T H E S I S

on

The European Earwig - Its Life History - Habits and Natural Enemies

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INTRODUCTION

Earwigs are insects belonging to the order Dermaptera and are easily characterized by the peculiar set of forceps borne upon the caudal extremity of the of the abdomen and also by the unusual folding of the hind pair of wings (Fig. 1). When at rest, these lie beneath the fore wings, which are abbreviated and extend over only a portion of the thorax, and are folded both transversely and radially. Some species have no wings. The group has often been associated with the order Orthoptera and even yet some authorities treat it along with the Orthoptera. There is a very close relationship.

At least four hundred species of earwigs are known, but the majority of them are found only in the tropical or semi-tropical regions. Fifteen species may be found in the United States. Of these only two are known to inhabit Oregon. These are the European Earwig Forficula auricularia Linne, and the Little earwig, Labia minor Linne. The European earwig, as its name implies came to this country from Europe and it is likely also that Labia minor is an exotic species.

Earwigs owe their popularity for the most part to the

European earwig and it is recognized mostly because of its unpopularity. It becomes obnoxious because of the great numbers of its kind which act both as a household pest and a destroyer of plant materials of many kinds. The species has been known in Oregon since 1910 when specimens were sent into the Oregon Experiment Station from Albany, Oregon. Since then the outbreaks of the pest have occurred in Portland, Oregon, Seattle, Washington, Vancouver and New Westminister, B. C. and in Providence, Rhode Island, In these cities they have become so serious as to constitute a major civic problem and thousands of dollars annually have been appropriated to combat them. They are spreading very rapidly in the Northwest and bid fair to become a major household and garden pest over the western half of the Pacific states and British Columbia. It seems that the European earwig has never become established in great numbers very far from the sea-coast. Mr. B. B. Fulton states that in 1923 the earwig was known to exist in the following Pacific Coast towns in addition to those already named: Astoria, Salem, Eugene, Corvallis, Forest Grove, Gresham, Roseburg, Dayton, Mill City, Colton and Blodgett, in Oregon; Vancouver, Camas and Anacortes, Washington and in Berkely,

California. He says also that unconfirmed reports have stated its existence in Edmonds and Everett, Wash. Since Fulton published his list the insects has made its appearance at Hillsboro, Troutdale and Fairview, Oregon and it is very likely that it has spread to other towns.

So serioues a problem has the presence of the earwig in Portland, Oregon, Seattle, Washington and Providence, Rhode Island become that these cities include thousands of dollars in their budgets annually for the purpose of suppressing them. In 1924 Portland, Oregon spent about $40,000.00 on her earwig campaign and Seattle, Washington has spent over $200,000.00 in an effort to hold the insect in check. The end is not in sight, for each year finds the outposts of the earwigs advanced beyond the year previous and a new generation to take the place of the one which occupied the ground held by the parents of the year before, despite a carefully planned poisoning campaign.

The present method used in control of the European earwig is very effective when applied efficiently, but it is proving rather expensive for the cities using it. Poison bait consisting of the following formula is spread lightly over the surface of the ground where earwigs are known to be:

Sodium fluride	1 pound
Molasses	2 quarts
Water	2 gallons
Wheat bran	16 pounds

This material is spread during the evening hours and during the season of year when the nymphal earwigs have begun feeding above ground. In Portland this is usually early in May, though variation in spring weather might easily delay or prolong their appearance. Such has happened more than once. It is best that all areas in a community be spread at the same time, because a few of the earwigs migrate from one block to another and have a good chance of escaping the poison. After a rain, or a sprinkling of the lawn or garden that has been spread, the material becomes washed of the soluble sodium fluoride poison and consequently is ineffective when eaten. Furthermore, it is of little value after it becomes four days old; especially if it has been spread where the sun may strike it. The reason for this has not been determined, but it is likely because of oxidation of the sodium fluoride.

The addition of molasses to the bait makes it very attrative to earwigs and they devour it readily. In Portland the annual campaign has been financed jointly by the County of Multnomah and by the City of Portland. A com-

missioner of the State Board of Horticulture has been placed in active charge of the work and the State Nursery Inspector has cooperated closely with him during periods of the actual campaign. During the spring and summer of 1924 over fifty men were busy six nights out of each week for a period of four and a half hours spreading areas of the city with poison bait. They were divided into crews with a foreman over each crew and assigned a definite street routing to follow each night. Careful check over the number of square feet covered by the combined crews each night was kept and also the amount of material required to cover a definite area. An average total of approximately five million square feet of soil received an application of poison during an evening's work of the crews. This rate was kept up from May 13 until July 19 when the campaign was declared closed. A central plant was kept employed mixing bait to be used by the crews and a small truck was assigned to accompany each crew for the purpose of hauling material from the central mixing plant and for returning empty sacks.

