THE GRASS THRIPS.

ANAPHOTHRIPS STRIATA (Osb).

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Introduction.

The Thysanoptera form a group of insects which, on account of their small size and apparent insignificance, have been much neglected by entomologists. Their position with reference to other groups has accordingly been doubtful, and at various times they have been assigned a place in no less than three different orders. Linnæus considered thrips as having affinities with the Hemiptera, and placed them in a genus immediately following his genus *Coccus*. While some of the followers of Linnæus retained them in this position, others referred them to the Orthoptera and still others to the Pseudoneuroptera. More recently, however, they have been placed in an order by themselves, to which the names Thysanoptera and Physopoda (Physapoda) have been given; but, as the former has priority, it should be adopted.

Although these insects are widely distributed and extremely abundant, being found in profusion in very many flowers, less than one hundred and fifty species have been described, of which about one hundred and twenty are from Europe and less than twenty from the United States. They range in size from one-fiftieth to one-third of an inch in length, the latter size having thus far been found only in Australian species. Undoubtedly the difficulties encountered in studying and accurately interpreting the mouth parts of such small animals have had much to do with the confusion regarding the systematic position of this group of insects.

Their mouth parts (Plate III., figs. 19, 20, 21 and 22) are intermediate in form between those of sucking and of chewing insects, but they probably take their food by suction. The mouth parts and other structures of the head are in part asymmetrical, a fact of considerable interest, as is also the location of the stigmata (Plate I., figs. 1 and 3). These are situated in adults upon the anterior angle of each side of the mesothorax and on each side of the first and eighth abdominal segments. A fourth pair, which is less conspicuous, is found upon the metathorax behind the place of attachment of the hind wings. In the larvæ the abdominal stigmata are found upon the second and eighth segments.

The metamorphosis also is interesting. The larva resembles the adult in form, and has similar mouth parts and food habits. The pupa, however, takes no nourishment, and is enclosed in a transparent skin, which is finally moulted as the insect reaches the adult form. The pupæ of some species possess a slight power of motion, their movements being very sluggish and uncertain; others are entirely motionless, and appear to have a nearly complete metamorphosis.

The members of this order live in flowers, upon the leaves or under the bark of plants and trees and in turf or fungi. In Australia they are said to form galls upon the leaves of trees, and in our own country they have been frequently reported as inhabiting galls formed by other insects. Several species have long been considered injurious to cultivated plants, especially to cereals. Extensive damage to grass also has been reported from all of the New England States, New York, southern Canada, Ohio, northern Illinois and Iowa. Without doubt the insect causing this damage infests a much larger territory than this, for it is so small that it easily escapes observation, and the damage really done by it is often attributed to other agencies. In order to become familiar with its life history, studies were made upon it at the entomological laboratory of the Massachusetts Agricultural College, under the supervision of Prof. C. H. Fernald, to whom I am much indebted for his able direction and kind encouragement in carrying on this work, the results of which are here given.

History.

In 1875, Prof. J. H. Comstock, in his "Syllabus of a Course of Lectures," mentioned a species of thrips which was doing very great damage to timothy and June grass by working in the upper joints. To this insect, of which he had seen only the larvæ at that time, he gave the name *Limothrips poaphagus;* but he published no description of it previous to the appearance of his "Introduction to Entomology," in 1888.

Five years before this latter date, Prof. Herbert Osborn published, in the "Canadian Entomologist," Vol. XV., page 155, the description of a species of thrips, under the name of *Thrips striata.* The description was made from a single specimen, and the food plant was unknown to Professor Osborn; but the published description agreed so closely with the "grass thrips" that the two were suspected to be identical. Not knowing whether *Limothrips poaphagus* Comst. and *Thrips striata* Osb. were positively synonymous, I sent some of my specimens to the Division of Entomology at Washington for determination, where they were referred

to Mr. Theo. Pergande, one of the highest authorities on this group of insects, who expressed the opinion that the specimens were identical with *Thrips striata* Osb., and placed them in the genus *Anaphothrips* Uzel. This is the only known genus in which some of the species have a distinct oblique suture near the end of the sixth antennal segment. I have made a critical study of the genera in Uzel's "Monographie der Ordnung Thysanoptera," and agree with Mr. Pergande that this insect should be placed in the genus *Anaphothrips*, which is characterized as follows: —

GENUS ANAPHOTHRIPS Uzel, Mon. der Ordnung Thys., page 143 (1895).

Ocelli present, body furnished only with short hairs; but there are no long bristles at the end of the abdomen and the hind angles of the prothorax. The antenna has eight segments, both segments of the stylus being moderately long. The species *virgo* has the sixth segment of the antenna broken near the end by an oblique suture, so that the antenna appears to have nine segments. Maxillary palpi with three segments. Prothorax about as long as the head. Legs unarmed. Wings generally present, but the species *virgo* is generally wingless. The cilia in the fringe of the costa of the fore wing are exceedingly short. The bristles on the veins are fine, and generally very short and inconspicuous. The bristles at the end of the abdomen are also very short and fine; but in *virgo* and *sordida* the bristles on the end of the ninth abdominal segment are short and stout. The males generally have two pairs of very short, stout spines on the upper side of the ninth abdominal segment, the anterior pair being much larger than the posterior. The species belonging here have no power to leap.

For the purpose of making a comparative study of the material before me with the types of Professors Comstock and Osborn, Professor Fernald obtained the loan of these types, and I find upon making the comparison that *Limothrips poaphagus* Comst., *Thrips striata* Osb., and the species which I have found in such abundance here in Amherst and upon which I have made the studies given in this paper, are identical; and, as the species was first described by Osborn, his name should hold, and this insect be known by the scientific name of *Anaphothrips striata* (Osb.).

