where opportunity is afforded, the accidental creation of a new disease due to a fungus may assume alarming proportions when once the parasitic tendency on the part of the fungus is stimulated, and the opportunity for exercising this function remains unchecked until too late.

That parasitism on the part of fungi is an acquired habit has been fully demonstrated (2), and is generally accepted, and everyday experience shows that those fungi at one time considered as pure saprophytes can, under favourable circumstances, become parasites, and it will probably prove that such modern parasites, as they may be termed on account of their adaptability, and favoured by the high standard attained to in the cultivation of economic plants, which entails their reduced power of resisting disease, will increase in numbers in the future.

Apart from the obligate parasites, rusts, smuts, and mildews, the comparative rarity of unmistakably parasitic fungi on wild plants is notable, whether in temperate or tropical regions. I have spent years in tropical forests, ever on the look out for fungi, and I cannot remember having once seen a member belonging to the Agaricaceae, Polyporaceae, or the Thelephoraceae that could be considered more than a wound-parasite, or growing on a tree that was obviously far past its prime, and I am inclined to consider that when a fungus has acquired a parasitic habit with a given host-plant, in course of time the balance between host and parasite becomes so adjusted that the fungus no longer acts as an injurious parasite, but slows down to the facultative parasite stage, or may even cease to be parasitic in any form on that particular host-plant.

This means that parasitism is not a fixed character when once acquired, but that its continuance is entirely dependent on circumstances, the influences being probably exercised by both fungus and host. My reasons for this line of thought are as follows:—It is a well-known fact that when a fungus has evolved a parasitic habit in connection with a given host-plant, the injury is most virulent at first, and gradually dwindles in intensity, provided the host remains free from the baneful influences due to cultivation, and eventually the injury becomes a negligible quantity, as in the case of the hollyhock.

In the tropics the same experience holds good. Fungi that are saprophytes, or wound-parasites at most, on the indigenous plants, at once become destructive parasites on introduced plants (*Hevea,* etc.), partly due to what may be termed lack of experience as regards the new enemy, and partly due to being placed under new conditions of growth, not always of a congenial nature.

As regards what may by way of comparison be styled ancient parasites, as the rusts, parasitic on equally ancient cultivated plants, the cereals, the case is different; these fungi have passed through their phases of parasitism and have resolved themselves into practically stereotyped biologic forms, confined to one or a few closely allied species without showing any great evidence of adaptability beyond what they already possess.

2. Disease Resistant Varieties.

The idea of breeding immune varieties is very much in vogue at present, and a very laudable idea it is, but the consummation is, I am afraid, doubtful. The host of fungi ready to become parasites when opportunity offers, are, I am afraid, equally capable of adapting themselves to modifications quite as marked as can be brought to bear on any more highly evolved plants, and if my idea that new varieties of plants are most susceptible to fugus diseases, or in other words are most readily attacked by fungi, then the manipulation and crossing necessary to produce the hoped for immune varieties should result in races especially suitable for experimental work on the part of fungi. Results so far in the production of immune varieties unfortunately support this idea. The fact that comparatively immune varieties of plants have been produced is generally admitted, but too frequently the outcome is as follows :—The plant proves to be more or less completely immune in the district where it was created, but on removal to a new district it breaks down, and is often, under these new conditions, more than ordinarily susceptible to disease. This again is a problem which should prove of interest to the physiologist, and necessitates a thorough knowledge of the conditions under which the plant exists in the field.

Butler's comments on this subject are interesting (3). "Several Australian wheats believed to be resistant have failed when tried in India. On the other hand 'Kathia,' which is very liable to all three rusts at Cawnpore, was found by Carleton to be worth recommending for trial as a resistent sort to *P. triticina* in the United States. Even within the boundaries of India it is probable that resistance in one locality will not mean resistance in another. Thus spelt wheat which in Bombay and at Hissa is highly resistant, was stated to have rusted badly at Nagpur."

No amount of laboratory work alone would be likely to solve the problem, for the simple reason that laboratory conditions are in the main more or less artificial, or in other words, different to those to which the plant is subjected in the field, or under natural conditions of growth. The same remark applies to cultures of fungi generally. Remembering how much more susceptible to infection plants are that are grown under glass, as compared with plants grown in the open, where the foliage is "hard" and the physiological functions work normally, and not strained at some point due to being grown under bell-jars or other equally unnaturally conditions, it would scarcely be expected that the results of experiments would be equal under the two conditions, and furthermore many results are obtained under artificial laboratory methods that cannot be repeated under natural conditions. As an example, the oospore or sexual form of fruit of *Phytophthora infestans* is unknown in a state of nature, yet under artificial conditions Pethybridge has succeeded in producing this sexual condition, thus completing the life-history of the fungus.

Broadly speaking, laboratory work with fungi, to which my remarks, for lack of wider experience, are confined, demonstrates the line taken under special conditions rather than what the fungus does under what may be termed natural conditions, hence the results obtained cannot always, as is often assumed, be used as a basis for field-work. However, the abstract knowledge thus gained is always of the greatest value in connection with the subject under consideration.

Before we can hope to breed immune varieties in a scientific way it is necessary to know exactly what constitutes immunity. This is a physiological problem which in all probability involves an investigation of both parasite and host-plant. The present method of endeavouring to produce immune races by the haphazard method of crossing allied plants until the desired result is attained is useful in so far as it proves to be of practical value, but cannot be considered by its most ardent advocates as a scientific method. The old proverb, "Circumstances alter cases," is applicable here. It does not follow that a carefully worked out life-history of a parasite acting in a given locality, and under a certain set of conditions, proves to be erroneous because it differs from the life-history of the same parasite attacking the same host-plant in a different locality, and under different conditions. Where climatic conditions are favourable, the uredo form of wheat rust continues throughout the year, and infects the crop without the intervention of the teleutospore or winter form of fungus fruit.

Under certain conditions a fungus forms perennial mycelium which enables it to set up infection the following season; under other circumstances it cannot do this, and has to fall back on winter fruit.

It would appear that the point reached in producing relatively immune races of plants consists, from the practical standpoint, in producing races that are only immune in the district and under the conditions where they were created, and until our knowledge of the physiological changes involved in the removal of the host-plant from one locality to another are better understood than at present, it is to be feared that little progress can be made in this direction.

The breeding of immune races is by no means the only method by which disease-resistant plants can be produced. Mann and Hutchinson (4) have proved that, by means of special methods of cultivation and of pruning, the tea plant can be rendered practically resistant to "Red rust," *Cephaleurus virescens*, Kunze, which under ordinary circumstances is the most destructive parasite known to the tea planter.

A point respecting which much more information would be of value is the period of the day during which the infection of plants by means of fungus spores attains its maximum. I have shown in the case of the vegetable marrow that plants protected during the night and left exposed during the day, remained practically free from mildew, *Erysiphe cichoracearum,* DC. An adjoining batch of plants that were protected during the day and left exposed during the night were soon covered with mildew, the spores presumably coming from a batch of mildewed plants growing in the vicinity. A similar experience has been recorded in the case of grape vines in the United States. One reason turns on the fact that spores can only germinate when a certain amount of moisture is present, and in dry, hot weather this is alone present during the night, as the result of condensation on the foliage. On the other hand, I have found, in the case of the rose mildew, *Sphaerotheca pannosa,* Lév., and cucumber mildew, *Erysiphe cichoracearum,* DC., that a far greater number of spores are liberated by day than by night.

A sheet of glass very slightly smeared with glycerine, fixed six inches above a badly mildewed marrow leaf, was practically covered with conida, after an exposure of six hours of sunshine, on a perfectly calm day, whereas a similar arrangement exposed during the night showed very few conidia. Do the conidia that become liberated and float during the day fall again during the night, laden with moisture? It is usually stated in text-books that the so-called winter fruit of fungi, oospores, teleutospores, and ascospores generally, require a period of rest before they are capable of germination, and that, as a rule, they germinate in the spring following their production, at the time their host-plant is in a suitable stage of growth for infection. What this really signifies is, that in this country the temperature is usually too low during the winter months to allow of the germination of the spores, as it is well known that many kinds of winter spores will germinate at any moment, granted the requisite conditions of moisture and temperature. I find that the teleutospores of *Puccinia malvacearum,* Mont., practically refuse to germinate at a temperature below 47° F. Between 47° F. and 52° F., as a rule about 8-10 per cent. germinate, but not vigorously, whereas when the temperature hovers round 60° F., about 80 per cent. germinate vigorously during any of the winter months. The same ratio I find holds good with some other resting spores. The same is true of many kinds of winter spores in a state of nature.

I have had under observation a particular bed that has been planted with hollyhocks for the past twelve years. A certain amount of rust, *Puccina malvacearum,* Mont., was present on the plants every year, but the relative amount was determined to a very great extent by weather conditions during the winter months. A continuously cold winter, with few or no intervals of mild weather of sufficiently long duration to raise the soil temperature to near 60° F., invariably resulted in the plants being very badly attacked by rust. On the other hand, when one or more warm spells of sufficient duration occurred during the winter, the attack of rust was always very slight. During the warm periods the teleutospores germinated, and no host-plant being present, the secondary spores perished. If two or three periods occur, favourable for the germination of spores during the winter months, but few spores survive to infect the host-plants in the spring.

I have noticed the same result with other species of fungi, where a spring infection depends on the presence of resting spores, and although I do not profess to predict the relative presence or absence of mildews, rusts, etc., as depending entirely on the nature of the past winter, yet I believe it is a factor to be taken into consideration. Moreland (5) has shown that in India the relative amount of rust attacking wheat is mainly influenced by weather conditions.

3. The Distribution of Plant Diseases.

The problem relating to the spread of diseases of economic plants yet remains to be solved. It is a remarkable fact that to whatever part of the world plants are sent, the particular disease from which they suffer at home follows them. In the case of perennials and woody plants, the conditions can be understood. As an example, take apple scab, *Venturia inaequalis,* Aderhold. The fungus is perennial on the branches, and might escape the eye even of an expert, and so be introduced along with its host. On the other hand, when dealing with annual plants, and the numerous kind of plants that are never exported in a living condition but only through the medium of seed, the advent of their special parasite in their new home is more difficult to explain, yet such is the fact; peas, beans, tomatoes, etc., are often as seriously injured in far off regions by the same parasite from which they suffer at home.

The appearance of the hollyhock in Europe has already been alluded to. In 1883 Cooke described a fungus as *Cladosporium fulvum,* parasitic on tomato leaves from Carolina. About ten years later this fungus was recorded as a parasite on cultivated tomatoes in this country. At the present day it is one of the most serious of fungus parasites on tomatoes, with which the cultivator has to contend, not only in this country but also on the continent. A lover of broad beans took some seed to Uganda; the plants grew vigorously, and promised to produce a full crop, but in course of time were completely crippled by *Uromyces fabae,* De Bary, the fungus from which the same plant suffers so much at home. Quite recently specimens of the following have been received at Kew from Nyassaland. Potato leaves attacked by *Macrosporium solani*, Cke., and by *Septoria lycopersici*, Speg.; French beans attacked by *Colletotrichum lindemuthianum*, Speg. All these parasites are well known in this country as parasites on the hosts mentioned above. *Mycosphaerella citrullina*, Gos., a well-known pest on melons in the United States suddenly appeared in this country a few years ago, and under the name of "tomato canker" is now widely spread and very destructive to tomatoes.

In the examples given, to which numerous others could be added, assuming that the fungus was not already present in the country to which the plants were exported, the possible means of transport of the fungus must be by some means carried along with the seed. Now we know of two different methods by which the disease can be carried by the seed. In the case of smuts or species of *Ustilago* and allies, in some species the exceedingly minute spores adhere mechanically to the surface of the seed, and when the latter is sown, its accompanying spores germinate, and enter the tissues of the seedling. The old method of destroying such superficial spores by the use of sulphate of copper has been superseded by the use of formalin. A yet more certain method of sterilising seed by the use of hydrogen peroxide, which does not injure the seed, has recently been described (6). The method of sterilising seed, at present in vogue, by means of fumigation is useless against dry spores; it does answer with living insects, may or may not kill insect's eggs, but will not kill fungus spores. A second method by means of which disease may be introduced is by the presence of hybernating mycelium of the parasite in the seed; this has been demonstrated in wheat, and the presence of the mycelium of "black stripe" in tomatoes, *Macrosporium tomato*, Cke., has been proved by I. Massee (7).

There is no known method by which hybernating mycelium in a seed can be killed and at the same time leave the seed intact, neither is there any method by which the presence of hybernating mycelium can be detected, other than by means of specially prepared microscopic sections. The only check against the introduction of contaminated seed into a new country rests with the importer, who should ascertain that the seed was produced in a district free from disease, and this is expecting the impossible, as very few growers produce, under their own supervision, all the seed they export. Hybernating mycelium and sclerotia are often present in bulbs, tubers, and rhizomes, and their detection is often impossible in the resting condition.

It is highly probable that careful investigation will reveal the presence of hybernating mycelium as the main factor in the spread of many diseases where the means of infection is at present unaccounted for. The potato disease, due to *Phytophthora infestans*, De Bary, illustrates this idea. The oospore of this fungus is not produced in a state of nature, and the conidia or summer fruit are very short lived, their function being to infect the host-plant the moment they are mature; failing this they perish. Notwithstanding this condition of things, potato disease is present wherever the potato is grown. The discovery of perennial mycelium in the tuber solved the mystery.

It is somewhat remarkable, and suggestive of the line to be followed in future investigations, that in those fungi where a vegetative method of reproduction, in the form of hybernating mycelium, sclerotia, etc., has been evolved for the purpose of tiding the fungus over that period of the year when its host-plant is in a resting condition, the winter fruit of the fungus, primarily intended to answer the same function, has been more or less completely arrested in its development, and the conidial or summer fruit is alone produced for the purpose of extending the area of distribution. As already stated, the winter fruit of potato disease is completely arrested.

Peronospora schachtii, Fckl., an allied species, having perennial mycelium in beet and mangels, produces but few oospores; on some occasions none are discovered. Then again, the host of diseases caused by species of *Botrytis,* are mainly perpetuated by means of sclerotia, the *Sclerotinia* or ascigerous form being quite rare in some species, altogether unknown in others. Apple mildew, *Podosphaera leucotricha,* Salm., so abundant on young leaves of apples throughout Britain and elsewhere, is perpetuated by mycelium hybernating in the buds; the winter fruit is rare. Scores of other examples could be given of injurious fungi, where the winter fruit is so rare that it could not be responsible for the amount of infection required to account for the presence of so much disease.