It was not difficult for those closely associated with the work to foresee an increasing annual expense on the part of infested communities in their attempts to control the pests. Annual campaigns are expensive and it is often

difficult to make a community budget fit such an unusual city enterprise as pest control.

Word was received from Dr. L. O. Howard, Chief of the Bureau of Entomology of the United States Department of Agriculture suggesting that the earwig problem might possibly be lessened through the importation and establishment of certain parasites of the earwig which seem very effective in Europe, but which do not occur in this country. The idea was relished by Portland authorities; they worked through Dr. Howard and the Oregon Experiment Station in getting in touch with persons in England who might supply quantities of the insects for use in Oregon. An appropriation of two hundred and fifty dollars was made to meet the expenses and arrangements were made with Dr. Imms of the Rothamsted Experiment Station in England to supply the material needed in Oregon. That station already had sent parasites of the European earwig to New Zealand where the latter insect has made itself exceedingly obnoxious. Just what success workers in New Zealand have had is not known to the writer.

Two species of tachinid flies were to have been sent over by Dr. Imms during the fall and winter of 1924 and the spring of 1925. The species Digonochaeta septipennis

was to have been sent in the pupal stage, while the s species Rhacodineura antiqua was to have arrived during the stage of larval infestation of the living earwig in the early spring of 1925. Preparations were made in detail to receive and care for the parasite material. Plans for an insectary were prepared by Mr. B. B. Fulton of the Oregon Experiment Station and constructed in the Piedmont district of Portland with funds supplied by that city. The writer, who was then working on control measures and performing biological work for the Portland Earwig Control Bureau, stocked the four small buildings with earwigs caught during the summer and cared for them until they went into hibernation for winter.

However, the program met with a serious hitch when word came from Imms of Rothamsted that his technical assistant handling the earwig parasites had become ill and would be confined indefinitely to a hospital, thus making it impossible for any shipments of material to be made until at least the fall of 1924.

Such a condition did not satisfy the officials in Portland, nor Professor Don C Mote of the Oregon Experiment Station who had made arrangements for rearing the flies. Professor Mote communicated with Dr. Howard of the Bureau of Entomology requesting him to use what means he

might have at his command to send at least enough of the parasite material over for study, so that when the bulk shipments arrived later we might have a year's experience to bank on. Dr. Howard responded surprisingly well by having a member of his bureau in Europe collect and send a fairly large number of puparia of Digonochaeta setipennis and later a couple of shipments of live European earwigs that were thought possibly to harbor the larvae of Rhacodineura antiqua. Hence a quantity of material sufficient to make a fair test on Oregon conditions in relation to the parasites is available for this year. It is not possible accurately to predict what success may be encountered, but from the appearance of the situation thus far it seems possible that puparia of Digonochaeta setipennis will be obtained in the fall, but the outlook for Rhacodineura is not so bright.

THE EUROPEAN EARWIG

LIFE HISTORY

Adult earwigs mate in the field during the summer and fall at which time the females always seek shelter beneath the soil to a depth of about two inches, or beneath a well bedded board or stone. Here they prepare a small chamber which serves as a resting place for the winter and a place

where eggs may be deposited. They may often seek a situation against the side of a house or against a stone wall where a greater degree of protection may be afforded. However, they burrow beneath the surface. The males may also seek shelter under the soil, or under rocks, but often they may be found buried in the rotting debris lodged in the crotch of a tree, or in such other shelters as they may be able to discover above ground. It is possible that females may occasionally fail to enter the soil, but none have ever been found above ground in winter by the writer and extensive searches have been made for that purpose. The reason for this probably lies in the responsibility of egg deposition resting upon the females which makes them seek adequate shelter. Earwigs have been found holed up in the soil for winter in Portland as early as October 5.

It is not known just how early in the season egg deposition may take place, but it is known that in many cases eggs may be held as early as November. On February 16, 1924 fifteen female earwigs, each with a batch of eggs averaging about forty in number, were dug out at Albany, Oregon and brought into the laboratory for study. About eighty-five per cent of the females discovered were found with eggs.