Since Professor Comstock's first mention of the injury done by this species of thrips to June grass and timothy, several economic entomologists have referred to the most conspicuous effects of its work, the dead tops of these grasses, as "silver-top" or "white-top." Many have questioned the agency of thrips in producing this injury, and have ascribed it to some other suctorial insect;

but the majority of writers were inclined to credit thrips with a part, if not all, of this damage. As they had no means of identifying the little pest, they have usually referred to it as the "grass thrips." This name has been very generally used for this species, but not for any other so far as I can learn, and I have therefore adopted it as the common name.

Methods of Study.

It was evident at the beginning of these studies upon the grass thrips that the insects must be brought into the laboratory, where close observations could be made upon individuals through all their stages. For this purpose, large-mouthed, two-ounce bottles were used. In these bottles specimens of the larvæ taken from the stems of "silver-topped June grass" were confined upon the leaves of their usual food plant. The successive stages were observed, and specimens mounted for more critical examination under a compound microscope. In this way generation after generation was followed through the year. It was found that mounts in Canada balsam best preserved the coloration and natural appearance of the insect. The most satisfactory results were obtained by killing and allowing the specimens to stand for a few hours in xylol before mounting in balsam dissolved in xylol. This method, however, does not show the finer details of the external anatomy. For these, the most satisfactory results were obtained by first allowing the specimen to macerate in a ten per cent. solution of potash from twenty-four to thirty-six hours, and then mounting in glycerine. If the natural form of the body is desired, the specimen may be removed from the potash solution and boiled slightly in a drop of glycerine upon a slide. This removes the potash from the interior of the body, and renders it clear. The specimen is then transferred to a cell, with glycerine as the medium.

White zinc cement makes a very satisfactory cell, as it can be built up rapidly, dries quickly, and, if properly finished, is very firm and durable. In mounts made in this way over three years ago the glycerine has had no appreciable effect upon the cement. Zinc cells, however, require a few days to dry before becoming firm enough for use.

Better mounts for use with high-power objectives may be made without a cell. The specimen may be transferred directly from the potash to a small drop of glycerine upon the centre of a slide, and covered with a slip. All surplus glycerine should be carefully boiled out and removed with a small piece of filter paper. This mount should also be finished with a coat of white zinc cement.

Some specimens which were mounted directly in cold glycerine appeared to be very satisfactory at first, but, after standing for some weeks, masses of needle-shaped crystals formed over the exterior of the insect, so as to obscure its outlines and render the mount practically useless. No analysis was made of these crystals, but they may have been phosphates which had been dissolved in the internal juices of the body. The glycerine gradually extracts these juices, and, as the phosphates held by them would be insoluble in glycerine, they immediately formed a crystalline precipitate.

Laboratory results have been verified as far as possible by field observation.

Egg. (*Plate IV., Fig. 29.*)

The females deposit their eggs in the tissue of the leaf, selecting those parts which are fresh and tender, and appear to oviposit as readily during the night as they do in daylight. The process of oviposition is as follows: The female arches her abdomen so as to bring the weight of her body to bear upon the slender four-valved ovipositor (Plate III., fig. 18), which is attached to the ventral side of the eighth and ninth segments (Plate IV., fig. 31). The ovipositor is then slowly worked down through the epidermis of the leaf and into its cell structure, the abdomen being gradually lowered during this operation, though otherwise the insect appears to be perfectly quiet. Then, by successive contractions of the abdomen, the egg is pushed back under the epidermis of the leaf. The complete operation requires about a minute and a half, after which the female usually moves off a short distance and begins feeding. Occasionally the ovipositor becomes so firmly wedged in the leaf as to hold its possessor prisoner for some time, frequently until death results.

The eggs may be readily separated from the tissue of the leaf and mounted for more careful study with the microscope, but care must be taken not to crush or distort them in these operations.

The eggs are reniform, and vary in length from .265 mm. to .33 mm., and in width from .085 mm. to .145 mm. The average dimensions, taken from about twenty-five eggs, are: length, .288 mm.; width, .11 mm. The color is a translucent white. By transmitted light they are seen to be filled with a mass of yolk globules which vary considerably in size.

The hibernated females begin egg laying very soon after the weather becomes sufficiently warm to start the grass. Specimens of these females show from one to eight fully developed eggs within the abdominal cavity. They may live and continue egg laying for

four or five weeks. The number of eggs laid by a single hibernated female has not been determined; but, from specimens kept in confinement in the fall, an average of between fifty and sixty was obtained, the highest number recorded being seventy-two.

The length of the egg stage varies much, according to atmospheric conditions. The eggs laid by the hibernated females hatched in from ten to fifteen days, but this period is shortened in the summer generations to from four to seven days.

Larva. (*Plate I., Fig. 1.*)

As the young larva emerges from the leaf, it works its way up until about four-fifths of its body projects above the surface.

The body is very soft, shiny and nearly white. The eyes are purplish red in color, and the ocelli are wanting in all the larval stages. The antennæ and legs are folded closely against the ventral side of the body, and their outlines and segmentations are very indistinct. The larva remains supported in an upright position by the tip of its abdomen while the body is drying and the legs and antennæ are being separated from the body. After waving these in the air for a short time, the tiny larva falls forward upon its feet and pulls itself entirely free from the tissue of the leaf. It is able to travel immediately, and usually moves a little way from the egg before stopping for a short rest, after which it begins feeding.