The climax in the way of hybernating mycelium, is perhaps reached by the fungus described by Freeman (8) parasitic on *Lolium temulentum.* A patch of mycelium is present in the grain, and on the germination of the latter the mycelium keeps pace with the growing plant, and finally a patch of mycelium is formed in the seed, and on germination the same process of growth is repeated.

In this case all trace of reproductive bodies on the part of the fungus have been completely arrested; hybernating mycelium alone is present which never leaves the host-plant. From 85 to 98 per cent. of commercial seed of *L. temulentum* was found to contain the fungus mycelium, and so complete is the symbiosis between fungus and host-plant that the latter on an average produced a greater number of seeds than uninfected plants, thenceforth we have two strains of *L. temulentum,* one infected for all time, another not infected, and with no possibility of becoming so, as spores have ceased to be produced by the fungus. This condition of things is perhaps not very far removed from Eriksson's theory, if we substitute tangible mycelium for mycoplasm, and it must be remembered that the presence of very delicate mycelium is not always easy to demonstrate in plant tissues.

4.—LEGISLATION AND PLANT DISEASES.

The fact that diseases caused by fungi do, by some means or other, invade new districts and new countries, has led to meetings of an international character for the purpose of discussing ways and means, by which such invasions may in future be checked. Much has been printed already as the outcome of such consultations, and perhaps the most striking feature up to the present is the almost entire absence of any suggestion of a practical nature that would in any sense cope with the difficulties of the subject. Legislation, tempered by diplomacy, appears to be the key-note dominating such meetings.

The various subtle methods by which fungi find their way from place to place are ignored, and man alone is looked upon as the transgressor, which is by no means always the case. So long as living plants and seeds are sent from one part of the world to another, there will be the possibility, even the probability, of introducing fungi, for which, in the present state of our knowledge on the subject, no person could be held responsible.

Protection against the invasion of fungi as at present carried out is practically valueless, nay even farcical, and suggests in some instances protection of another nature. What can be more absurd than on insisting that a consignment of bulbs shall be certified free from disease before they are allowed to enter a country, when it is known, or should be known, to those who formulate the law, that each bulb would have to be cut open before the required certificate could be given. The same argument applies to potato disease, and in fact to every disease, when present in an incipient or inconspicuous form.

Experienced mycologists and plant pathologists are now to be met with in every country, but are such always employed to pronounce on the freedom or otherwise of importations, or on diseases of the home district? My own experience is to the contrary, and in many instances, I am afraid, the rule-of-thumb man, with little or absolutely no training, is placed in a position not justified by his attainments, and it must not be forgotten that horticulturists and farmers are very apt to detect bluff and incompetence, hence their belief in the assistance that can be rendered is considerably diminished.

If only those who legislate on the question of checking the extension of diseases of plants only knew, or consulted with those who do know, something of the methods by which fungi are distributed throughout the world, much that passes for law at the present day would never have seen the light. Take the case of the cereal rusts, wheat mildew, etc. The teleutospores or winter-spores adhere so firmly to the straw that they are not removed by threshing; when such straw is eaten the spores pass through the alimentary canal uninjured, and they can be found on fragments of straw in quite rotten manure capable of germination. It is only necessary to add that straw and hay on which winter-spores are certain to be present are taken to every part of the world, one time or other. Further extension of this subject is unnecessary, which alone is sufficient to account for the presence of rust wherever cereals are grown, without having to fall back on Ericksson's mycoplasm theory or the transportation of myriads of spores from one continent to another.

Several genera of European fungi, as *Pilobolus, Saccobolus, Ascobolus,* etc., are only met with on the dung of horses, cattle, etc. The spores of these fungi at maturity are ejected with force from the fruit of the fungus, and in most instances alight on the surrounding grass. The spores, when ejected, are surrounded by a viscid substance, which when exposed to the air becomes hard and insoluble in water. By such means the spores are firmly fixed to the grass. When such spore-laden grass is eaten, the spores commence to germinate in the alimentary canal, and the fruit of the fungus is eventually produced on the dung, and in due course ejects its spores. Such spores retain their vitality for a long time, and hay taken from England and other European countries, has introduced these dung fungi into practically every country throughout the world.

The spores of most fungi causing plant diseases are ejected from the fruit of the fungus, and adhere to the surrounding bodies, where they remain until conditions are favourable for germination, and as such conditions coincide with those required for the commencement of active growth of the host-plant, infection follows. Fumigation, which is sometimes depended upon, will not kill such spores in the resting condition, consequently the plant is often infected during its first season of growth in its new home. This condition of things accounts for the many instances where consignments of bulbs, tubers and plants of various kinds have been dispatched in a condition apparently free from disease, but which arrived at their destination teeming with disease, due to the conditions during transit being favourable for the rapid growth and development of the fungus concerned. Too frequently, however, the latent germs of disease, though present, do not manifest themselves during the journey, but at some later date. Quarantine, as applicable in the case of animals, appears to be the only real safeguard. A year's growth under supervision, before being distributed, would in most instances reveal the presence of any injurious parasite, granting that the inspection was conducted by a properly trained person, capable of detecting a disease during every stage of its development. At present an inspector is considered to be fully qualified when capable of recognising a disease only in its most latent stage, when all harm is done, spores dispersed, etc., and it becomes a matter of minor importance whether the disease is recognised or not, having done its worst, and fully provided for its reappearance next season.

5. The Training of the Plant Pathologist.

Most people have at last realised that fungi do cause plant diseases. This perhaps accounts for the fact that, in this country at least, it is considered that a person is competent to undertake the duty of investigating plant diseases, after having gained a certain amount of knowledge relating to fungi, in some instances followed by a period of study dignified by the name of research, which may or may not result in elucidating points in the life-history of some fungus. Of course it would be well that the life-history of every fungus should be known, but, from the standpoint of plant diseases, there is very little to show that a knowledge of the life-history of a fungus has, up to the present, been of value in reducing disease. We have known the history of wheat rust, *Puccinia graminis*, Pers., and of the fungus causing potato disease now for a considerable time, but the disease in each instance is as much in evidence as ever. The same is true of many other diseases where the life-history of the fungus concerned is known.

In the case of human ailments, the general condition of the patient is considered to be of primary importance, quite apart from the organism causing the disease. In plant pathology, the mycologist, through no fault of his own, but through the outcome of faulty training, looks upon the host-plant as a passive agent in connection with a disease, which is altogether a wrong estimate.

The spores of parasitic fungi dispersed by the wind are apt to alight on every kind of plant, but it is well known that they cannot infect every kind of plant they alight upon. Why? Is the fungus or the host-plant most concerned in this matter, and for what reason? Why is it that in one district a particular disease is rampant, whereas in an adjoining district the same plant escapes injury, the opportunity for infection being the same in the two places? Is it always the fungus that is the determining factor? and if so, then by all means include physiology as a factor in the so-called life-history of every parasitic fungus. Personally, I consider a sound knowledge of the host-plant, more especially from a physiological standpoint, of far greater importance than a knowledge of the life-histories of fungi, as a means of combating plant diseases, but undoubtedly, a sound knowledge of both host and parasite is essential to success.

We cannot hope to eradicate fungi, neither can we hope to eradicate their parasitic tendencies, hence the only apparent hope of success depends on a discovery of the cause why some plants in a plot are attacked while other remain free from infection. Such questions may appear abstruse, by some even ridiculous, yet they have to be met before we can hope to be of any real service as plant pathologists.

At present the scientific standard of plant pathology, in this country at least, is little above that of spraying to check disease, which is useful in proportion to the benefit derived therefrom, but which has no permanent value, and has to be repeated yearly.

6. Eriksson's Mycoplasmic Theory.

Eriksson's (9) mycoplasmic theory cannot be dismissed without notice in dealing with the subject of fungi in connection with plant diseases. The theory is not generally accepted, probably mainly for the two following reasons. It is quite subversive of our preconceived ideas that infection can only take place through the medium of spores, which are produced in such immense numbers that any other method appears superfluous; secondly, on account of the somewhat unusual requirement as part of the theory, that the protoplasm of the fungus must remain for a period of time blended with and indistinguishable from the protoplasm of the host-plant, after which it materialises, or assumes the form of mycelium in the tissues of the host-plant. The last named argument against the theory can only be seriously entertained by those unacquainted with the life-history of the fungi belonging to the Chytridiaceae, etc., where the zoospores enter the cells of the host-plant, and lose their individuality completely for a time, when the protoplasm again materialises and produces the fungus.

It is generally considered, in this country at least, that the elaborate investigation conducted by Marshall Ward (10) settled once for all, Eriksson's mycoplasmic theory. Did it? Eriksson distinctly stated that a certain amount of infection is due to spores, and the formation of mycelium running between adjoining cells, the penetration of haustoria into the cells, follows infection. Eriksson argues that spores are not present in sufficient numbers to account for the simultaneous appearance of rust over wide areas, and maintains that in some varieties of cereals, the fungus is present in the seed in the form of protoplasm, or mycoplasm. This mycoplasm, mixed with the protoplasm of the host-plant, is carried up with the growing plant, and eventually materialises or concentrates first under the form of minute compact masses in the cells of the host-plant. These masses give origin to the mycelium of the fungus, which eventually produces sori, or masses of spores.

The weak point in Ward's refutation of Eriksson's theory is the fact that he used material that he infected with spores, and, as would naturally be expected, found intercellular mycelium giving off haustoria into the cells. Such haustoria Ward considers to represent Eriksson's primitive masses or corpuscles, originating from mycoplasm. This may be quite true, but it would have been far more convincing if Ward had obtained some of Eriksson's seed reputed to contain mycoplasm, instead of using material that had been infected by spores.

Whether Eriksson's theory in its concrete form survives or not, time will prove, but the serious epidemics on a large scale indicate that they are not due to infection by air-borne spores. In a case of infection known to be due to spores, whether in a house or in a field, there are one or more points of infection; from these centres the disease gradually spreads, as spores become mature and are dispersed by wind or other agents. The case is very different where very large areas, through their entire extent are simultaneously smitten by rust, as in India and elsewhere. If such simultaneous outbreaks are due to infection by spores, it implies that an enormous number of spores must have been liberated simultaneously in some other locality, and such locality has not yet been indicated, neither has the resistance of proverbially short-lived uredospores been shown capable of surviving the passage from wherever they are supposed to come, and arriving in a condition capable of setting up a wholesale infection. Furthermore, the spores capable of infecting cereals are highly differentiated, or known as biological species, often only capable of infecting one species or even a variety of a species; hence in the locality from whence such spores are supposed to have come there must have been an extensive area of the same kind of cereal growing as the one the spores are capable of infecting.

The cereal rusts of India have been investigated by Butler (11), who writes in his summary as follows :—" No entirely satisfactory explanation has yet been given of the way in which the disease originates each year. There is strong reason to believe that it cannot arise from spores from the previous crop, nor to any great extent from other grasses affected with the same rusts. No 'intermediate' host (bearing the fungus in the aecidial stage) has been found, nor is it likely to be found, which can commonly produce the disease in the greater part of the infected area. A hereditary origin is possible through the use of infected seed, but it is not proved so far as India is concerned. The possibility of infection by spores deposited from the atmosphere having their origin in other wheat-growing countries is under investigation."

The idea of floating spores being the means of infection has its advocates. I cannot accept the theory, for the following reasons. In Norway, Sweden, Denmark, Belgium, France, and other neighbouring countries, just over thirty species of *Puccinia* are parasitic on wild plants, yet not one of these species of *Puccinia* has been recorded as having occurred in Britain, although every host-plant on which they occur in their native country grows wild in Britain. On the other hand, about an equal number of species of *Puccinia* occurring in Britain are absent from the countries indicated, although their host-plants grow in these countries.

Similar defined areas of distribution between the countries mentioned could be given for other groups of fungi. Such fungi have probably had the opportunity of centuries of time wherein to extend their range from one country to another, but have not yet succeeded; is it then probable that myriads of spores have been carried from Europe, and arrived in a condition capable of infecting the enormous areas of grain in India and Australia, as has been suggested?

7. Conclusion.

It was at one time believed that bacteria were not capable of causing plant diseases; this idea, however, has unfortunately proved to be wrong, mainly due to the researches of Dr. Irwin Smith.

In this country we have several diseases of undoubted bacterial origin, the worst of which is probably the one now known as Crown-gall, which attacks a large number of plants of widely separated affinities. However, bacteriology is a subject of itself, and can only investigated by specialists.

Finally, a considerable number of diseases from which fungi, insects and bacteria are exempt, are known, amongst which may be classed Bitter-pit of apples, Chlorosis, etc.

When potatoes are grown in the same district and from the same stock of tubers two or three years in succession, the yield gradually deteriorates, and at the same time the injury from *Phytophthora* decreases in virulency in proportion as the vigour and yield of the crop decreases. Why? Such problems clearly demonstrate that a knowledge of mycology alone is but of comparatively little value from the practical standpoint of arresting plant diseases, and that I presume is the object in view when a person is required to investigate plant diseases; the applicant, in ignorance of what is really required, asks for a mycologist, which in his innocence or ignorance he considers capable of meeting all requirements.

As to whether the destructive disease known as Silver-leaf should be classed as a physiological disease or not, appears to be an open question. According to recent investigations it is stated that sometimes the disease is undoubtedly caused by *Stereum purpureum,* Fr., but at other times it may be due to undetermined physiological causes. This is, to say the least, alarming, and subversive of common experience, to admit that a specific disease can be engendered by two or more factors. We can only hope that future investigation may prove the disease to be due to some one specific cause.

Some competent authorities who have read the MS. of this harangue have suggested that it more or less deprecates the value of academic investigation. If this is so it is far from my intention. What I wish to emphasise is, that in my opinion the knowledge of a smattering of mycology, taught from an academic standpoint, is not, as is generally considered in this country, a sufficient guarantee that the person so equipped is competent to undertake a post as a plant pathologist.

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REVIEWS.

FLIES IN RELATION TO DISEASE—BLOODSUCKING FLIES. By Edward Hindle. Pp. xvi + 398, 88 text figs. Cambridge: The University Press, 1914. Price 12s. 6d. net.