Upon examination of these under a glass in the laboratory, they were found to contain fairly well developed embryos. Proof of this was borne out when on February 22 (six days after being brought in) the young earwigs began to hatch and within two days from that time virtually every egg had given rise to a nymph earwig. Of course, this was under the warm conditions of the laboratory.

In the field eggs may be deposited in early spring, during the warmer winter days, or in the fall. Very few female earwigs will be found with eggs in the body after the middle of March. The time of hatching varies with the weather, though usually it occurs during the month of April. During the period between April 18 and April 24 the writer made a special survey of a heavily infested area of Portland to determine the approximate percentage of earwig eggs yet unhatched and to determine what stage the young were in. Hundreds of nests were uncovered, but only six were found to contain unhatched eggs. These were taken to the laboratory and kept under normal out-of-doors temperature. All were hatched by April 23 and April 21 was the last day any eggs were found in the field until a second brood appeared.

Mr. B. B. Fulton observed that hatching usually starts during the blossoming period of the native broad leaf maple and cherry tree and is practically completed by the time apples are in full bloom. These observations tally well with those made by the writer during the season of 1924.

The maternal spirit of the female earwig runs deep and during the winter and early spring she guards her eggs carefully against intruders. She keeps them spotlessly clean and always in neat little piles. When the nymphs hatch, they seem veritably to fill the little cell, where they swarm over and about their mother. Through it all she remains placid, occasionally thrusting her head down to a group of them in a communicative attitude. The nymphs often feed on tender root tips found about the walls of their cells, or accept bits of food the old mother brings in from the outside. Rarely do they make pilgrimages from the cell before they have reached the second instar. Before reaching the adult stage earwigs moult four times.

When first hatched a nymph is very white, is without any sign of wings, and has only eight segments to the antennae. After each moult, segments are added to the

antennae until in the adult stage they have fourteen. Wings become evident as growth progresses. After each moult, the earwigs are snowy-white in appearance and seem rather inflated, though this latter condition disappears after a few hours and the white soon becomes a dull gray, or a reddish brown if it is the last moult.

Moulting of earwigs has been observed many times by the writer. The old skin splits down the median line on the head and dorsal aise of the thorax. After this it is all up to the earwig. One male being watched went through vigorous, difficult contortions, resting occasionally to recuperate, but attempting to retain all he had gained in his struggle for freedom. After each pause he would twist away with renewed vigor, till finally he burst forth as white as snow, his old skin slipping over his forceps. The process must be rather painful, for a newly moulted earwig is rather a frail, tender little creature and shuns his associates like a sunburned human.

Adult earwigs are markedly different in color than the nymphs. Fult describes them in part as follows: "The adult female earwig is about 16 mm. or 5/8 inch in length including the forceps when alive. In dead speci-

mens shrinkage of the abdomen reduces the length. Males are about the same size or considerably larger. The general color is dark reddish brown; head decidedly reddish (burnt sienna);wing covers and edge of pronotun medium yellowish brown; center of pronotun practically black; legs pale yellowish-brown, forceps pale at base, black on distal part and along both lateral edges." Sexes of adults are readily distinguished from each other by the fact that those of the male are flattened considerably at the bases and are strongly curved inward resembling ice tongs or calipers; those of the female are nearly straight, though are curved slightly inward at the tips.

The fact that two broods of earwigs are produced annually in Oregon is now known. Duringthe spring and summer of 1924 close watch was kept on female earwigs to ascertain whether or not a second lot of eggs might be deposited, for in their native habitat only one brood a year seems to be the rule. Daily observations were made by dissecting the females and on May 2 a number of earwigs were examined and about 90% contained an average of thirty eggs apiece. These were quite undeveloped. From that time on I examined dozens of earwigs in the field and

and scarcely any failed to show signs of eggs. By May 10 eggs in the bodies of most of the females had become well developed and indications pointed to the fact that egg deposition in the field would soon commence. Indeed, many females were found to be holding themselves up in the soil, apparently for egg deposition and an increasing per cent were found under the soil as the season advanced. By May 22 few adult females could be found above ground. The adult males for the most part had died off prior to that time and very few were to be found alive in the field. Nearly all of those under observation in captivity were dead at this date. It is very likely that they live only long enough to fertilize the females for the second generation of young.