The length of the larva very soon after its emergence is about .3 mm., and its width about .1 mm. The body is cylindrical, tapering posteriorly from the eighth abdominal segment. The head is nearly as wide as the thorax. The antennæ are comparatively large, approximate at their base, and composed of seven segments, of which the last four are closely joined and appear almost like a single conical segment. The fourth segment is larger than any other, and is distinctly ringed with whorls of minute setæ, while the second and third are indistinctly ringed. The basal segment bears one small spine on the inner side, the second segment four short spines which are directed forward and one very long spine directed backward toward the head. The third segment bears five short spines, and the terminal part of the fourth and each of the following segments a number of spines which are quite long and stout. The legs are stout, the tarsi one-segmented and terminated by two claws, and the bladder-like expansion of the adult is present. The abdomen is composed of ten segments which are much compressed longitudinally, and, except the tenth segment, are marked with six longitudinal rows of setæ, three pairs to each segment. The four dorsal rows also extend forward

along the segments of the thorax and the head. The tenth abdominal segment bears six very long setæ, two dorsal, two lateral and two ventral.

The body of the full-grown larva is fusiform, about 1.2 mm. in length and about .3 mm. in breadth, while the width of the head is about .1 mm. The antennæ (Plate IV., fig. 27) are seven-segmented, somewhat separated at their base and rather thick for their length. Their color is usually darker than that of the body, often nearly black, and the segmentation beyond the fourth segment is more distinct than in the immature larva. The first four segments are nearly equal in thickness, the third and fourth nearly equal in length, and each is as long as the first and second segments together. The last three segments are much smaller, the fifth one being the shortest. The spines are arranged much as in the younger stage. The third segment is distinctly ringed, and without setæ.

Each segment of the body, except the last two, bears setæ, which are short, slightly thickened at their extremities, and are arranged as in the young larva, those of the last two segments being longer and acute. The integument of the body is roughened by transverse rows of clearly defined ridges. The body is marked by dorsal and lateral longitudinal stripes of yellow, which are most distinct upon the thorax, the dorsal stripe being the widest.

Pupa. (*Plate I., Fig. 2.*)

The general form of the young pupa resembles that of the larva. The color of the legs, wing pads and antennæ is a clear white, while the head, thorax and abdomen are very light yellow and the eyes bright red. When the larva first enters the pupal stage the antennæ are apparently three or four segmented, much shortened and directed forward as in the larva, but after a few hours they are laid back upon the head and thorax. The wing sheaths, which are short, are developed outside the body. The legs are rather thick and clumsy, and as the insect advances in the pupal stage its movements become more and more sluggish and uncertain. No food is taken in this stage.

Upon the dorsal side of the ninth abdominal segment, near its posterior margin, are four prominent, stout, recurved, hook-like processes, while the abdominal setæ are slender and acute. In the fully developed pupa, before the final molt, the form of the body more closely resembles that of the imago. The wing sheaths extend backward along the sides of the abdomen to about the sixth or seventh segment, and the fore pair bear a few small spines. The pupal skin is partially separated from the enclosed insect.

The mature larvæ select secluded spots in which to pass the pupal stage. A few may be found transforming within the sheaths of the upper leaves, but the majority go down the stem to the old leaves and sheaths at the base of the stem near the surface of the ground. The duration of the pupal stage varies not only in the two forms of the adult but also at different seasons. In the first generation in the spring it requires from two to three days for the larvæ to transform to the wingless adult form, and from four to five days to the winged adult, but as the weather becomes warmer they transform more rapidly.

Imago. (*Plate I., Figs. 3 and 4.*)

There are two forms of the adult females, one of which possesses wings, while the other has merely the rudiments in the form of short pads. The description of the winged form is as follows: The length varies from 1 to 1.6 mm., the average being about 1.32 mm. and the width of the thorax is about .28 mm. The color is light yellow, with brownish or blackish markings.

The head, which is rounded in front, is marked with transverse striæ and a dusky border posteriorly (Plate IV., fig. 25). The antennæ (Plate IV., fig. 28), composed of eight segments, are approximate, whitish at the base, gradually becoming more dusky toward the apex, where they are nearly black. The sixth segment has an oblique suture toward the terminal end, which gives the antenna the appearance of consisting of nine segments. Segments three to six are distinctly ringed with whorls of small setæ, each segment bearing a number of stout spines, which are most numerous on the last three. Some of these spines are thick and blunt, rounded at the ends and slightly tapering. Unlike the other hairs, they are not brownish, but are thin-walled and transparent. They vary considerably in size and position, the longest one being found upon the inside of the sixth segment. Upon the dorsal side of the third segment and the ventral side of the fourth, two of these spines appear to have united, forming a delicate crescent-shaped appendage, which is attached by a short trunk to a clear, membranous depression near the end of these segments. The function of these structures is not known, but, as they are found only upon the antennæ, they are doubtless organs of sense, and may be called sense cones.

The eyes are large, and of a dark-red color. Three orange-red ocelli are present, arranged in the form of a triangle with the vertex in front, placed near together and well up on the vertex of the head between the eyes. The thorax is of a darker yellow color than the rest of the body, and is marked with elongated dusky

patches forming a broken subdorsal stripe on each side, the forward end of which curves outward. The wings (Plate II., figs. 7 and 8) are slender, somewhat sword-shaped in form, unmarked, and each wing is provided with a scale, which is connected by a membrane to the posterior side of the base of the wing. The fore wing has two longitudinal veins, and slight traces of one or two cross veins may sometimes be seen. There is a row of small spines upon the anterior margin and along each longitudinal vein. The hind wing has a single median vein, upon which, near the base, is a pair of rather slender spines directed backward toward the body. Near the base of the costal margin is a row of four or five short spines, hooked at their tips, which in flight engage a membranous fold on the under side of the scale of the fore wing (Plate II., fig. 9), and the surface of both wings is covered with minute setæ. Long fringes occur on both margins of the wings, except on the basal fourth, that on the hind margin of the hind wings being composed of a single row of spiral hairs, while that on the hind margin of the fore wings consists of a double row of spiral hairs.