This is a companion volume to Dr. Graham-Smith's work on the non-bloodsucking flies, and forms an admirable epitome of our knowledge of the subject.

Dr. Hindle's main object has been to collocate the more important observations concerning the part that biting flies play in the transmission of disease, and in carrying out this important work he has included notes on the classification of the species concerned, and also descriptions of the infections transmitted. Special attention has been devoted to the modes of life of the more important insects mentioned, to the manner in which infection is transmitted from one host to another, and also to any preventive measures directed either against the flies or the diseases themselves.

The author's plan, after a short introduction and chapters on the structure and classification of the Diptera, is to give a description of each family, and in most cases some important member of the family is described in detail; then follows a description of the infections. How carefully and thoroughly this has been carried out a persual of the chapters relating to the Culicidae will show. In the first chapter we find concise, but lucid, accounts of the external and internal anatomy, the life-cycle, food-habits and methods of feeding of the adults, hibernation, longevity, flight, enemies, etc. Following this is a most valuable chapter on classification, followed by another on anopheline-transmitted diseases, in which that of malaria occupies the foremost place. The same detailed treatment is adopted in dealing with the remaining families, all of which are well illustrated by excellent figures.

We congratulate Dr. Hindle on the production of a work that will find an immediate welcome from economic entomologists, Medical Officers of Health, and a still wider public interested in the prevention of fly-borne diseases.

SOME SOUTH INDIAN INSECTS. By T. Bainbridge Fletcher. Pp. xxii + 565, 50 pls. and 440 figs. Madras: Government Press, 1914. Price 9s.

To all workers in economic entomology in India, this work must for some considerable time to come be of the greatest value. The large number of insects treated of, to all of which the author has appended the source of the original description and the synonomy, together with notes on the distribution, life-history, food-plants, and methods of control, make it a most valuable treatise.

The first portion of the work constitutes a general introduction to economic entomology, the various chapters treating of the definition and structure of insects, classification and nomenclature, metamorphoses, means of defence in and communication amongst insects, tropisms, insects and plants, symbiosis and parasitism, insect pests, the control of insect pests of crops, caterpillar pest of crops, etc. Here we find much valuable and practical information carefully illustrated.

The second and larger portion deals with nearly four hundred species of South Indian insects in systematic order, with a wealth of illustration. The value of many of the plates is considerably lessened by being printed on a tinted background; those without this disfiguring feature, especially Nos. 2, 12, 15, 23, 25, 44 and 48 are excellent, whilst the extraordinary low price of the book places it within the reach of all.

THE HOUSE-FLY (MUSCA DOMESTICA, LINN.): ITS STRUCTURE, HABITS, DEVELOPMENT, RELATION TO DISEASE, AND CONTROL. By C. Gordon Hewitt. Pp. xv + 382 and 104 figs. Cambridge: The University Press, 1914. Price 15s. net.

In a sense this is a revised, second edition of the author's well-known work issued in 1910, but the large amount of work published during the past four years, which is here reviewed, really makes it more than this. Dr. Hewitt was the first investigator in this country to work out the structure and development of the house-fly, and his three papers published in the *Quarterly Journal of Microscopical Science*, must for many years to come form the basis of our knowledge of the subject. They have undoubtedly served this purpose to all subsequent workers, and students of insect anatomy and economic entomology have now the opportunity of possessing a copy of this valuable and interesting work, which is undoubtedly the leading one on the subject.

Although we miss the beautiful plates in the former edition, the illustrations throughout are excellent, and there is a copious bibliography.

INSECTS AND MAN. By C. A. Ealand. Pp. 343 and 116 figs. London: Grant Richards, Ltd., 1914. Price 12s. net.

This work should find a ready acceptance amongst a wide circle of readers, containing as it does an unusual amount of information upon the economic relations of insects to plants and live stock, and in connection with the transmission of disease. The author has endeavoured to compile in non-technical language, a concise summary of the varied relations of insects and man, and he has done so with considerable success. No other work of its kind is anything like so comprehensive, and a careful persual has revealed few errors. The different chapters are well written and provide excellent summaries of the present state of our knowledge, which, to the layman, cannot fail to prove valuable.

The volume is excellently printed and produced, and the illustrations good and carefully chosen.

In so admirable a work it is to be regretted that the author has not always quoted the source of his information, the authority in many cases is not even quoted in the special index.

INSECTS INJURIOUS TO THE HOUSEHOLD AND ANNOYING MAN. By Glenn W. Herrick. Pp. xvii + 470, 8 pls. and 152 figs. New York: The Macmillan Company, 1914. Price 7s. 6d. net.

There is a voluminous literature on the subject of injurious insects found in houses and others which are a source of annoyance to man; there are also a few books on the subject in which the authors have sacrificed scientific accuracy and really important information for the sake of much that is fabulous and inaccurate.

Professor Herrick has succeeded in presenting us with a handbook on the subject that will be appreciated by all laymen from the fact that it is delightfully written, up to date, and based on investigations which have been carried out by different workers in all parts of the world. The references to the economic literature, of which nearly five hundred papers are cited, will serve to show the thoroughness with which the author has treated his subject.

In addition to actual insects, reference is made to various spiders, ticks, mites, and centipedes. Curiously, no mention is made of furniture mites (*Glyciphagus*), which are so troublesome and annoying in this country.

HANDBOOK OF MEDICAL ENTOMOLOGY. By Wm. A. Riley and O. A. Johannsen. Pp. ix + 348, 174 figs. Ithaca: The Comstock Publishing Company. Price $2.

The authors use the word entomology in its widest sense, embracing the whole of the Phylum Arthropoda. The present work is the outgrowth of a course of lectures dealing with the subject of the transmission and dissemination of diseases of man by insects, given by the senior author in Cornell University, and it offers to the student of medicine and entomology an admirable survey of the subject and of the discoveries and theories underlying some of the most important modern work in preventive medicine.

Of the many works on the subject this forms one of the best we have seen, and throughout the authors are careful to quote the authorities for the wealth of detail dealt with.

The illustrations are all excellent, many of them being used as text figures for the first time.

A Text-book of Grasses. By A. S. Hitchcock. Pp. xvii + 276 and 63 figs. New York: The Macmillan Company, 1914. Price 6s. 6d. net.

Systematic and economic agrostology have not received anything like the attention in this country that has been devoted to them abroad, and especially in the United States, hence we have no work which covers the ground dealt with by this excellent text-book. Its author is well known as the systematic agrostologist in the United States Department of Agriculture, and we naturally expect from such a source a work that is thoroughly practical and up-to-date. A careful persual leaves us more than satisfied, for the author has provided us with just the concise manual that is wanted by every student of agriculture. The little biology taught in our agricultural colleges might very profitably be improved by the addition of a course of agrostology as laid down in the work before us.

THE

JOURNAL OF ECONOMIC BIOLOGY.

ON THE EARLY HISTORY AND SCIENTIFIC NAME OF THE WOOLLY APPLE APHIS.*

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INTRODUCTION.

THE woolly aphis, *Eriosoma lanigera* (Hausmann), is without doubt one of the most troublesome and widely distributed apple pests. Its ravages have long been known. Even as early as 1832 the Académie de Rouen offered a gold medal for an essay "Exposer l'Histoire naturelle du Puceron lanigère" This is sufficient evidence of the importance of the species at that time. It is now present in nearly every region of the globe in which the apple is grown, and the losses caused by it can scarcely be estimated. But notwithstanding the fact that the ravages of the "louse" are only too well known, its life history has remained little understood. The writer was, therefore, in January, 1912, instructed to make a detailed study of the species.

EARLY HISTORY.

The earliest European account of this insect seems to be the original description by Hausmann (15) in 1802. It was next discussed by J. Banks (5) in a paper read in 1815 and printed in 1817. In connection with this paper a plate depicting the insect was published. Contrary to the general rule with early accounts, this plate is fairly accurate. In 1816 Salisbury (28) gave an account of the insect, and figured what he supposed to be the egg. This writer held it to be indigenous to Europe, but his grounds for so doing seem not very strong, for he bases his conclusion upon statements of his gardener, and he himself confused several species. Kirby and Spence (18) state definitely that the insect was not known in England until 1787, and that it was traced by Banks to a nursery in Sloan Street, and had

* This paper is, with the author's kind permission, extracted from his recent important publication on The Woolly Apple Aphis (Rpt. No. 101, Bureau of Entom., U.S. Dept. Agric., 1915, pp. 1-55, pls. i-xv).

probably been introduced from America. It must, however, judging from Banks' remarks, have been well known in England by 1794.

Amyot and Serville (2) give Tourgard as authority for the statement that the insect first appeared in France in 1812, and in Belgium in 1829. Of French writers, Blot and De Longchamps, on the other hand, believed the insect indigenous. It has in late years been studied in all the important European countries.

In the United States no very early records occur. This is hardly to be wondered at considering the status of entomology in the early days. No doubt the "louse" was well known here before anyone would venture to lower his dignity by referring to it. The following reference in the *Domestic Encyclopædia* (9) may apply to this insect: "Blight-insects (Aphides or plant-lice) may be destroyed by the smoke of tobacco, or by scattering on them Scotch snuff. Another method is to place a few of the larvae of beetles, called ladybirds, or Lady-cows (*Coccinellae septem-punctatae*) on the plants infested with the blites, which, it is asserted, will be thus in a short time destroyed."

In 1817, Coxe, in his *Cultivation of Fruits*, states that white-washing the trunks "destroys many kinds of lice injurious to fruit trees," but he describes none of them. The aphis was discussed by J. Buel in 1836 under the name, *Aphis lanata*, and a somewhat complete account was given by Harris (13) in 1842. In cultural manuals it was described by Kenrick in his *New American Orchadist* (1844), by Downing in *Fruit and Fruit Trees* (1845), and by Thomas in *Fruit Culturist* (1846). It was considered also by early entomologists, such as Fitch, as will be noted under the specific name.

In Canada it was reported in 1856 from Nova Scotia (17), and in 1871 Bethune (6) gave an account of the species in Ontario. It is interesting to not that in the files of the Bureau of Entomology there is a communication dated London, Ont., Aug. 20, 1876, in which *lanigera* is recorded from *Crataegus*. This is possibly one of the earliest observations on the interesting habit recently so well pointed out by Miss Patch (24).

In the South the insect has been observed and studied in Mexico by Inda. It is also abundant in Brazil, and Rivera reports it as very troublesome in Chile.

In South Africa, according to Mr. C. P. Lounsbury, the aphis is one of the most troublesome of apple pests, being distributed throughout Cape Colony. In Natal, too, it is abundant, and, to quote Fuller (10), "is found all over the country, and is certainly the worst of all pests—insects or fungi, attacking this favourite fruit." It is also reported by Mr. C. W. Howard to be injurious in the Transvaal.

In Australia the work of Messrs. T. Lang and Co. in 1868-70 was the beginning of the commercial application of aphis-resistant stock. Such an undertaking by a commercial firm argues for a very early introduction. In America the Australian work was reviewed in the *Californian Horticulturist* (1872), and in 1874 Mackay discussed the ravages of the insects in Australia, New Zealand, and Tasmania (21).

The first record given by Atkinson (3) in India is 1889, but when an insect such as the woolly aphis "has destroyed nearly every orchard in Conoor" it has undoubtedly long been a resident.

Recently this same insect has been discussed at length in Japanese (16). The author of that article, in giving its history, credited *Aphis lanigera* to Hausmann, but in treating the genus *Erisoma* wrote it *Eliosoma*. No references to the species have been found in Chinese literature, but without doubt it exists in that country.

It will be seen, then, that the woolly aphis is distributed over practically the entire apple-growing regions of the world, and the question naturally arises, Whence did it come? It is difficult at this late date to ascertain with certainty the home of such an insect. So far as the evidence goes, it would seem, however, to be of American origin. This conclusion is based upon the following facts:—

1. Tradition recounts the importation of the species into Europe from America.
2. The primary host of the species is the American elm.
3. The summer generations occur in this country upon crab apples, mountain ash, and *Crataegus*—all native trees.
4. The spring migrants must be rare in Europe, judging from published accounts of elm insects.
5. In spite of its conspicuous character, the insect is not discussed in the older European horticultural works.

The writer considers the species to have been originally an elm-*Crataegus* feeder which later adopted the apple. This he believes because of the widespread, though not abundant, occurrence of the insect on these trees in their native home. Throughout the limestone regions *lanigera* has been present on the thorns for many years. That it was not recorded on these trees until the early seventies is, he believes, because the facts were not considered worthy of note. Moreover, in the north he has seen the insect on *Crataegus* so far removed from orchard trees that there could have been no flight between the two. It is, then, his firm belief that the original home of *Eriosoma lanigera* was throughout the great limestone regions of temperate

America. When these regions were planted to apple, the aphis adopted these trees as its secondary host, and by means thereof has spread throughout the world. Its habits have been altered to suit both host and climate in many countries, but in its native home it still continues its regular cycle of alternation.

SEXES AND EGGS.

The earliest account of the ovipara of this species and of the egg is, to the best of the writer's knowledge, the following, by L. O. Howard (1880):—

"The winter egg was found on several occasions during the winter in crevices of the bark over which a colony had been stationed during the summer. It was a rather long ovoid, measuring .322 mm. (.125 inch) in length, and was very similar to the winter egg of *Colopha ulmicola* (Fitch), as described by Riley in Bulletin No 1, vol. v, Hayden's Survey.

This egg was laid, as Professor Thomas supposes, by a wingless female, differing from the ordinary agamic form to a certain extent. These females we only know from finding their skins around the winter egg, since they often die without depositing it. The males we have not seen."

The first complete account of the sexual forms seems to have been that of Goethe (12). He gave figures of both male and female. Numerous other accounts appeared from time to time. Of these one of the most interesting is that of Lignières (20). This writer describes the courtship of the species, and from our observations at Vienna, Va., the males still retain the customs of their forefathers. Alwood's account in 1904 appears to be the first full American publication on the sexes (1), and since that date many descriptions, more or less complete, have appeared. It should be noted that the so-called male figured by Buckton in his monograph is nothing but a first-instar wingless viviparous female.

GENERIC NAME.