While no eggs were found in the field as early as June 1, it is very likely that many were deposited up to that date and that egg deposition progressed during the latter part of May and the first half of June. On June 2 two nests of earwigs in the first instar were found, though in each instance the females were not in evidence; but the young were undoubtedly of the oncoming second brood. During the early days of June the young of the second brood became more numerous daily. Literally hundreds of nests were unearthed each containing about 40 nymphs with the old female standing guard. Never were eggs found, but they

had been deposited in abundance and probably hatched soon after being laid.

Not all females that come through the winter have two broods of young. Those that do not have the second brood die off shortly after their young reach the point where they break off family relations and begin to shift for themselves. It is very likely that from 30% to 40% of all the females do deposit eggs for the second brood.

Observations of the period up to June 18 show that the majority of earwigs of the first brood become mature by that date, that earwigs of the second brood appear in large numbers, and that very few of the last year's earwigs remain alive beyond this period.

During the latter days of June, or about the time Royal Ann Cherries are ripe, virtually all of the first brood had reached the adult stage, a few were in the fourth instar; and a few probably in the third, though it is difficult to differentiate at this point between individuals of the first and second brood.

The majority of those earwigs of the second brood reached the second instar by July 16 and many were in the third and fourth instars by that time. They become mature during August.

To summarize what we know of the second brood of earwigs, we may say that they are hatched during the first half of June, or possibly a little later, when the first brood are reaching the adult stage; that they emerge to feed in numbers around July 1 and that they reach the adult stage about the middle of August, or perhaps a little later. Of course there is a wide variation in the time of emergence and time of maturity of this second brood. A few come early and some stragglers are present, but the statement made heretofore will include the greater portion.

Mention has been made of the fact that not all females of the previous year's generation deposit two batches of eggs. Why this is so, or just what influence it is the result of, is not known. Can it be that only those of the first brood are favored with two layings, while those of the second brood develop only one? Or do part of each brood deposit two batches and part only one?

In order to settle, as far as possible, a few of these mooted questions, the writer, during the summer of 1924, inclosed in a tight pen several hundred earwigs of the second brood, and in another pen of the same dimensions were placed about the same number of earwigs of the

first brood. These will be watched closely during the spring and summer of 1925, but as yet no data is available on them. The pens afford quite natural conditions for the insects, they are fed daily (except during winter) are unprotected from above, but have concrete walls against which to nestle under the soil.

HABITS

For the most part the European earwig is nocturnal, though occasionally may be found prowling about in broad daylight. In feeding habits they are omnivorous. When hungry they will tackle virtually anything that may contain food material. Normally they relish dandelion, milkweed, lamb's quarter, cabbage, rhubarb, whole beet, potato tubers and tops, carrots, lettuce, kale, prune leaves and tender twigs, dahlia, peony, and various other of the more succulent plants. Also they readily devour Kentucky Wonder bean leaves, but seem to despise the common bush bean leaves including the wax bean, navy bean, and shell bean. Meat scraps, raw or cooked, are considered a delicacy and most of our ripe native fruits are eaten with gusto. Whole peaches and cherries cast into the insectaries where thousands of earwigs were confined were soon devoured, the stones left as clean and dry as though

they were washed.

Reports have been received that earwigs eat holes in fine linens, destroy curtains in the homes and ruin clothing by chewing holes in it. Very likely this is all a mistake, for various tests have been performed by the writer in an attempt to find truth in such reports; yet not a particle of incriminating evidence could be directed toward the insects. Small pieces of linen, silk, cotton and wool cloth were placed in jars containing earwigs and no food was added. They were left under those conditions for six days, but did not touch the cloth. In addition, earwigs are easily kept in confinement by tying a piece of gauze over a jar to serve as a top. They would easily escape if they were prone to devour cloth. Many times they have been found upon curtains in homes, but never has the writer discovered any damage to the curtains result from they mandibular exercises.

It has been supposed that the European earwigs commonly remain upon the ground during the spring and early summer period and in late summer ascend the trees and remain there for some time. It became quite important to find whether or not such a habit persisted among the earwigs, for the method of control generally relied upon becomes ineffective if they do not feed upon the ground.

During the summer control campaign of 1923 in Portland, crews were enlisted to put a preparation in the trees where the earwigs were thought to be most plentiful.