The legs (Plate III., figs. 23 and 24) are concolorous with the body, and are sparsely set with fine hairs, in addition to which there is a row of five or six stout spines upon the under side of the hind tibiæ. The tarsi (Plate III., figs. 16 and 17) are composed of two segments, the division between them being very oblique. The second segment is terminated by the remarkable bladder-like structure which has suggested the name Physopoda for this order. The bladder cannot always be seen, as it is retracted when the foot is raised in walking and distended when the foot is put down again.

The abdomen consists of ten segments, of which the first seven are dusky on the dorsum, except at the sides, and segment eight has a dusky spot in the centre of the dorsum. The apex of the abdomen is slightly dusky, and surrounded with black spines. The hairs are scattering and fine except on the last two segments, the next to the last segment bearing four short, stout spines near the posterior edge of its dorsal surface.

The wingless female (Plate I., fig. 3) is slightly longer than the winged form, varying in length from 1.1 mm. to 1.65 mm., the average being about 1.47 mm. The description of the winged form applies to this, except that the general color of the body is more yellowish, the dusky markings upon thorax and abdomen are less distinct or wanting, and the dusky posterior border on the head is darker and more prominent. The abdomen is slightly more elongated, which may be due to its distension by eggs rather

than to difference in structure. The wing pads are folded back upon the thorax, in which position the fore pads completely cover the hind ones. The fore pads (Plate II., fig. 12) extend nearly to the posterior edge of the thorax, and are marked by longitudinal rows of short, stout spines, which vary in number. These spines are wanting on the hind pads (Plate II., fig. 13), but both pairs are covered with minute setæ.

About 98 per cent. of the adults which pass the winter are of the wingless form, while from 90 to 95 per cent. of the first generation in the spring develop wings; and the wingless form is far outnumbered by the winged until late summer, when the proportion declines, and in October only a small number, about the percentage that hibernates, of winged adults can be found. The females continue to deposit their eggs, and the young larvæ develop and may be taken from the grass upon warm fall days until snow covers the ground; but only the adults survive the winter. I have seen specimens revive after having been exposed to a temperature of 21° below zero. At frequent intervals during the winter I brought in grass from the field taken from beneath snow, or entirely exposed, and in no case did I fail to find females which became lively upon being kept a short time in a warm room. Accidentally I found that these hibernating females could survive for several days though submerged in a weak solution of potassium hydrate, and they have even revived after being frozen solid in a two per cent. solution of potassium hydrate; but, so far as my experiments went, freezing in pure water killed them. The hibernated females become active in the spring as soon as the weather is sufficiently warm to start the grass, and continue to deposit eggs for from four to six weeks. The appearance of a number of winged adults early in May marks the maturity of the first generation; but, as the hibernated females are still active, there can be no distinct line between the generations out of doors after this time. Laboratory experiments show that there may be eight or nine generations in a season. The length of the life cycle varies from thirty days for the first generation to twelve days during the heat of summer.

I have sought in vain for the males of this species, for, although I have mounted over a thousand specimens, have bred many more in bottles in the laboratory, and have taken and examined large numbers of them in the field, I have never seen any that I even suspected were males. A series of experiments, begun in the laboratory July 22, 1898, and continued into December, proved that no males are developed in the fall generations. Experiments

were begun this season (1899) by confining hibernating females in bottles before the weather became warm enough for them to move out of doors. These became active and deposited eggs, from which succeeding generations have been bred without the appearance of any males. I conclude, therefore, that this species is parthenogenetic, and reproduces without the intervention of any males, at least for a series of generations, in this locality. The eggs may be seen in the abdomen before being laid, and I have found as many as eight fully developed in a single female.

Feeding Habits.

The adults of this species feed entirely upon the leaves and external parts of the grass. They are very seldom found within the sheath of a leaf, but frequently congregate in numbers within the terminal leaf before it has fully unrolled. They select the fresh, tender parts of the grass, and consequently their work is most apparent upon the upper leaves. The mouth parts (Plate III., figs. 19, 20, 21 and 22) are formed entirely for sucking. The bristle-shaped mandible and the similarly formed lobes of the maxillæ are used to pierce the epidermis of the leaf and the wall of a cell below. As soon as the juices contained in this cell have been extracted, the piercing mouth parts are withdrawn and another cell is punctured, the empty cells presenting a shrunken, whitish appearance. The insects usually feed lengthwise of the leaves, their path being marked by whitish streaks in the tissue of the leaf and by dots of dark excrementitious matter.

The larvæ seek a more protected place in which to feed, and may be found in large numbers within nearly every sheath of June grass (*Poa pratensis*) during the latter part of May and through June. A favorite haunt is in the head, just as it is making its appearance. The minute larvæ work their way down inside the sheath, and some of them, reaching a node where they must stop, continue to feed upon the juices from the very tender stem within until shortly before they enter the pupal stage. The larvæ may be found within any sheath; but it is almost always those that enter the top sheath which cause the "silver-top," as these directly cut off the supply of sap to the head. Examination of affected stems shows that at a point just above the upper node the stem has been sucked dry for about half an inch of its length (Plate I., fig. 6).

While I cannot state positively that this species is ever carnivorous, my observations have led me to suspect that such may sometimes be the case, though normally it is certainly herbivorous. I

have seen specimens of this or some other species so closely allied to it as to be indistinguishable to the naked eye, when confined in bottles, carrying around the victims which they had impaled upon their piercing mouth parts, apparently being engaged in sucking the juices from the bodies.

Food Plants.