In the original description of the species *lanigera* was placed under the genus *Aphis*. In 1820 Leach characterized the genus *Eriosoma* in a footnote in connection with a paper read by Mosley (22) before the Horticultural Society of London. The paper was read in 1817 and published in 1818. The genus was characterized as follows:—

"*Eriosoma* has its body covered by woolly matter; its abdomen has neither horns nor tubercles, and its antennae are short. The body of Aphis is naked, its antennae are long and setaceous, and the abdomen is furnished with a tubercle, or horn-like process on each side."

The genus was erected for "Latrielle's third division of the genus *Aphis*," and the *Aphis lanigera* of Hausmann is indicated as type. Previously what is supposed to be this species was cited as *Coccus mali* by Bingley (7).

In 1819 Samouelle published his *Entomologist's Useful Compendium*," and on page 232 (30) characterized the genus, "*Eriosoma*—Leach's MSS." It seems evident that the printed copy of the Society's Transactions had not reached Samouelle when his book went to press, but "Leach's MSS." is evidence of the fact that he knew that the characterization of the genus would shortly be published. The obscurity of the generic description in the Transactions has led to the crediting of the genus to Samouelle. Some recent writers also have used *mali* as the specific name, following Samouelle, who, in this connection, substituted it for *lanigera*, no doubt from "Leach's MSS."

Seemingly without knowledge of either of the generic descriptions just mentioned, Blot (8), in a paper read in 1823 and published in 1824, described the genus *Myzoxyle* for the apple "louse," as follows:—

"Genre nouveau détaché du genre *Puceron*, et auquel l'auteur donne pour charactères distinctifs des antennes de cinq articles renflés, dont le second est le plus long, et le troisième est le plus court; point de tubercules ni de cornes à l'anus; des tarses de deux articles, et deux crochets accolés difficiles à distinguer. Le nom *Myzoxyle* vient de deux mots grecs, qui signifient suce-bois."

This spelling was changed to *Myxoxylus* in 1831, and *mali* was used as specific. Another variation of the same word was *Myzoxile*, used by Avrilly (4) in 1834. It was not until 1841 that Hartig (14) erected his genus *Schizoneura*, which has for some years been the name used in connection with *lanigera*. It would seem that Hartig was in doubt about the name *lanigera*, for it was written thus: "*Schiz.lanigera*, Banks?"

From the foregoing there seems little doubt that *Eriosoma* is the generic name which should be used for this species, and that the synonymy of the genus will stand as follows:—

Eriosoma, Leach, 1818.
Eriosoma, Samouelle, 1819.
Myzoxyle,[1] Blot, 1824.
Myzoxylus, Blot, 1831.
Myzoxyle,[1] Avrilly, 1834.
Schizoneura, Hartig, 1841.

[1] Without standing.

Specific Name.

The woolly aphis was first described by Hausmann (15) under the name of *Aphis lanigera,* as follows :—

Aphis lanigera.

"I. Blattlaus der ersten Generazion. Länge eine, Breite eine halbe Lin. Der Körper eiförmig und stark gewölbt. Kopf, Augen Fühlhorner, Saugrüssel, und Schenkel haben eine schwärzliche, Halsschild und Hinterleib eine dunkel honiggelbe Farbe und Glanz. Der Hinterleib überall mit einer zarten, weisslichen, ins Bläuliche sich ziehenden, flokkigen Wolle bedekkt, die oft zwei bis dreimal die Länge des Körpers übersteigt. Fühlhörner, Beine und Saugrüssel sind im Verhältnisse zur Grösse des Körpers sehr kurz. Die Hörner auf dem Rükken fehlen dieser Art.

II. Vollkomme Blattlaus der zweiten Generazion. Flügellos; etwas kleiner und schmaler als die Blattlaus der ersten Generazion; im Uebrigen ihr gleich.

III. Unvollkommne Blattlaus der zweiten Generazion. Von den vollkommne nur durch die geringe Grösse und hellere Farbe des Körpers unterschieden.

Aphis lanigera nährt sich von dem Safte der Borke und des Splints der Apfelbäume. Da sie in grossen Haufen nebeneinander lebt, so bekommt die Borke der zarten Zweige durch die vielen Stiche ihres Rüssels das Ansehn eines feinen Zellgewebes. Bei grössern Zweigen, deren Borke härter ist, sucht sie sich unter diese zu arbeiten, um aus dem darunter liegenden Splinte, in welchen sie ihre Saugrüssel leichter einsenken kann, Nahrung zu ziehen. Zuweilen bringt sie an den Zweigen sogar Auswüchse hervor, in dem der Reiz, den sie durch ihre Stiche verursacht, einer starkern Zufluss der Säfte nach einer Stelle, bewirkt.—Diese Blattlaus giebt, wie *Aphis bursaria,* einen weisslichen, gummiartigen Saft von sich der sich oft zu Tropfen von i Linie im Durchmesser anhäuft."

One year later, according to Atkinson (3), Bingley discussed the species under the name *Coccus mali.* In 1820 Leach (19) in connection with his generic description, displaced *lanigera* in a most convenient manner, as follows :—

"Since all the Eriosomata, as their name imports, have their bodies covered by woolly matter, the term *lanigera* is objectionable in a specific sense. The name *Mali* might therefore be substituted for it, and as this species occurs principally on the *Pyrus malus,* I therefore propose to call it *Eriosoma Mali.*

He was in this apparently followed by Samouelle, who discarded "the *lanigera* of authors" for *mali*. The French writers apparently followed Leach in using *mali*, but in 1841 Hartig (14) returned to *lanigera*, crediting the name, however, to Banks.

The *Pemphigus americanus* of Walker (1852), has been placed as a synonym of *lanigera*, but the writer can find nothing in the description which would confirm this, and Walker lists several species of *Schizoneura*. With Fitch's *Pemphigus pyri*, however, the case is different, and there is scarcely any reasonable doubt that the insect he had was *lanigera*. For some time Riley was of the opinion that our form and the European were distinct, and this led him to retain Fitch's *pyri*, though he considered it an *Eriosoma*. Very recently Woodworth (33) has issued a publication on the woolly aphis, under the name *Schizoneura ulmi*, L., but this is an evident error. The synonymy of the species will stand as follows :—

ERIOSOMA LANIGERA (Hausmann).

Aphis lanigera, Hausmann, 1802.
Coccus mali, Bingley, 1803.
Eriosoma mali, Leach, 1818.
Erisoma mali, Samouelle, 1819.
Myzoxylus mali, Blot, 1831.
Schizoneura lanigera, Hartig, 1841.
Pemphigus pyri, Fitch, 1856.
Eriosoma pyri, Riley, 1869.
Schizoneura ulmi, Woodworth, 1913.

ULMI, Linnaeus : The European elm leaf-curl aphis is a very characteristic species which winters on the elms, forming a curl similar to that of our *americana*, and migrates to *Ribes* during the summer. The summer form was described as *fodiens* by Buckton. In studying our species on the elm, Riley, who had seen the European insect, separated ours therefrom under the name *americana*. Unfortunately, in his description he did not go into sufficient detail in regard to the antennae to allow of separation on the description. This has led later writers here to doubt the validity of *americana*. In particular may be mentioned Gilette (11), who referred our form to *ulmi*. In her published work Miss Patch also seems inclined toward the same view, although she has informed me by letter that she considers the two distinct.[1] This condition of affairs has arisen, the writer believes, on account of the lack of European material in this country, and the presence here rarely of true *ulmi*. A glance at the figures (Report

[1] Since the foregoing was written Miss Patch's note distinguishing the two species has been published. (27).

No. 101, pl. iii, F—K), will show a considerable difference between the two species in regard to spring migrants. The fall migrants, however, may be more easily confused, as the antennae are of almost equal lengths. In *fodiens,* however, there is one character which easily separates it from *americana.* This is the presence of the large fringed sensoria on segments V and VI of the antennae. The writer has never seen a fringed sensorium of the fifth segment of *americana,* and those upon the sixth are all very small. The spring migrant of *ulmi* has the third segment of the antennae as long as III-IV of the *americana* migrant, and this alone will separate the two species. There is, however, the same character of the sensoria noted in *fodiens.* The figures of Theobald (31) would seem to indicate that his artist has confused two species in his drawings. *Ulmi* is correctly referred to in the text, but what seems to be *lanigera* is figured.

AMERICANA, Riley: In a recent note by Miss Patch (25) the specific name *americana* has been placed as a synonym of *lanigera.* To the writer there appears some doubt on this point, and sufficient evidence seems available to justify retention of the name, for the present at least. The evidence is of two kinds, structural and biological. In lots of elm aphids received in 1912 for migration tests there appeared two forms of migrants which were easily separated by the naked eye. The first of these was a large, rather long-legged form, with thin antennae. The other was smaller and more compact. Under the microscope the most marked difference was noted in the distal segment of the antennae. The large forms all had a proportionately longer segment, whereas those of the small forms were short and thick. Differences in the wings were also noted. This character, however, is not constant. These two forms were noted very plentifully at Vienna, Va., where the writer's experiments were conducted, and they were received from localities as far south as New Mexico, and as far north as Michigan. It was noted that most of the larger forms came from curled leaves of the elm, while most of the small ones were found in the rosettes. The insects were therefore separated into two lots, using only the naked eye, and the lots were placed separately upon apple twigs. The small forms began depositing young upon the apple in less than one minute, whereas none of the large forms deposited young, but all died. The writer was never able to rear the offspring of any of the large forms upon the apple, and all of the specimens collected from apple leaves in the spring had the characters of the small form.

There seems also to be a difference in the habits of the stemmothers.[1] Those which produce the large forms are, as a rule, leaf-curl forms, and appear later than those which produce the small form. These latter have been sitting at the base of a bud for 10 days and waiting for the leaves to grow and form a rosette around them. Taking all this into consideration, the writer has thought best to restrict the name *lanigera* to those small forms, mostly from rosettes, which establish themselves on apple so readily, and to retain the name *americana* for the larger forms, which the writer has not been able to rear upon apple.

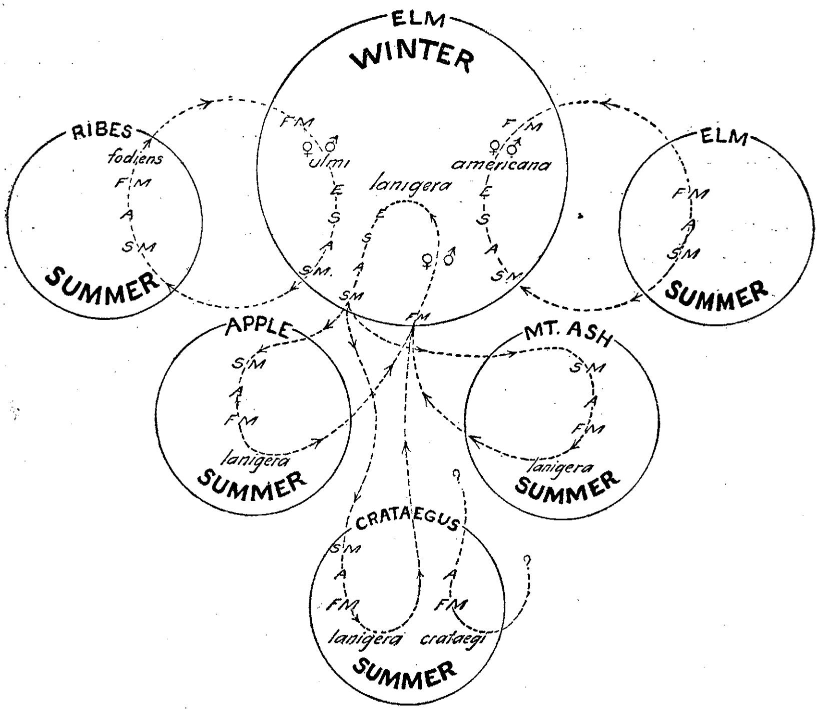

Fig. 1.—Life cycles of elm-feeding species of *Eriosoma*.
E, egg; S, stem-mother; A, wingless viviparous female; SM, spring migrant; FM, fall migrant. (Original).

CRATAEGI, Oestlund: A species of woolly aphis attacking *Crataegus* has been described under the foregoing name by Oestlund (23). We have made no careful studies on this species recently, but collected it quite commonly in Ontario during 1909 and 1910. The fall migrants are very similar to those of *lanigera*, though

[1] Since this paper was submitted Gillette (11) has expressed this same opinion.

our specimens are slightly larger. The antenna is very close indeed to that of *lanigera,* and it is with difficulty that the two are separated. Measurements of a long series of specimens show that the relative lengths of the segments are not always constant, and though this character is most reliable it cannot always be depended upon. *Lanigera* occurs quite commonly upon *Crataegus,* and spring migrants from elms are found to establish themselves on that tree in the same manner as they do on the apple. The writer believes that a large series of reproduction experiments from the forms occurring in nature on *Crataegus* should be made before placing *crataegi* under *lanigera.* Such a series he has not been able to make; he therefore retains *crataegi,* although he believes it to be *lanigera.* The principal difference betwen this form and the woolly aphis is that segments V and VI of the antennae of the migrant are longer in proportion.

RILEYI, Thomas: There yet remains for discussion the species known as *rileyi,* Thomas, the original *ulmi* of Riley. This name is generally applied to those forms making knotty growths on the twigs and trunk of the elm, the migrants of which are most commonly observed in the fall. These seem to be the summer and fall generations of a true elm species, which migrates to other elms in the same way that *lanigera* migrates to the apple. It is true that spring migrants are also observed in the midst of colonies of *rileyi,* and these the writer believes come from sexes deposited in the old colonies by wingless females or fall migrants which, through inability or desire, fail to migrate. Hibernation also takes place in heavy colonies, and it is possible, therefore, that the cycles may overlap in point of time. The writer knows that this will happen with *lanigera,* as he has reared fall migrants of that species all winter in the greenhouses at Vienna, Va.

The migrations of the different species from elm are indicated in figure 1.

LANUGINOSA, Hartig: This European species the writer has been unable to study. From Tullgren's (32) figure of the antenna it would appear very close to some forms he has seen in this country. It is greatly to be regretted on this account that a study of the species could not have been made in connection with the others. Since specimens could not be obtained, the writer ventures here no opinion, merely pointing out the possibility that a study of the form might throw some light on the relations as we know them.

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SOME OBSERVATIONS ON THE RATE OF DIGESTION IN DIFFERENT GROUPS OF WILD BIRDS.

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In considering the economic status of any particular species of wild bird, few investigators have hitherto paid any attention to the time the food takes to digest, and yet it is at once apparent that this factor must have a very important bearing upon the statistics given for stomach contents.