An opportunity to study the summer habits of earwigs in regard to tree climbing presented itself when large quantities of these insects were being trapped alive for use in parasite rearing during the spring and summer of 1924. Tar paper bands were placed on the trunks of the trees about one foot from the ground. During the night the earwigs would swarm by the thousands up the trees. Most of them, when they came to the bands, would remain there, for these proved an excellent shelter against the light of dawn, and, in addition, they provided a place where the earwigs could congregate in large numbers, a feature to their liking. Each morning the bands were removed and the earwigs allowed to drop into an apron below. Trapping continued from about June 1 to August 5. There were fully as many earwigs in the trees in June as in August.

The next question to present itself was in regard to how long the earwigs remained in the trees. In order to determine this point, the trunk and limbs of a cherry tree located in a heavily infested area, were banded in such a way as to apprehend any earwigs coming from the

ground, and above them on the scaffold limbers were placed bands to intercept any coming down the tree toward the ground.

To begin with the tree was unbanded and very heavily infested with earwigs. Will those earwigs remain up the tree for a long period, not coming to the ground to feed, or will they come down within a day or two to feed or roam about? Do they remain in the tree to feed in order to escape the hotter ground region, or merely to meander around without any serious objective in view? These were some of the mooted questions it was wished to have settled. The value of knowing their habits in this regard would be in the method of applying poison during the campaign to control them.

On July 31, 1925 the bands were placed on the tree. The next day when these were removed it was found that under the bands so placed to catch descending earwigs were very many of the insects, and that the bands placed to intercept ascending earwigs also were harboring an abundance of them. Examination of the trees was repeated on two consecutive days. On the second day few insects were found to have descended, and on the third day practically all had come down from the tree. None could go up the tree from the ground, so it seems logical to

assume that earwigs do not remain up the trees for very long, but just incidentally crawl about among the branches. A search of the limbs and foliage after the third day of banding did not reveal more than a dozen earwigs.

The question has arisen from time to time as to whether or not the earwig is deleterious to fruit and foliage of fruit trees. During the summer of 1924 the writer had very good conditions under which to observe their habits in this regard. In a heavily infested region in the Clinton-Kelly district of Portland were several well laden cherry trees of the Royal Ann, Bing and Lambert varieties, Earwigs swarmed through the trees daily, yet very little damage resulted from their presence. Where a robin or another bird would take a bite from a cherry, the earwigs would usually drill in and finish the job. Occasionally they would demolish a few of the more tender leaves, but in no instances were they observed to cause serious damage to either fruit or foliage.

The reason for this apparent lack of interest in the fruit and leaves of the trees undoubtedly was due to the abundance of tender feed upon the ground. Merely because

they have not as yet turned their attention to orchards is not a criterion that they may not do so. If is likely that they will whenever it becomes necessary to existance, for they are indiscriminate feeders. Earwigs never obtained a foothold in the better orchard areas of Oregon. In the cleanly cultivated orchards of Hood River or the Willamette Valley, where little vegetation could be found upon the ground, it would be only natural for them to attack the foliage with a vengence - and earwigs can easily thrive on apple, prune, or cherry foliage, or upon any of the cucurbits.

NATURAL ENEMIES OF F. AURICULARIA

THE TACHINIDS.

Parasitism among insects is common and maintains a proper balance among all insect life. A parasitic insect, as generally defined, is one which passes its entire larval stage within or upon an individual host. Many of the orders of insects include parasites of insects and other organisms and chief among these are the Order Hymenoptera and the Order Diptera.

There are various types of parasites based upon the host supporting their larvae and the interrelations of these types are often very complex. According to H.S. Smith, there exist at least seven fairly distinct types of parasitism. First we may have primary parasitism. This is easily illustrated in the case of the parasite Compsilura concinnata which attacks the gypsy moth and the brown-tail moth, neither of which is a parasite.

Again, we may find cases of indirect parasitism wherein a parasite deposits eggs upon another insect, not for the purpose of feeding upon it, but to feed upon a primary parasite it already contains. Such a case on record is that of the Chalcidoid parasite Perilampus hyalinis which deposits eggs upon the larvae of

Hyphantria cunea, that these may hatch and feed upon a primary parasite which feeds internally upon Hyphantria. It is unable to breed upon Hyphantria alone. It apparently makes no difference what kind of a primary parasite resides in Hyphantria cunea, just so long as it is an internal parasite.

Secondary parasitism differs from indirect parasitism in that the adult of the secondary parasite deposits its eggs directly upon or into the body of the primary parasite, while the adult of the indirect parasite deposits her eggs in or upon the host of the primary.