This minute pest attacks a number of species of grass; but by far the greatest damage is done to June grass (*Poa pratensis*) (Plate I., figs. 5 and 6), few fields of this escaping more or less serious injury. After the first of July, by which time June grass has usually matured, the insect changes to some later species, as timothy (*Phleum pratense*), when this is present. They may be found in abundance upon barn-yard grass (*Panicum crus-galli*) from midsummer till late in the fall. About the middle of July, 1898, I found them quite common upon a field of young corn which was nearly surrounded by grass land, but later in the season they could not be found upon corn. Many other grasses show unmistakable traces of the work of thrips by their whitened heads, and a list of these, with the percentage of "silver-top," estimated on June 29, 1898, is given below; but I cannot positively connect this species with all the injury.

The percentages given were obtained by counting the injured and uninjured heads upon a small area on which the damage appeared to be of average severity. Slight traces of "silver top" are indicated by a dash in the column of percentage.

	Per Cent.		Per Cent.
Poa serotina,	30	*Festuca elatior*,	–
Poa nemoralis,	80	*Festuca ovina*,	95
Poa compressa,	40	*Festuca duriuscola*,	95
Poa arachnifera,	20	*Festuca tenuifolia*,	40
Poa Fletcheri,	10	*Festuca rubra*,	20
Poa aquatica,	35	*Panicum crus-galli*,	–
Poa pratensis,	75	*Panicum sanguinale*,	–
Poa trivialis,	10	*Phleum pratense*,	–
Poa cæsia,	10	*Elymus striatus*,	–
Agrostis alba,	30	*Elymus virginicus*,	–
Agrostis canina,	20	*Bromus erectus*,	–
Agrostis stolonifera,	25	*Bromus inermis*,	–
Agrostis vulgaris,	25	*Avena flavescens-vera*,	–
Festuca Oloft,	20	*Agropyrum caninum*,	–
Festuca heterophylla,	35	*Arrhenatherum avenaceum*,	–
Festuca pratensis,	–	*Lolium perenne*,	–

Remedies.

A knowledge of the life history of this insect suggests to us a few ways in which it may be most easily combated and its damage lessened. As the females hibernate above ground, burning in early spring must destroy large numbers of them. To be effective, the burning must be close and thorough, and the burned space either quite large or isolated from other infested fields. This must be done before the grass starts, which is usually about the first of April, because the females hibernate very close to the base of the stems, and a close burn after the green blades appear cannot be obtained.

The damage appears to be most severe on worn-out meadows, fields and lawns. This suggests stimulating the plants, to give them additional vigor, and harvesting as early as possible. The June grass should either be cut as soon as the heads begin to turn white, or fed green.

So far as I can learn, the seed of this grass is sold only in lawn mixtures, and is not used for field seeding. The June grass comes in gradually, as the stouter-growing species usually sown run out. Attacks are most severe on fields that have been seeded for several years and have become partially exhausted. This suggests ploughing deeply, and planting for at least one year with some cultivated crop before reseeding.

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Explanation of the Lettering of Figures in the Following Plates.

All figures in these plates are drawn from *Anaphothrips striata* (Osb.) except figs. 5 and 6, which show its work.

AF. Anterior fringe of long straight hairs.
Ant. Antenna.
BA. Basal segment of antenna.
BE. Basal enlargement of the mandible.
Bl. Bladder terminating the tarsus.
Bs. Base of stem of *Poa pratensis*, taken from just above the upper node.
C. Coxa.
CE. Compound eye.
CL. Chitinous lever.
CM. Connective membrane.
CP. Chitinous plate.
CR. Chitinous rod, internal.
EG. Egg groove.
Fa. Facets of compound eye.
Fe. Femur.
FL. Fore leg.
FV. Fore vein.
FWp. Fore wing pad.
H. Head.
HL. Hind leg.
HV. Hind vein.
HWp. Hind wing pad.
L. Ligule.
LP. Labial palpi.
LM. Lobe of the maxilla.
LV. Left lower valve of the ovipositor.
MF. Membranous fold near the posterior edge of the scale of the fore wing.
ML. Middle leg.
MP. Maxillary palpus.
MS. Membranous space to which the labial palpi are attached.

Ms. Mesonotum.
Mt. Metanotum.
O. Ocelli.
Op. Opening in which a muscle is attached to the base of the mandible.
OS. Oblique suture near the end of the sixth segment.
PF. Posterior fringe, composed of long, spiral hairs.
Pt. Prothorax.
R. Reticulate markings, which are most prominent upon the posterior part of the dorsal surface of the head.
RV. Right lower valve of the ovipositor.
S. Stigma.
SC. Thick, clear sense cones.
Sc. Scale of wing.
Sp. Spines upon the veins of the fore wing.
St. Style of the antenna.
Su. Suture between the first and second tarsal segments.
Ta. Tarsus.
TE. Thickened edge of the ninth abdominal segment.
Th. Teeth upon the ovipositor.
Ti. Tibia.
Tr. Trochanter.
UV. Tip of right upper valve of the ovipositor.
WE. Wings extended in position for flight.
WF. Wings folded at rest.
WS. Wing sheath.
7. Seventh abdominal segment.
8. Eighth abdominal segment.
9. Ninth abdominal segment.
10. Tenth abdominal segment.

Explanation of Plate I.

Fig. 1. Full-grown larva. $\frac{6 \cdot 2}{1}$.

Fig. 2. Pupa. $\frac{6 \cdot 2}{1}$.

Fig. 3. Wingless adult female. $\frac{6 \cdot 2}{1}$.

Fig. 4. Winged adult female. $\frac{6 \cdot 2}{1}$.

Fig. 5. Head of *Poa pratensis* normally developed. $\frac{1}{2}$.

Fig. 6. Head of *Poa pratensis* arrested in its growth by the attack of *Anaphothrips striata* (Osb.), also showing the shrivelled condition of the stem just above the upper node. $\frac{1}{2}$.