In investigations upon the rook,[1] the starling,[2] and the bullfinch,[3] this was frequently brought home to the writer, but not until quite recently has it been possible to carry out any systematic investigation on the subject.

Previous references to the matter are few, Treadwell,[4] Weed and Dearborn,[5] and Forbush[6] have demonstrated that the rate of digestion in birds is rapid, the time varying from one to four hours.

Bryant[7] has more recently investigated the rate in the western meadowlark (*Sturnella neglecta*), by feeding captive juvenile birds and examining the condition of the food at intervals after feeding. The following table gives a summary of his results :—

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[1] Journ. Econ. Biol., 1910, vol. v, pp. 49-67.
[2] The Food of some British Wild Birds. London, 1913.
[3] Journ. Econ. Biol., 1912, vol. vii, pp. 50-57.
[4] Proc. Boston Soc. Nat. Hist., 1859, pp. 396-399.
[5] Birds in Relation to Man. Philadelphia, Pa., 1903, pp. viii + 380.
[6] Trans. Ill. State Hort. Soc., 1907, pp. 305-335, 12 tables.
[7] Univ. Calif. Publications in Zool., 1914, No. 14, pp. 377-510, pp. 21-24, 5 figs.

[Journ. Econ. Biol., September, 1915, vol. x, No. 3.]

TABULAR RESULTS OF EXPERIMENTS ON THE TIME OF DIGESTION IN THE WESTERN MEADOWLARK (*Sturnella neglecta*).

Experiment.	Time without food.	Time between feeding and killing.	Food given.	Condition of food on examination.
1	3¾ hrs.	2 hrs.	4 large grasshoppers (*Camnula pellucida*) 12 small grasshoppers 1 robber fly 1 bettle (*Coniontis* sp.) 5 ants	Finely comminuted and largely digested
2	5¾ hrs.	3¾ hrs.	20 grasshoppers (*Camnula pellucida*) 10 ants	About one-quarter of volume remained; all soft parts digested
3	3¼ hrs.	2 hrs.	30 kernels wheat	15 kernels left undigested; hulls still undigested
4	3½ hrs.	2 hrs.	1 May beetle (*Ligyrus gibbosus*) 1 weevil (*Rhygopsis* sp.) 12 grasshoppers (*Camnula pellucida*)	Only hard parts left in stomach (heads, wing-covers, knee-joints, etc.)
5	4 hrs.	5 hrs. ?	28 grasshoppers	Stomach empty

"From these data it can be safely concluded that insects are digested in two to four hours, and that the stomach is completely emptied every four hours. Beetles and ants, owing to the chitinous parts, remain longer in the stomach than do grasshoppers. Cutworms are doubtless digested much more rapidly. Grain is more difficult to digest than insects and remains in the stomach longer (four to five hours)."

He concludes: "All evidence, therefore, points to the fact that four hours can be considered a sufficient period of time to assure the digestion of the stomach contents of a western meadowlark. The contents of the stomach at the time the bird is killed must have been taken within four hours previous to the collection of the bird. The daily consumption must, therefore, be considered about three times the capacity of the bird's stomach. As the birds start each day with an empty stomach, and with the additional stimulus of hunger, the greater amount consumed during early morning hours compensates for the smaller amount taken during the middle of the day."

Ward,[1] referring to the rate of digestion of fish in gulls, states: "After experiments, we have estimated that the great black-backed gull, in confinement, digests fish at the rate of 4 ozs. per hour, and smaller gulls at a somewhat slower rate." . . . "Provided the bird's stomach is empty when the fish is taken, a black-headed gull is able to digest a five-inch sprat within three hours, so that not a trace of any bones can be detected. As a result of experiments with sprats filled with methylene blue, it is certain that a gull shot in the afternoon may show no traces of three or four fish taken in the morning. Signs of molluscs, various crustaceans, and even soft food like earthworms, etc., can be traced for longer periods. There is no doubt that in a gull that has recently taken a fish among other food the fish is often missed. On the other hand, when the gizzard is already full of some soft material which is not easily triturated, the fish cannot enter into the gizzard, but remains in the gullet for four or five hours, and is very little altered in appearance, though greatly softened by digestive juices. Some fish can be traced for longer periods than mentioned above by the presence in the gull's gizzard of the otoliths or ear-bones."

The few experiments I have made were designed to test the time required to digest different kinds of food, and if different species of birds required longer or shorter periods.

I hope later to give the results obtained from a series upon a much larger scale and with a greater variety of species; but, I think, the results so far obtained are distinctly interesting and useful, and indicate that the investigation is one well worthy of following out.

The question of the rate of digestion must ultimately prove of great value when considering the quantity of food consumed by any particular species, for, as Bryant has pointed out (*op. cit.*, p. 413) the daily consumption must be considered about three times the capacity of the bird's stomach.

From the three experiments tabulated on p. 68 two important facts are clear, viz.:—

(1) That the rate of digestion differs in the rook from that in the house sparrow, and

(2) That all three species digest the stomach contents in a period of from four to four and a half hours.

[1] Suffolk and Essex Fishery Board. Report of Sub-Committee on Feeding Habits of Gulls during 1913.

Time without food.	Time between feeding and killing.	Nature of food.	Condition of food on examination.		
			Rook.	Starling.	House Sparrow.
3½ hrs.	2½ hrs.	4 Slugs (*Agriolimax*)	Partly digested	Partly digested, but could be identified	2 slightly digested, 2 very little changed
		3 Wireworms	do.	Partly digested	Broken up and partly digested
		3 Larvae of Winter Moth	Hard parts and parts of skin present	Head, hard parts and skins present	Hard parts and 3 partly digested bodies
		10 Grains of Wheat	Grains	quite soft but not	digested
3½ hrs.	3½ hrs.	4 Slugs (*Agriolimax*)	Few small pieces present	Two pieces present	No trace
		3 Wireworms	Hard	parts only present	
		3 Larvae of Winter Moth		do.	
		10 Grains of Wheat	Hulls still remaining and mass largely digested	3 partly-digested grains and hulls present	Very largely digested
3½ hrs.	4½ hrs.	4 Slugs (*Agriolimax*)		Stomachs empty.	
		3 Wireworms		,, ,,	
		3 Larvae of Winter Moth		,, ,,	
		10 Grains of Wheat		,, ,,	

THE ANTENNAL FORMULA OF *Dactylopius crotonis*. A CORRECTION.

I have just discovered an extraordinary mistake in my paper "On some Coccidae affecting Rubber Trees in Ceylon" (Journ. Econ. Biol., May, 1911, p. 35).

In my description of *Dactylopius crotonis,* the antennal formula is given as 1, (6, 7), (2, 3), (4, 5). This is completely wrong. It should be as follows:—8, (2, 3), (6, 7), (4, 5).

E. ERNEST GREEN.

ERRATA.

The following corrections should be made in Mr. J. T. Wadsworth's paper in the last issue of the Journal:—

p. 2, tenth line from top, for "since 1883" *read* "since 1833."

p. 5, line 24, for "other" *read* "others."

p. 8, line 34, for "Kelbe" *read* "Kolbe."

p. 11, line 18, for "figure" *read* "figured."

p. 16, line 14, for ' later" *read* "latter."

p. 18, line 35, for "points" *read* "joints."

p. 21, line 2, for "he" *read* "the."

p. 21, last line but one of footnote, for "that latter species" *read* "that of the latter species."

REVIEWS.

THE SYRPHIDAE OF THE ETHIOPIAN REGION, based on material in the Collection of the British Museum (Natural History), with descriptions of new genera and species. By Professor Mario Bezzi. Pp. 146 and 28 text figs, London: Published by the Trustees of the British Museum, 1915. Price 6s.

Although a large and cosmopolitan family of Diptera, comparatively few species of Syrphidae have hitherto been known from the Ethiopian region. The total number recorded was only 189, to which Professor Bezzi has added, in the present work, 60 new forms, making the total number at present known 249.

The author gives a complete catalogue of all these, together with their varieties, and excellent diagnostic keys of all the genera and species represented in the collection.

The Ethiopian Syrphid fauna is characterised by the complete absence of *Pipiza* and allied genera, also of *Platychirus* and *Chilosia;* and the almost complete absence of the genus *Volucella.* The region is especially rich in the genera *Asarcina, Graptomyza, Syritta,* and *Eumerus,* and many peculiar forms of *Microdon.* The most prominent character is to be found in the great development of the forms of the *Eristalis* group.

To Dipterologists the work will prove of great service.

A REVISION OF THE ICHNEUMONIDAE, based on the Collection in the British Museum (Natural History), with descriptions of new genera and species. Part IV. Tribes, Joppides, Banchides and Alomyides. By Claude Morley. Pp. xii + 167, 1 pl. London: Published by the Trustees of the British Museum, 1915. Price 6s.

A fourth part of Mr. Claude Morley's invaluable "Revision" treats of the three Tribes, Joppides, Banchides and Alomyides, enumerating 459 species, of which 218 are in the British Museum. One new species is described, *Banchus nobitator,* from the Amur Province of Siberia, it is very closely allied to *B. falcator,* Fabr.

There is an excellent coloured figure of *Joppa nominator,* Fabr., by Mr. Rupert Stenton.

This "Revision" has now assumed such proportions that it becomes indispensable to all students of this important group of insects.

THE MUTATION FACTOR IN EVOLUTION, with particular reference to Oenothera. By R. R. Gates. Pp. xiv + 353, 114 text figs. London: Macmillan and Co., Ltd., 1915. Price 10s. net.

The voluminous literature that exists with reference to the genus *Oenothera* is truly astounding, and, if for no other reason, students of genetics will welcome Dr. Gates' work, in that it affords a very valuable summary of the investigations that have been carried out, in all parts of the world, on the genetic problems connected therewith.

Whether the author has proved his special contention respecting the mutation of the genus is a moot point, for the genus is full of complications, and a considerable amount of close analytical work yet remains to be done before we can definitely state that the ordinary phenomenon of Mendelian segregation does not in this case occur.

To all interested in the subject we would especially commend a perusal of chapters vi to viii, which constitute a masterly exposition on the cytological basis of the mutation phenomena, hybridisation, and the relation between hybridisation and mutation; whilst the two following chapters, with equal lucidity, set forth the theory of mutations and their significance as related to heredity and ontogeny.

The work is well illustrated, and there is a very full bibliography.

TYPICAL FLIES. A PHOTOGRAPHIC ATLAS OF DIPTERA, INCLUDING APHANIPTERA. By E. K. Pierce. Pp. viii + 47, with 155 photographic figures. Cambridge: at the University Press, 1915. Price 5s. net.

An illustrated text-book of the commoner British Diptera has long remained a desideratum, and it is likely that many years will elapse before this order of insects is served with half the number of manuals that deal with Lepidoptera or Coleoptera. The present little book, as its author tells us, does not claim to fill the gap, but nevertheless it should prove of value to a beginner in entomology.

The manual of N. American Diptera by Williston is still the best introductory text-book for the families and genera, but without access to a named collection the help that a text-book alone can render is very much discounted. Collections of Diptera are few and far between in this country, and the best substitutes for the identification of the more striking forms are good illustrations. For the more obscure families, and the recognition of most of the genera, a manual and a reference collection are necessary to the unaided beginner. With the help of Dr. Sharp's account of the Diptera in his second volume of the "Cambridge Natural History," and Mr. Pierce's atlas, the student should have little difficulty in placing the flies he may collect—in so far as they pertain to families illustrated in the latter. In a comparatively short time, however, he will no longer derive much aid from these photographs, for their scope is necessarily very circumscribed. Each day's collecting will ensure a harvest of species, and yet he will frequently find himself unable to sort out a considerable number of them into their respective families. He should, however, by this time, be able to recognise typical members of most of the leading groups, which is probably as far as Mr. Pierce would aspire to lead him with the assistance of his atlas. With the majority of the Acalypterate Muscids, however, photographs are not likely to prove of much help.

As actual photographic illustrations of Diptera most of the figures are excellent, and the technical difficulties attending their production are very considerable. As the author tells us, in photography on an enlarged scale no amount of "stopping down" will produce an image which is sharp throughout, unless the subject be fairly in one plane. The amount of shrivelling and distortion which many species undergo when set and dried, only add to the difficulties of the photographer. Taking into account these pitfalls, we have nothing but praise for the manner in which he has surmounted them.

Should the author eventually contemplate issuing a second atlas, we think it would be a distinct advantage if a few lines were added beneath the figures indicating the colouration of each species. Also the titles of a few of the more general works on Diptera might be appended to the Preface.

A. D. I.

PLANT-LIFE. By Charles A. Hall. Pp. xi + 380, 74 pls. and 80 text figs. London: A. and C. Black, Ltd., 1915. Price 20s. net.

As a popular exposition of plant-life Mr. Hall's new book is distinctly above the average, for he has escaped very many of the pitfalls of the popular writer, and at the same time has, in a very pleasing style, compressed into his work a wonderful amount of interesting information.

The coloured illustrations are considerably above the average, indeed, in some cases they are superior to anything we have seen. This being so, it is unfortunate that a few of them should have been spoilt by being printed on a coloured background. A comparison of plates ii and iv well illustrates how absurd this system is. The majority of the photographic plates are also very good. The work is well printed on excellent paper, and is in every way creditable to all concerned in its production.

ELEMENTARY HUMAN BIOLOGY. By J. E. Peabody and A. E. Hunt. Pp. xii + 194 and 55 figs. New York: The Macmillan Company, 1915. Price 4s.

This volume constitutes the third section of the author's *Elementary Biology*. In its present form it makes an excellent text book on physiology and hygiene of a very practical character, and one which we cannot too highly recommend.

THE

JOURNAL OF ECONOMIC BIOLOGY.

ON THE "HARVEST BUG" (*MICROTROMBIDIUM AUTUMNALIS*, SHAW).

BY STANLEY HIRST.

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WITH 2 TEXT-FIGURES.

THERE are numerous scattered references in scientific literature relating to the minute larval Trombidiid mite, commonly called the "Harvest Bug," or *Leptus autumnalis,* and it is usually, at least, mentioned in text-books dealing with Medical Entomology and Parasitology. It is only in comparatively recent times, however, that the larval mites of this type have received careful attention at the hands of acarologists. In 1904 Oudemans and Heim pointed out that in France two, or even three, different larval forms belonging to the Trombidiidae assail human beings during the hot and dry months of the year. The larval forms concerned are *Microtrombidium autumnalis,* Shaw, *Metathrombidium poriceps,* Oudemans, and possibly also *Trombidium striaticeps,* Oudemans.