In addition to those forms of parasitism outlined above tertiary and quarternary parasitism and superparasitism and multiparasitism are regarded as significant types. An example of a true tertiary parasite is that of the Eulophid, asecodes albitarsis, a parasite of Dibrachys boucheanus which in turn parasitizes primary parasites of certain moth larvae. In order to exist, asecodes albitarsis is obliged to seek out the secondary Boucheanus. Smith defines tertiary parasitism as "that type of symbiosis where a parasite is obligatory upon an obligatory secondary." A true quarternary, which must be very rare in nature, must therefore be

obligatory upon an obligatory tertiary.

Superparasitism exists when a host is attacked by two or more species of primary parasites, or more than once by the same species. Multiple parasitism occurs when two or more different species of primary parasites simultaneously attack the same individual host.

Entomologists often have made use of the natural phenomenon of parasitism in controlling outbreaks of injurious insects, and, while the method is not a new one, it has gained much favor during the last few years.

The family Tachinidae of the Diptera is one of the most beneficial groups of primary parasites known and the one most exploited by economic entomologists. The family is a large one and the larvae are in nearly all cases parasitic upon other insects, especially the larvae of Lepiodptera. About one hundred and eighty-five genera are indiginous, or at least known, to North America.

Williston described the Tachinidae as follows: "Rather small to rather large, bristly flies, thinly or not all pilose, usually thick-set. Eyes pubescent or bare; those of the male more approximated than those of the female, or contiguous. Front with a row of bristles on each side, descending to or below the base of the antennae; with or without orbital bristles.

First antennal joint short; second joint usually shorter than the third; third joint usually more or less elongated, sometimes dilated or fissured; decumbent; arista bare, three-jointed, the first joint always short, often atrophied and imperceptible; second joint sometimes elongate and geniculate. Face always with a well-marked medium depression, which sometimes has a carina in its middle. Proboscis sometimes elongate and slender, but usually short and with long labella; palpi never with more than one joint, which is sometimes rudimentary. Ocelli present. Abdomen composed of four or five visible segments; with marginal and lateral, and usually with discal bristles; sometimes nearly covered with strong, erect spines. Legs usually rather stout, seldom moderately elongate, always with bristles. All the veins of the wings simple, basal cells large, three posterior cells present, the first of which is always narrowed or closed (save in those rare cases in which the distal section of fourth vein is obliterated)1 auxialliary vein distinct in its whole course. Squamae large."

In Short, it may be said that flies which have the arista bare, or possibly slightly pubescent, the

squamae well developed, and the first posterior cell narrowed or closed, may be included within the Tachinidae.

DIGONOCHAETA SETIPENNIS FALL (Fig. 2)

Several shipments of Digonochaeta puparia were received during December of 1924 and up until April 1925. In addition several more were sent to the Federal Entomological Station at Forest Grove, Oregon where Mr. I. P. Rockwood cared for them until they emerged in the spring. The first of the puparia arrived in December 13, 1924; the last on April 25, 1925. All except the first lot which came were collected in the field in England by Dr. W. R. Thompson of the U. S. Bureau of Entomology. Puparia of the first shipment were reared in confinement.

The method used by Dr. Thompson in preparing the material for shipment proved very satisfactory. Each puparium was inclosed in a gelatine capsule and all were packed together in a small paper box banked with cotton . In turn, this smaller box was packed firmly in cotton and inclosed in a large wooden box which was

tightly nailed. (Fig. 3).

In all, seven shipments totaling 333 puparia were received from France and England. The puparia of D. setipennis (Fig. 4) range in length from 2 mm. to 4 m m., are quite oval in shape and of a reddish brown color. Two anal spiracles are easily seen on the posterior end of the puparium, which is more pointed than the anterior end. The spiracles are black. It has been found in work done at Corvallis that the smaller puparia almost invariably give rise to male flies, while the larger ones harbor the females. So far it has not been possible to separate them according to sex before they have emerged, because there is a medium range in size where they may be either male or female. As development of the fly within progresses a few of the puparia have been observed to show rather distinct segmentation on the posterior end, but this does not apply to all.