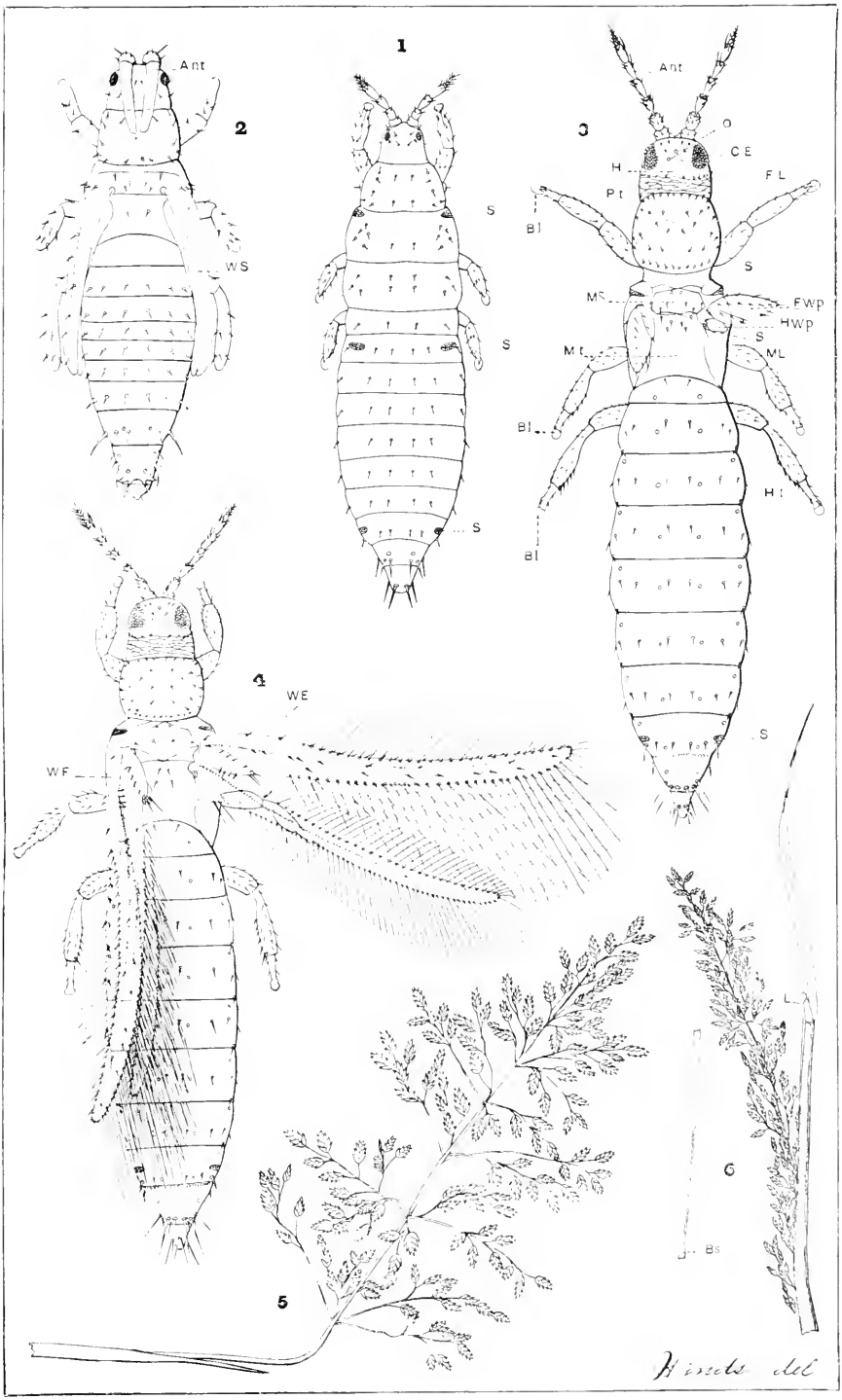
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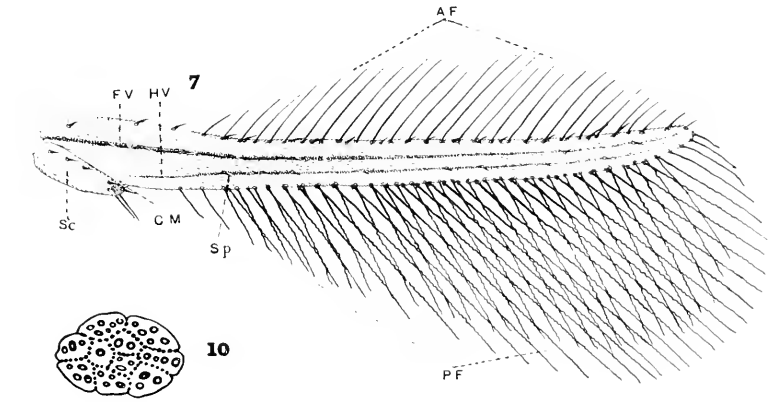
Plate I.

Explanation of Plate II.

Fig. 7. Right fore wing. $\frac{9}{1}^{3}$.
Fig. 8. Right hind wing. $\frac{9}{1}^{3}$.
Fig. 9. Bases of wings as joined together during flight. $\frac{1}{1}^{6}{}^{2}$.
Fig. 10. Stigma from the second abdominal segment of the larva. $\frac{7}{1}^{2}{}^{0}$.
Fig. 11. Stigma from the first abdominal segment of the adult. $\frac{7}{1}^{2}{}^{0}$.
Fig. 12. Fore winged pad of wingless female. $\frac{2}{1}^{1}{}^{2}$.
Fig. 13. Hind wing pad of wingless female. $\frac{2}{1}^{6}{}^{4}$.
Fig. 14. Scale of fore wing, detached. $\frac{2}{1}^{1}{}^{2}$.
Fig. 15. Base of hind wing. $\frac{2}{1}^{1}{}^{2}$.