In 1910, Bruyant succeeded in raising a nymph from one of his larva of *M. autumnalis,* and he also mentions that he has examined a similar nymph reared by Brandis in 1895 from the "Harvest bug," common at Halle. This nymph was determined by Bruyant and Oudemans as that of *M. pusillum,* Hermann, but Oudemans now seems to think that this identification is doubtful (See Arch. Naturg., 1914, Bd. lxxix, Abt. A, heft 9, pp. 125-129). So far, only *M. autumnalis* has been found attacking human beings in this country.

Whilst taking a holiday at Ventnor during the month of September this year, I became aware of the fact that this mite was very troublesome in the district. This pest chiefly occurs on the high chalk downs situated at the back of the town and neighbouring villages. People walking or gathering blackberries on the downs are often attacked by the mite, and the local irritation of the skin caused by its bites may persist for many hours or even for days, if not attended to. It is alleged that residents become immune from attack after long sojourn in affected districts. The following description and the accompanying figures are based on specimens swept from the grass on St. Boniface Downs.

Microtrombidium autumnalis, Shaw.

(Figs. 1 and 2.)

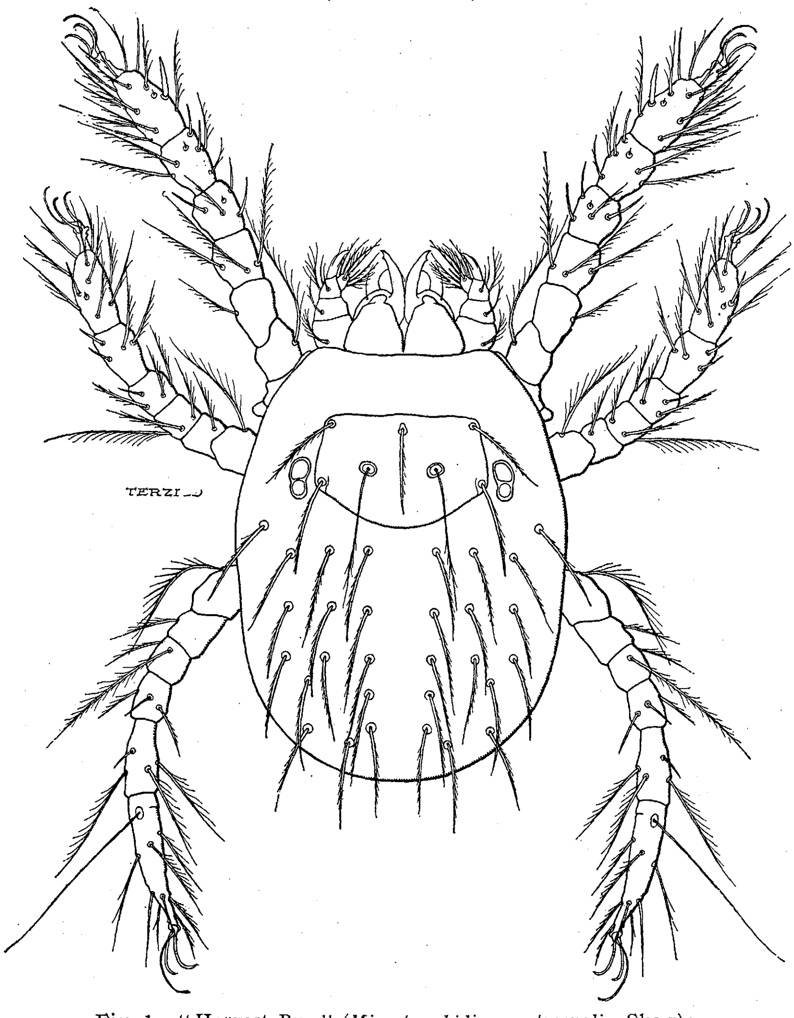

Fig. 1. "Harvest Bug" (*Microtrombidium autumnalis*, Shaw); dorsal view.

Larval form.—Body oval. Scutum wider than long; its anterior margin almost straight, but with a slight projection in the middle and slightly concave on each side of this projection; posterior margin rather strongly convex. Hairs on scutum seven in number; those at the posterior angles and also the pseudostigmata being very long; sockets of pseudostigmata situated practically midway between the anterior and posterior margins (not so near the posterior margin as figured by Oudemans). Posterior eye slightly smaller than the anterior one. Specimens from Ventnor have the dorsal hairs of the body arranged in transverse rows as follows: 2, 6, 6, 6, 4, 4, and a few posterior hairs. Other specimens collected by W. Drury on a dog usually have the hairs on the dorsal surface similar in number and arrangement. The number of hairs in the transverse rows on the dorsum in Dr. Johnston's specimens from Berwick is higher (and therefore resembles Oudeman's figure in this respect), the first transverse

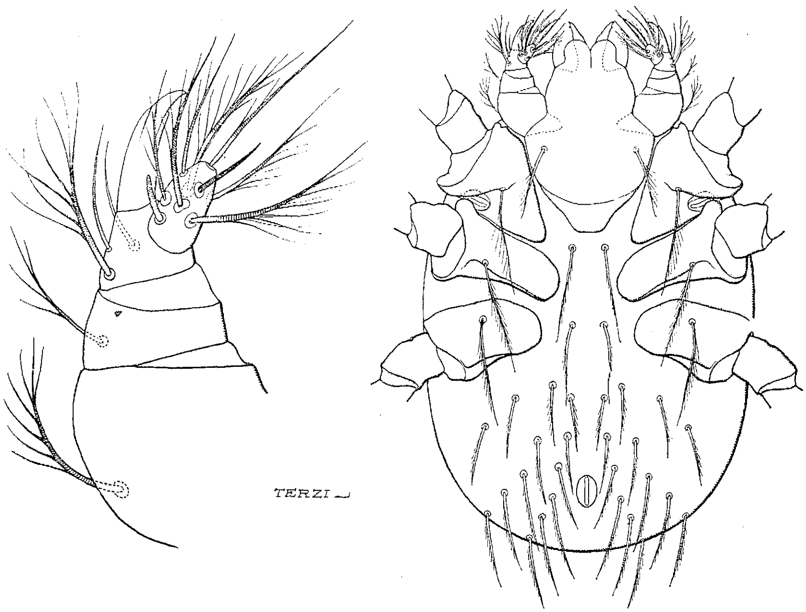

Fig. 2. "Harvest Bug" (*Microtrombidium autumnalis*, Shaw); palp and body from below.

row after the two shoulder hairs consisting of 8-9 hairs, the next of 8, then a row of 6, and so on. There is, however, a certain amount of variation in the number of dorsal hairs in these specimens, and I do not consider that the number of hairs is a character that can be greatly relied upon in separating the larvae of different species of Trombidiidae from one another. Hairs on ventral surface arranged as shown in figure.

Palp.—Hairs on dorsal surface of palp distinctly plumose, except the dorsal and lateral ones on the tibia, which are very fine and not feathered; ventral hair of tibia feathered, however. Seven (sometimes six?) plumose hairs are present on the tarsus of the palp, and also two plain ones, one of them being blunt and rod-like, but the other, which is slightly longer, is pointed at the end. Claw with three prongs or branches, the middle one being the longest and stoutest.

Legs.—Numerous feathered hairs are present on the legs; distal half of femur of first leg with two or three exceptionally long feathered hairs on its dorsal surface, and a similar hair is present in the same position on the second and third legs; there are also one or two rather long plumose hairs on the tibia of the third leg; a long, curved hair also occurs on each trochanter. Besides these feathered hairs, the patella of the first leg has two rather short, plain hairs or setae above, and a latero-ventral hair; two similar hairs are present on the tibia; tarsus with the usual stout, rod-like process and stiff slender hair; a very short hair is also present on each of the three distal segments of this leg. The number of plain hairs on the second leg is much the same as in the first, except that there is only one dorsal hair on the patella, and the latero-ventral one is also missing; the very minute hair is only present on the tarsus of this limb. Patella and tibia of third leg each with a single, rather short, plain hair on the dorsal surface; tarsus with a very long and fine sensory hair placed near the proximal end of its dorsal surface. Third tarsus long and gradually narrowed.

Length of body, .21 mm.

Colour, red.

Material.—Numerous specimens found amongst grass on St. Boniface Down, Ventnor, Isle of Wight (10-ix-15); collected by S. Hirst. Specimens occurring in patches on dog (at Woking?) ix-99 (W. Drury). Specimens from ear of rabbit, Berwick, 1848 (Dr. G. Johnston). Also specimens taken on a woman in Lincolnshire (exact data not known; these specimens were sent by Dr. C. F. George to Mr. C. D. Soar, and the latter published drawings based on them in November number of *Knowledge*, 1912.

The following is a selection of some of the more important papers on this subject:—

1. HEIM, F., ET OUDEMANS, A.—Sur deux nouvelles formes larvaires de *Thrombidium* (Acar.) parasites de l'Homme. C. R. Ac. Sci., 1904, vol. 138, pp. 704-706, text-figs. 1-9.

2. BRUYANT, L.—Essai de détermination spécifique des Rougets de l'Homme (*Leptus autumnalis*, Latr.). Paris, C. R. soc. biol., 1909, vol. 67, pp. 207-209.

3. BRUYANT, L.—Description d'une nouvelle larve de Trombidion (*Paratrombium egregium*, n. gen., n. sp.), et remarques sur les Leptes. Zool. Anz., 1910, vol. 35, pp. 347-352, text-figs. 1-4.

4. OUDEMANS, A. C.—Über die bis jetzt genauer bekannten Thrombidium-Larven ünd uber eine neue Klassifikation der Prostigmata. Tijdschr. v. Ent., 1909, vol. 52, pp. 19-60, pls. 4-7.

5. OUDEMANS, A. C.—Die bis jetzt bekannten Larven von Thrombidiidae und Erythraeidae, mit besonderer Berücksichtigung der für den Menschen Schädlichen Arten. Zool. Jahrb. (Syst. Suppl.), 1912, vol. 14, pp. 1-230, 57 text-figs.

ON THE TSUTSUGAMUSHI (*MICROTROMBIDIUM AKAMUSHI*, BRUMPT.):— CARRIER OF JAPANESE RIVER FEVER. [ACARI.]

BY STANLEY HIRST.

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WITH 2 TEXT-FIGURES.

THE larval forms of Trombidiidae occurring in Japan are of especial interest, owing to the fact that the Kedani or River Fever of the Echigo and Akita Provinces is conveyed by one of their number. According to Ashburn and Craig,[1] it is possible that this disease is also found in the Philippines, and Dr. Schüffner[2] has written a good account of a very similar complaint, "Pseudotyphus," which occurs at Deli, Sumatra. He gives a micro-photograph of a larval Trombidiid which may, perhaps, transmit this disease; possibly, however, it is conveyed by a true tick (Ixodidae). A detailed description is given in the present note of some specimens of a larval Trombidiid taken from the ears of field mice living in the infected area, Echigo, Hondo. These specimens were sent by Dr. Miyajima—the well-known authority on this disease—to Prof. G. H. F. Nuttall, of Cambridge, and the latter kindly lent them to me for examination. Whilst investigating this mite, I managed to obtain specimens of larval Trombidiidae from several other localities in Japan, and soon found out that at least four other larval forms belonging to the genus *Microtrombidium* exist in that country. Specimens of them have been forwarded to Dr. A. C. Oudemans, of Arnhem, for investigation.

Microtrombidium akamushi, Brumpt.

(Figs. 1 and 2.)

Larval form.—Scutum oblong, but not very wide, the posterior margin is almost straight. The usual seven hairs are present on it,

[1] Philippine Journ. Sci., 1908, B. III, pp. 1-39.

[2] Pseudo-Typhus in Deli (Variante der Japanischen Kedani Krankheit). C. R. 3e Congrès Bienn. (1913). Far East. Ass. Trop. Med. Saigon, 1914, pp. 309-315 4 pls.

all of them being long and slender, the middle one of the anterior margin exceeds the scutum in length; pseudostigmata inserted nearer to the posterior margin than to the anterior; they are very slender, and only the distal half is feathered [the basal half lacks the very minute hairs which are present on it in a larval form from Machado, near Noluchi, Aomori Ken (on *Micromys speciosus*), and another larval form from Takamori, Kumamoto Ken, Kyushu (*Microtus* sp.)]. Both eyes

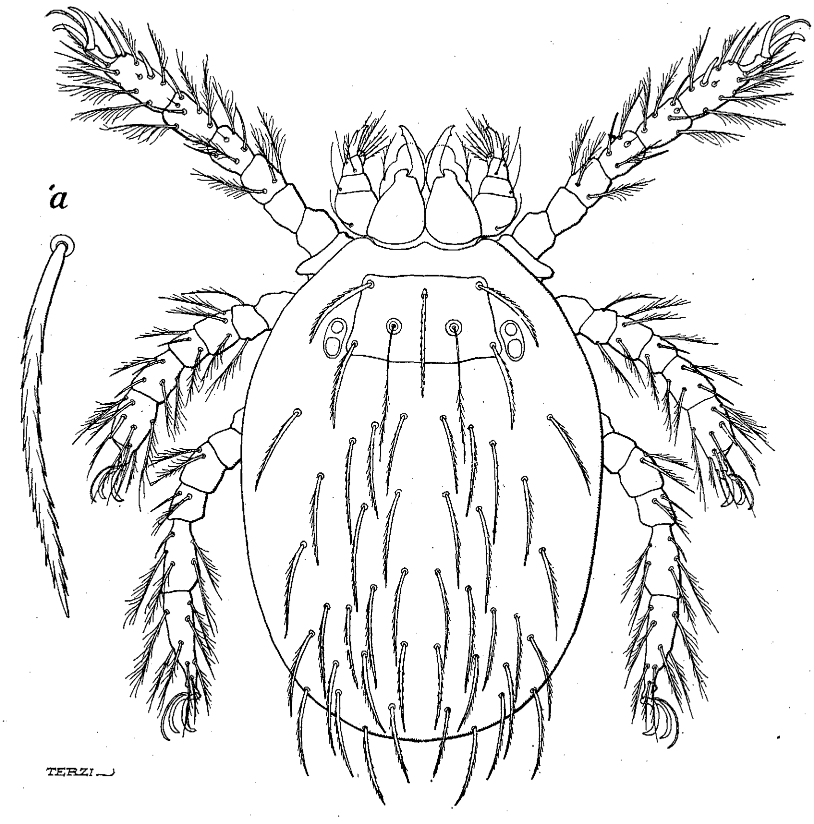


Fig. 1. *Microtrombidium akamushi*, Brumpt, larval form from above.
a. One of the dorsal hairs greatly magnified.

are well developed. Hairs on dorsum very like those of *Microtrombidium autumnalis*, Shaw; they are comparatively slender, and have the accessory hairs short and fine. These dorsal hairs are arranged as follows: 2, 8, 6 (rarely 8), 8-10, 8, and a few posterior hairs. Ventral hairs arranged as shown in figure. The first coxa sometimes presents an unusual feature in having two hairs instead of only one. Finger of chelicera with a very slight denticle just before the end as in *M. autumnalis*. Hair on galea of maxilla strongly feathered. Hairs on dorsal surface of palp plain, except the one on the tibia, which is distinctly feathered; lateral and ventral hairs on tibia plain. Tarsus with seven feathered hairs and a blunt rod-like hair. Claw of palp with three prongs. Legs slender and moderately long; the last tarsus fairly long and slender. Hairs on legs strongly feathered; a very long curved hair is present on each trochanter.

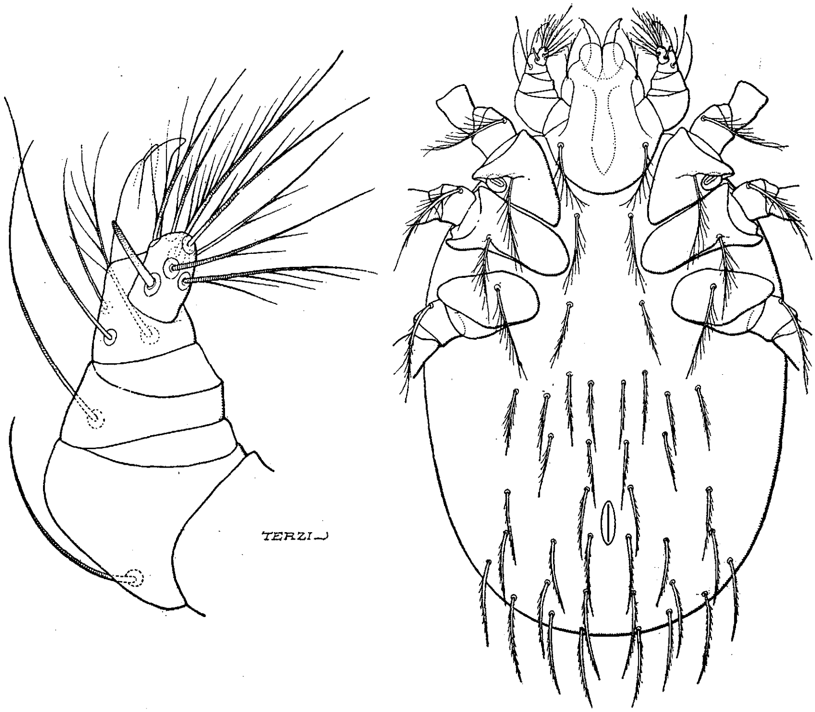


Fig. 2. *Microtrombidium akamushi*, Brumpt, ventral view of palp and body.

Besides these feathered hairs, there are a certain number of plain, unfeathered ones on the legs. Patella of first leg with two plain hairs, one being dorsal and the other lateral in position; tibia with two plain hairs above; tarsus with the usual stout, rod-like hair or process, and also the stiff seta; a very short hair is also present on each of these three segments. Patella of second leg with a single plain hair above; tibia with two plain hairs on its dorsal surface; tarsus with the usual rod-like hair. Patella and tibia of third leg each with a single hair on the dorsal surface; third tarsus only furnished with feathered hairs, it lacks the long tactile hair present on this segment in the form *M. autumnalis*. Length of body .18 mm. (small specimen), .34 mm. (distended specimen).

Material.—A number of specimens labelled "*Leptus* sp., Tsutsugamushi, off ears of field mice living in the infected area, Yechigo, Japan (10-v-1908), presented by Dr. Miyajima."

Note.—All the larval forms of *Microtrombidium* from Japan which I have been able to examine are evidently closely allied. They usually resemble one another in the following important structural details :—Hair on galea of maxilla always strongly feathered. Hairs on dorsal surface of palp not feathered,[1] except that on the tibia. Tarsal claw with the end trifurcate. Number of plain hairs on the legs apparently always as described above for the larva of *M. akamushi*. Last tarsus lacking the long, fine, tactile hair present on that segment in *M. autumnalis,* Shaw. Pseudostigmata situated well behind middle of scutum. The shape of the scutum, size and shape of eyes, and especially the minute details of the feathering of the hairs on the body, present considerable differences, and it is possible to distinguish the different Japanese "Harvest Bugs" from one another by utilising these characters. The number of hairs on the dorsum also varies in different larval forms, but is not always constant, and is not a very good character.

[1] In Tanaka's three figures of the Akamushi Mite (Centralbl. Bakt. Jena, Abt. 1, XXVI, pp. 432-439, 2 pls. (1899), all the dorsal hairs on the palp are shown as feathered. This must be a mistake on the part of his artist. It is possible that the larval form described above, is not identical with that figured by Tanaka. If this prove to be the càse, I propose the name *M. brumpti* for the form described in the present note.

ON SOME BRITISH MACHILIDAE (*THYSANURA*).

By RICHARD S. BAGNALL, F.L.S.

A New Name for Machilis brevicornis, Ridley.

Praemachilis parvicornis, nov. nom.

Machilis brevicornis, Ridley. Entomologists' Monthly Mag., June, 1880, xvii, p. 2.
Premachilis brevicornis, Bagnall. Trans. Vale Derwent Nat. Field Club, 1908, n.s. i, p. 29.

The name *brevicornis* was used long prior to 1880, by Latreille and Lucas.

Two more New Species of Petrobius.

It was only in 1913 Professor Carpenter showed that the "rock-jumpers" of our shores should be referred to more than one species, when he carefully diagnosed *P. maritimus*, Leach, gave the name *P. oudemansi* to the Dutch species figured by Oudemans as *P. maritimus*, and described a second Irish species, *P. brevistylis*. In July, 1915, Miss Anna J. Reilly described yet another *Petrobius* from the Isle of Wight (*P. vectensis*), and probably there are several more awaiting discovery.

In describing the following species I have pleasure in naming one of them after Professor G. H. Carpenter, as a small mark of esteem.

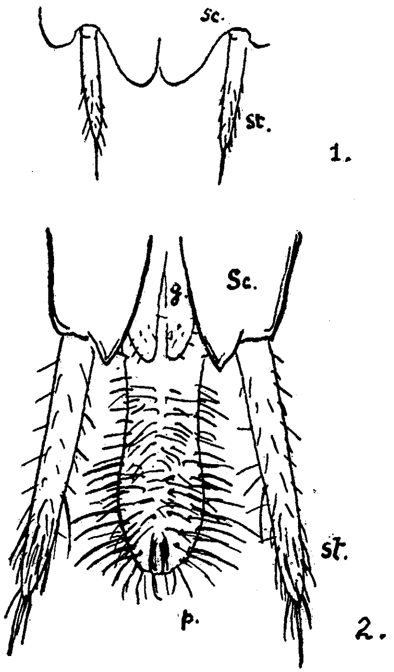
Petrobius carpenteri, n. sp.

(Figs. 1 and 2).

Length of body (excluding tail processes) about 11 mm. Antennae longer than body, and general aspect and colouring as in *P. maritimus*. Tail process about as long as body. Mandible with apex blunt. Maxilla with lacinia slightly shorter than galea. Maxillary palps with their six elongate segments, relatively 9, 11, 13, 15, 15, 8.5, the antepenultimate swollen distally. Eighth abdominal sternum with subcoxae produced into rounded lobes (Fig. 1.). Ninth abdominal sternum with subcoxae produced into prominent pointed processes; styles long and moderately slender, terminal spine only about one-fourth the length of the appendage; setae strong, and rather long at the distal third. Gonapophyses reaching practically to the tips of the subcoxae. Penis long, reaching nearly to the tips of the styles, at least to 0.8 their length (Fig. 2). Ovipositor of female about 0.7 the length of cerci, which are three-eighths (.375) the length of the tail process.

Habitat.—In large numbers, Blackhall Rocks, near Hartlepool, August, 1915.

In the short apical joint of the maxillary palpi this species most closely approaches the Dutch species, *P. oudemansi,* Carpenter, but in that species the penultimate joint is *twice* as long as the apical.



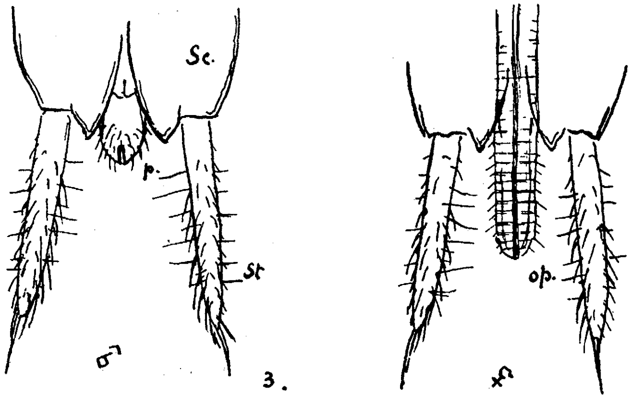
Figs. 1 & 2. *Petrobius carpenteri*, n.sp. Male, Ventral aspect.
1. 8th abdominal segment.
2. 9th abdominal segment.
Sc. Subcoxa, *st.* Stylet, *g.* Gonapophysis, *p.* Penis.

Further, the penis in *P. oudemansi* only attains one-half the length of the ninth abdominal stylets, whilst the gonapophyses do not reach the tips of the subcoxae.

Petrobius modestus, n. sp.

(Figs. 3 and 4).

Length of body (excluding tail process) 7 to 8 mm. Antennae and tail process as long as or longer than the body, general aspect as in *P. maritimus,* but not so robust, and the colour lighter than in that species. Cerci about one-third the length of the tail process. Maxillary palps with their six elongate segments relatively 6, 8, 10, 11, 11, 8, the antepenultimate swollen distally. Mandible with blunt apex. Maxilla with lacinia only slightly shorter than galea. Eighth abdominal sternum in male, with the subcoxae produced into two broad rounded lobes. Ninth abdominal sternum with the subcoxae produced into pointed processes; styles elongate and slender, with terminal spine about one-third the length of the appendage; setae strongest on distal two-thirds within; several slender erect setae, those on the inner margin being longer than the diameter of the style. Penis extraordinarily short, only just reaching beyond the apex of the subcoxae (Fig. 3).



3. 4.

Figs. 3 & 4. *Petrobius modestus*, n.sp., Ventral aspect of 9th abdominal segment.
3. Male. 4. Female.
Sc. Subcoxa; *st.* Stylet; *p.* Penis; *op.* Ovipositor.

Ovipositor of female also exceptionally short, reaching to half the length (or thereabouts) of the styles (Fig. 4).

Habitat.—Amongst dead leaves in rock crevices near the shore, Grange-over-Sands, Lancashire, November, 1915.

This species may be chiefly recognised by the curiously short penis in the male, and ovipositor in the female. The ovipositor in all the other species is long and slender, reaching far beyond the tips of the styles and almost to the tip of the cerci.

This species and the preceding one have the subcoxae of the ninth abdominal segment in the male produced into prominent processes, as in *P. maritimus*. The subcoxae of the eighth abdominal segment in the male are somewhat intermediate between *P. maritimus* and all the other species.

RECENT PUBLICATIONS ON ECONOMIC ORNITHOLOGY.

BY WALTER E. COLLINGE, M.Sc., F.L.S., F.E.S.

The University, St. Andrews.

The Feeding Habits of the Rook.[1]—The Economic Ornithological Committee of the British Association, to say the least, moves slowly. Appointed in the autumn of 1908, it decided that attention should at first be concentrated on three species, viz., the rook, the starling, and the chaffinch. Since then the economic status of all of these three birds has been carefully investigated and the results published by Hammond, Collinge, and Florence; the interim report, therefore, on the rook appears somewhat belated.

Mr. H. S. Leigh has examined the gizzards of 218 birds, of which nine were empty, and he summarises the results, which add little to our present knowledge, as follows :—

"1. That a large proportion of the food of the rook consists of grain, and that it is taken mainly in the autumn, winter, and early spring months.

2. The total amount of animal food is not so large as grain, but reaches a high percentage during May, June, July, August, and September.

3. There is some evidence to show that a grain diet may be preferred, but there is also evidence which shows that a great many insects (about half of which are injurious) are taken by the rook, particularly in its nestling stage, and that it is therefore most important to have a good supply of birds during this phase in its life-history.

4. It is difficult from the evidence yet obtained by this inquiry to say whether the rook is, on the whole, a beneficial or an injurious bird, as the material upon which the account is based is not sufficiently representative."

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[1] Leigh, H. S.—Interim Report on the Feeding Habits of the Rook (*Corvus frugilegus*, Linn.). London, 1914, pp. 1-15.

English Skylarks in Australia.[1]—The following interesting note by Mr. C. French, Junior, is quoted *in extenso* :—

"The English skylark was first introduced into Australia by the Royal Zoological and Acclimatization Society of Victoria in 1863. In that year numbers were let loose in Melbourne, 80 more in 1867, 30 in 1870 and 1872, 100 in 1873-4, and some were let loose near Sydney about 1870.

During the last few months the English skylark has been much in evidence, especially in the Carrum, Mentone, and Cheltenham districts. There these birds have been causing considerable annoyance and loss to market gardeners and others by the manner in which they have been destroying the young seedlings and plants of cabbages, cauliflowers, turnips and lettuces. Recently I visited the garden of a well-known market gardener residing near Mentone, and was surprised to see numbers of these birds engaged among the vegetable seed-beds. On examining these beds, I found that row after row of seed and seedling vegetable plants, also young cabbage plants that had been planted out, had been eaten. I requested the owner to shoot a few of the birds for examination purposes. Three birds were shot, and on examination their crops were found to contain cabbage and turnip seeds, young cabbage and radish leaves, gravel, but no insects whatever.