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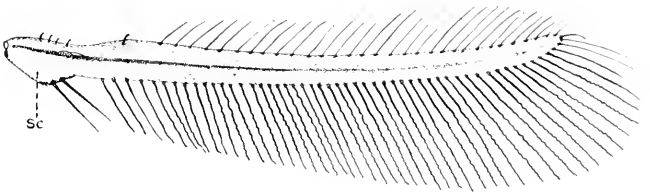

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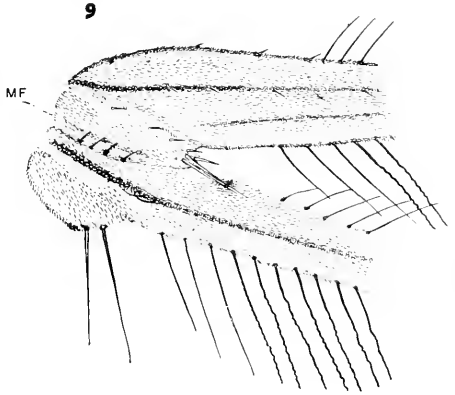

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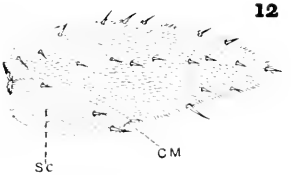

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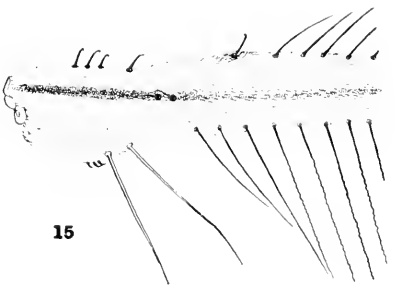

Plate II.

Explanation of Plate III.

Fig. 16. Under side of the tarsus and end of the tibia of the middle leg. $\frac{1}{1}\frac{8}{0}$.

Fig. 17. Side of tarsus and end of tibia of the middle leg. $\frac{1}{1}\frac{8}{0}$.

Fig. 18. Ovipositor. $\frac{3}{1}\frac{7}{0}$.

Fig. 19. Labrum. $\frac{7}{1}\frac{2}{0}$.

Fig. 20. Labium. $\frac{7}{1}\frac{2}{0}$.

Fig. 21. Right maxilla, external view. $\frac{5}{1}\frac{0}{2}$.

Fig. 22. Unpaired mandible. $\frac{7}{1}\frac{2}{0}$.

Fig. 23. Right hind leg. $\frac{2}{1}\frac{1}{2}$.

Fig. 24. Right fore leg. $\frac{2}{1}\frac{1}{2}$.

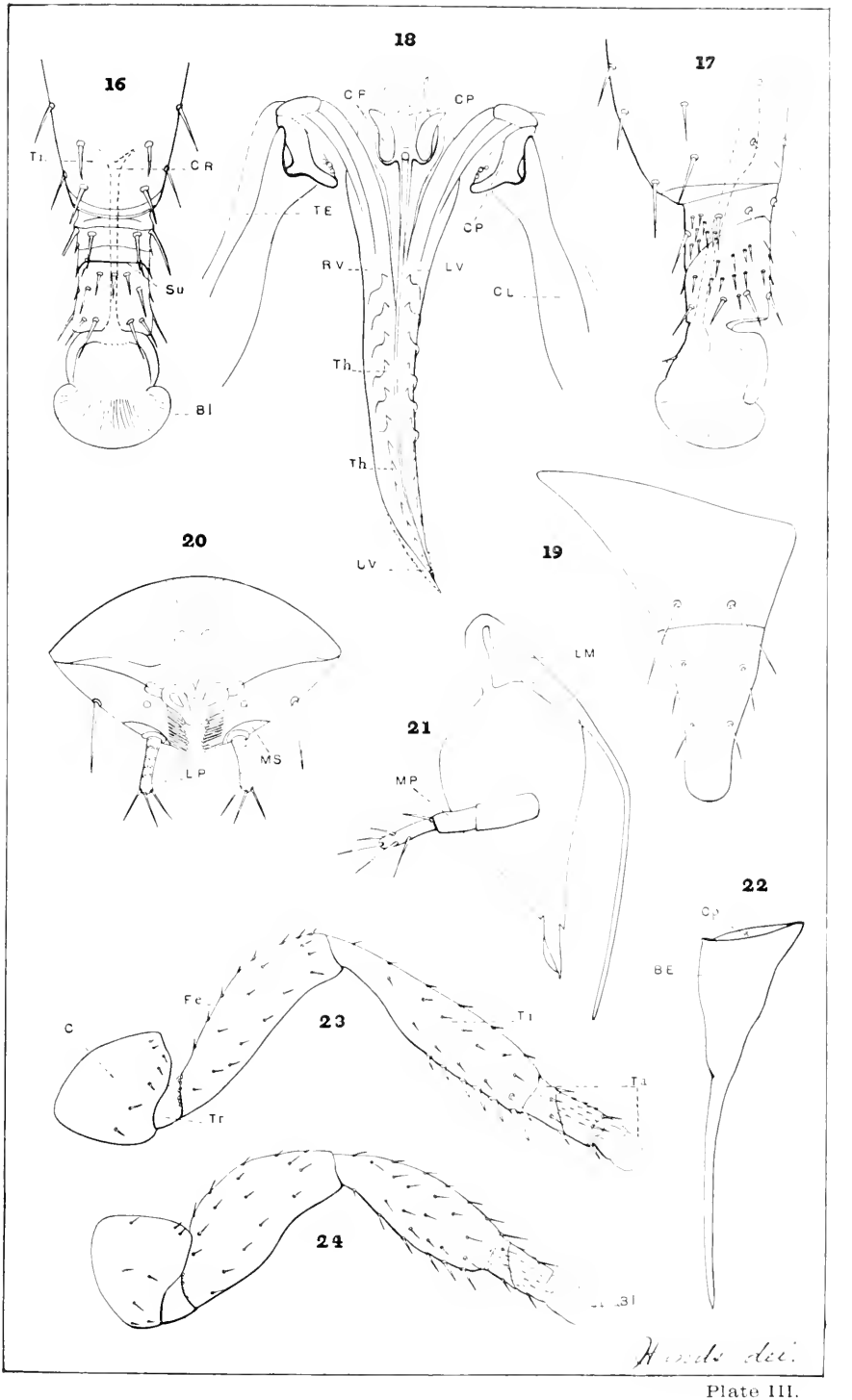
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Plate III.