The owners of the garden informed me that numbers of the birds had been destroyed by means of poisoned wheat. I also examined the crop of several of these, and the result was the same in every instance. Their crops were full of vegetable seeds and vegetable matter, not a solitary insect being found in any of them. If food was scarce, I could understand these birds attacking vegetable crops, but at the present time insects are plentiful, this being an unusual season for them.

It is rather unfortunate that such a beautiful and interesting bird has developed a liking for vegetables. It shows how careful the authorities should be of introducing birds of other countries into Australia, even if they are insectivorous in their own land."

How to Attract Birds.[2]—Mr. W. L. McAtee, in an interesting and well-illustrated bulletin, discusses the various means by which the number of birds may be increased. Protection, he points out, is the

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[1] French, C., Junior.—Birds destructive to Vegetable Crops. English Skylarks (*Alauda arvensis*). Journ. Agric. Victoria, 1914, p. 736.

[2] McAtee, W. L.—How to attract Birds in North-eastern United States. U.S. Dept. Agric., Farmers' Bull. 621, 1914, pp. 1-15, 11 figs.

prime requisite in any area, and the results are in direct proportion to the amount given. He draws attention to the value of a vermin-proof fence round bird sanctuaries, of provision of breeding-places, water supply, and food, artificial and natural.

The Food of Birds.[1]—Miss Laura Florence's second report contains details of the stomach contents of 1,390 birds referable to 81 species. Apart from a few cases, such as the blackbird, greenfinch, house sparrow, chaffinch, starling, rook, wood pigeon, black-headed gull, herring gull, and common gull, only a very few specimens have been examined of the remaining species. Personally, we fail to see what useful purpose is attained by the destruction of 1 golden-crested wren, 1 willow wren, 2 coal tits, 4 wrens, 1 tree creeper, 3 pied wagtails, 2 swallows, 1 reed bunting, 1 swift, and 38 lapwings.

With reference to the three above-mentioned species of gulls, Miss Florence is of opinion that the black-headed gull is undoubtedly beneficial to the agriculturist, but the other two species might well be left unprotected until their numbers have greatly decreased.

Meadowlarks, Robins, and Blackbirds.[2]—The United States has for many years led the way in economic ornithology, and largely through the efforts of the staff of the Department of Agriculture, public opinion has been educated, in consequence of which numerous agencies, having as their object the conservation of game and other birds, have arisen. Of these, the Audubon Society is doing a useful work in the various States.

In the present leaflet Mr. H. C. Bryant asks the question, "Shall we kill meadowlarks, robins and blackbirds?" Briefly, he summarises the economic status of these birds, showing that the balance is in their favour as insect-eating birds, and concludes that, "In addition, therefore, to the evidence that these birds are distinctly beneficial to agricultural interests is the evidence that none of these birds can be considered game birds, and the placing of an open season on them not only violates the spirit of the present law, but is a distinct backward step in game legislation."

Pheasants and Agriculture.[3]—Miss Evershed gives a brief account of the excellent work she is doing in connection with the feeding habits

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[1] Florence, Laura.—The Food of Birds. Report for the Year 1911-1912. Trans. H. & A. Soc., Scotland, 1914, pp. 1-74

[2] Bryant, H. C.—Shall we kill Meadowlarks, Robins, and Blackbirds? California Audubon Soc., 1915, Leaflet No. 8.

[3] Evershed, A. F. C.—H.—Pheasants and Agriculture. 19th Rpt. East Anglian Game Protection Soc., 1914, pp. 17-20.

of the pheasant. She has examined 313 crops, and finds that "the roots and stems consist largely of tubers of lesser Celandine and roots of bulbous buttercups. There is no trace of mangold or any other agricultural root crop. The leaves are mainly those of weeds, but also include some grass and clover. The flowers belong chiefly to the natural orders—Compositae, Ranunculacae, and Leguminosae. Fruits and seeds consist almost entirely of those of weeds. The non-hand fed cereal grains must *not* all be regarded as representing damage done by the pheasants, as the *majority* of the grains have been picked up in the stubble after harvest, or in the region of stacks, and very little of it consists of newly-sown corn crops—approximately only 4.3 per cent. The miscellaneous food includes stones, soils, shot, etc. On the whole, the balance seems decidedly in favour of the pheasant."

The Food of Nestling Sparrows.[1]—The author has examined the stomach contents of 98 specimens from fruit-growing districts, and 41 specimens from suburban districts. He summarises as follows:—

"In a single day 100 nestling house sparrows require nearly 2,000 insects for food in fruit-growing districts, and about a third of that quantity in suburban districts.

Excepting for a few spiders and earthworms, the whole of the food consists of injurious insects. It may be said that during the whole of the nesting period the parent birds are feeding upon food similar to that fed to the young.

In spite of all that has been written with reference to the depredations of the house sparrow, we do not yet possess that completeness of knowledge that justifies us in condemning it as an 'avian rat,' or a bird that should be exterminated. That it is far too plentiful no one doubts, but seeing that practically all modern houses provide numerous and safe nesting-places for it, this is scarcely surprising.

It is extremely difficult to arrive at any satisfactory and convincing conclusion as to the precise economic status of this species, but after carefully considering the results obtained from an examination of the stomach contents of 404 adult birds, and 42 and 287 nestling birds, and also from an examination of the faeces, the writer is of opinion that if this species were considerably reduced in numbers, the good that it would do would probably more than compensate for the harm, especially in fruit-growing districts."

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[1] Collinge, Walter E.—Some Observations on the Food of Nestling Sparrows. Journ. Bd. Agric., 1914, vol. xxi, pp. 618-623.

REVIEWS.

PYCNOGONIDA. British Antarctic ("Terra Nova") Expedition, 1910. Natural History Report, Zoology, vol. iii, No. 1, pp. 1-74, 22 figs. By W. T. Calman. London: Published by the Trustees of the British Museum, 1915. Price 5s.

The present report on the Pycnogonida of the British Antarctic ("Terra Nova") Expedition is of unusual interest, in that it comprises no less that forty-four species, of which eleven are new, thus exceeding in extent that of any previous Antarctic expedition yet reported on. Further, it serves to emphasise the fact, that although nearly two hundred species have been described up to date, there is every reason to suppose that as yet we are a long way from exhausting the list, and that our knowledge of these interesting animals must be regarded as far from complete.

Although Dr. Calman describes no new forms that throw any fresh light on pycnogonidan morphology or phylogeny, he has given us a most detailed and lucid account of the species examined, illustrated by excellent figures. His work will materially help to remove some of the errors that have unfortunately become associated with certain species, and at the same time it forms a very valuable addition to the literature in the subject.

TICKS: A MONOGRAPH OF THE IXODOIDEA. Pt. III. The Genus *Haemaphysalis*. By G. F. Nuttall and C. Warburton. Pp. xiii + 349-550, pls. viii-xiii, and figs. 309-450.—Bibliography of the Ixodoidea. II. By G. H. F. Nuttall and L. E. Robinson. Pp. 1-32. Cambridge: The University Press, 1915.

The authors of this monograph have entered into such detail and are so well known as authorities upon their subject that any criticism on our part would be presumptuous, but with all interested in the subject, we feel a deep debt of gratitude to them for the care and trouble that have been taken to make this third part as complete and detailed as is possible.

The method of treatment is similar to that of previous parts, the synonomy and literature relating to the genus are first given, followed by the generic characters and keys for the determination of species, then the specific descriptions of the valid species of *Haemaphysalis* and of their varieties, with a wealth of figures. The geographical distribution and hosts of the genus are next considered, and Dr. Nuttall contributes a very useful chapter on the condemned and doubtful species, and a most interesting one on the biology of *Haemaphysalis*.

Much of the beauty and clearness of plates 8 and 9 are lost through being printed on a tinted paper; otherwise the illustrations are excellent.

BRITISH ANTS: THEIR LIFE-HISTORY AND CLASSIFICATION. By H. St. J. K. Donisthorpe. Pp. xv + 379, and 92 figs. Plymouth: William Brendon & Son, Ltd., 1915.

Authoritative works on our British fauna must ever appeal to a wide circle of naturalists, and when such a work deals with so fascinating a group of animals as ants, and makes any pretence at completeness and thoroughness, it may be sure of a wide circulation and ready acceptance.

Mr. Donisthorpe's long experience and careful studies of our British ants are at once a guarantee, and after a careful perusal of his book, we feel that he is to be congratulated on the completion of a piece of work that for some time to come must rank as the standard one on the subject.

The first part is devoted to a brief, but lucid account of the external and internal structure, the life-history, psychology, geographical and geological distribution, and on mounting, preserving and observing the species.

The second part gives a systematic account of our indigenous genera and species. Here the synonymy, original descriptions, habitat, and much other information, is given in great detail and well illustrated. The work closes with a useful record of cosmopolitan and introduced species, and a very full bibliography and index.

The only adverse criticism we offer is a protest against the very objectionable method of quoting the synonymy, and the sources of the literature in the bibliography. Should a second edition be called for, as we hope it will, these two matters would well repay most careful attention.

VIGOUR AND HEREDITY. By J. Lewis Bonhote. Pp. xii + 263, 11 pls. and diagrams. London: West, Newman & Co., 1915. Price 10s. 6d. net.

This is one of the most readable and interesting works on the subject of heredity that has been published. Throughout it sparkles with a living interest, and contains a wonderful store of original observations.

The author, after briefly pointing out the inadequacy of existing theories, and the many difficulties to the unconditional acceptance of Mendel's Law as the sole basis of heredity, advances a further theory in which Vigour, *i.e.*, a state of high metabolism, is the dominant factor. Dividing the work into three parts, the first is devoted to an enunciation of the theory, the second to the experimental side, and the third to a discussion of this and other theories.

Mr. Bonhote has certainly provided all Mendelians with a considerable amount of debatable matter, and at the same time has produced a most thoughtful and stimulating work, deserving of very careful study, and one that no one interested in the study of heredity can afford to neglect.

The Spirit of the Soil. By G. D. Knox. Pp. xiii + 242, 17 figs. London: Constable & Co., Ltd., 1915. Price 2s. 6d. net.

It is frequently a very difficult matter to interest the general public in scientific matters, even though they directly concern them, but the author of this work will, we feel sure, appeal to a large public who wish to understand something of Prof. Bottomley's work in connection with a new fertiliser from peat. Mr. Knox's style is good throughout, and he unfolds a most interesting story for all concerned with horticulture or agriculture.

It is not possible here to give even a summary of this beyond the very briefest. Certain aerobic bacteria are capable of liberating from peat soluble humates which, in addition to forming a plant food-supply, serve as a medium for the cultivation of the nitrogen-fixing bacteria. This bacterised peat has been experimented with on a variety of plants, all of which have benefited. Further, Prof. Bottomley has isolated from the peat certain bodies which he terms auximones, which act as growth stimulators.

The evidence that has been produced for the presence of these bodies seems to us scarcely sufficient, and at present we feel that the case is "not proven," in spite of the very interesting manner in which Mr. Knox tells his very readable story of the spirit of the soil, and we trust that further demonstration and experimentation will be forthcoming.

The Structure of the Fowl. By O. C. Bradley. Pp. xi + 153, 73 figs. London: A. and C. Black, Ltd., 1915. Price 3s. 6d. net.

This excellently illustrated students' manual should prove of value to a wide circle of readers, for it is written in a concise and lucid style, and not overburdened with matter foreign to an elementary text-book.

It forms a very useful introduction to avian anatomy and embryology, whilst all who have to deal with the fowl in health or disease will benefit by a careful perusal of its pages.

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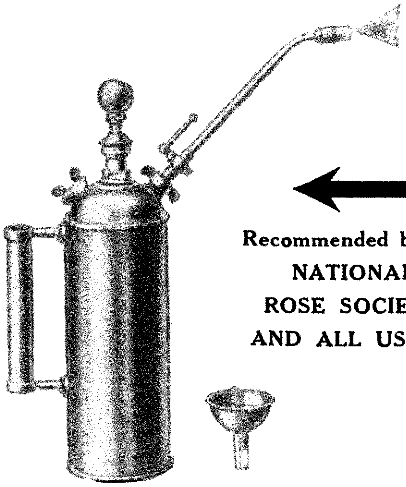
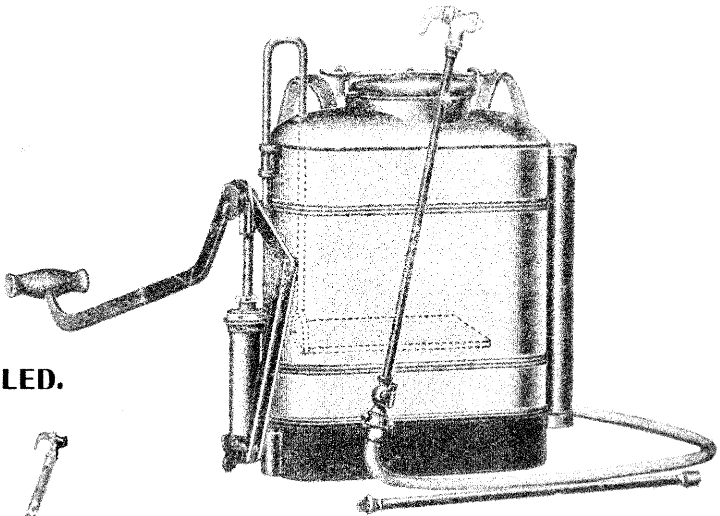
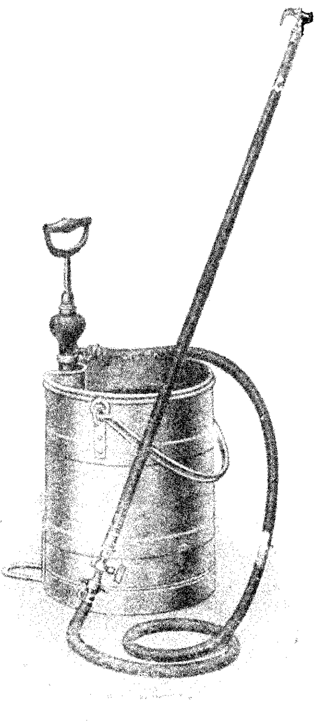
Contents.







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