Explanation of Plate IV.

Fig. 25. Dorsal view of head. $\frac{188}{1}$.

Fig. 26. Left antenna, drawn from the type specimen of *Anaphothrips striata* (Osb.). $\frac{280}{1}$.

Fig. 27. Left antenna of full-grown larva. $\frac{370}{1}$.

Fig. 28. Right antenna of adult female. $\frac{370}{1}$.

Fig. 29. Egg. $\frac{135}{1}$.

Fig. 30. Dorsal view of abdominal segments, 7 to 10. $\frac{145}{1}$.

Fig. 31. Ventral view of abdominal segments, 7 to 10. $\frac{145}{1}$.

Fig. 32. Side view of abdominal segments, 7 to 10, ovipositor hanging down. $\frac{132}{1}$.

Fig. 33. Inside of left lower valve of the ovipositor. $\frac{185}{1}$.

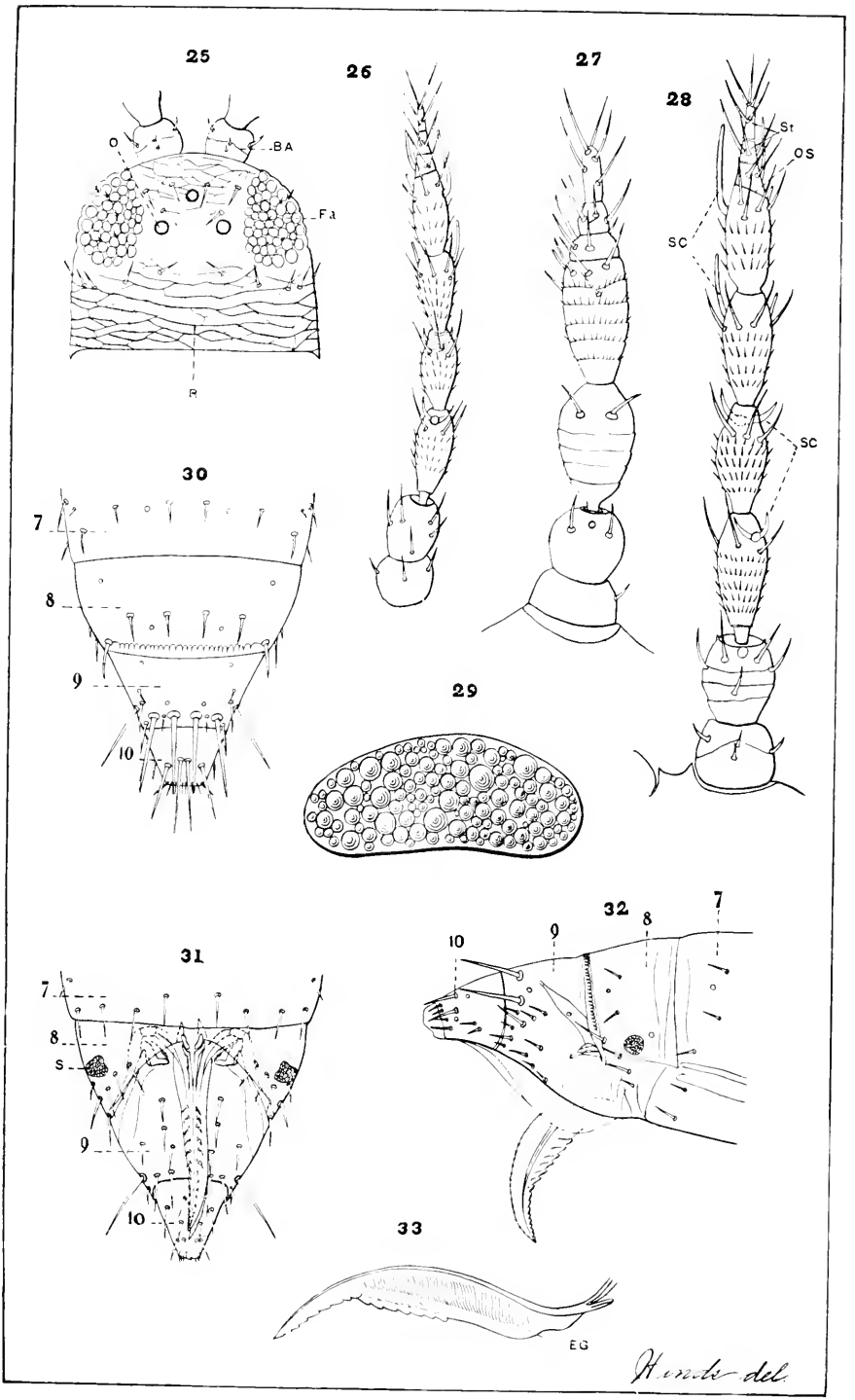
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Plate IV.