Adult flies of Digonochaeta are generally black and rather stocky and are heavily covered with thick, black spines over parts of the head, thorax, abdomen, and legs. They are about five m m. in length. The abdomen is banded dark and grey above, but lighter underneath and withoutout spines along mediam line of abdomen, save for five

distinctly separate oval patches of black which are heavily spined and extend in a row from the base of the abdomen to the ultimate segment. Antennae pale orange underneath to grey or black above. Arista bare and nearly as long as antennae. Mouth-parts orange in color and quite prominent. Three ocelli are situated on vertex of head. Compound eyes nearly always red. Vein V. runs quite straight until it approaches the distal and of the wing, where it angles sharply toward vein III -4-5, thus almost closing cell III 5. Such condition is not found in Rhacodineura antiqua. Vein VII 2 runs out in the middle of cell VII 2. Vein I is equipped with fine spines which are coarser near the base of the wing and disappear before reaching half the distance of the vein.

It is not difficult after some study to determine the sexes of Digonochaeta setipennis. The abdomens of the males are much narrower, smaller, and more sharply pointed than those of the females. This may not be apparent unless one has each of the sexes together for comparison. Examination of the genital parts is the only infallible method yet found for determining of sexes.

The male genital parts (Fig. 5) are located on the last segment of the abdomen which is cupped on the ventral side to allow them to protrude. The penis, which is quite long, extends horizontal anterior to the abdomen and lies between two genital claspers which are capped with a slightly yellow pubescence. These are really not a part of the genital organs, but are modified appendages of the last segment of the abdomen. They are easily manipulated by the fly and may be seen to open and shut like pincers when viewd at the right moment under a lens. Another pair of claspers, which appear to be distinctly associated with the genital parts, are located posterior to those with the yellow caps. These are sickle-shaped, black and originate from the same chitinous base. They extend forward, when at rest, nearly to the modified abdominal claspers, and are capable of being moved. They cannot be seen unless viewed under the microscope and then it is often difficult, because of their dark color, to make them out.

The entire array of genital parts are raised slightly externally. In some specimens this raised area is more pronounced than in others. The anus is located posterior to the base of the penis. When first emerged, the genital

parts are light in color and quite distinct. After a brief period, however, they become much darkened and the parts are not so easily differentiated, though the yellow capped claspers are always rather easily noticeable when viewed under a lens.

The external genital parts of the female (Fig. 5) Digonochaeta are not so complex as those of the male. They, too, are situated on the last segment of the abdomen and appear only as a raised protuberance in the area surrounded by the edges of the last abdominal sclerite. Theovipositor normally can not be seen, but has its opening just in front of the anus.

The original description in German as given by Professor Fallen is as follows:

"Tachina

T. setipennis oculis nudis nigra maculatim albicans; antennis elongatis palisque nigris, nervis alarum alternis setosis.

Sälsynt. Äger föregaendes storlek. Ögonen runda, pannan hvit med vibrissae. Sista antenn-leden mer än 4 ganger längre än den andra, jämbred. Trenne af abdomens segmenter äro nästan hvita, i spitsen svarta. Fjerde langnerven är mycket inböjd och gar ihop med costalnerven i yttersta vingspitsen. Vingfjallet hvitt."

From. Svenska K. Vetenskaps Academiners Nya Handlingar ns.s.v.31,1819 p. 273 (Fallen, C.F. Försök att bestämma de i Sverige funne Flugarter, som kunna föras till släget Tachina,p.253-287.

METHODS AND MATERIALS USED IN REARING D. SETIPENNIS

The first shipment of puparia arrived in December during a cold spell and just proceding weather that entertained a temperature below freezing for at least ten days. It was believed necessary to place the puparia in a situation where the temperature would not vary much and where the frost could not hit them.

Clean sand was sterilized and allowed to cool all day. Small, two inch flower pots were then sterilized and about an inch of the sand placed in them. Sterilization was for the purpose of destroying the spores of moulds and fungi which might prove deleterious to the puparia. The puparia were then removed from the gelatine capsule and placed on top of the sand two to each pot. An inch of sand was then added, which caused the puparia to be surrounded by about an inch of sand in all directions. No water was added to the sand until after the cold spell, for it was feared that freezing of the moist sand would prove fatal to the puparia.

Light gauze covers were tied securely over each pot to prevent escape of any flies or hyperparasites which might have emerged early. The whole lot containing 47 puparia were placed in a fruit cellar located in the basement of a residence in Corvallis. The little room was constructed of concrete entirely and provided an excellent place for winter storage of the puparie.

A recording theremometer was installed in the cellar but it failed to function well, so a daily record at this time was not obtained. However, the maximum and minimum temperatures for the entire period from December 15 to March 2 were obtained. Never did the mercury fall below 30° F. nor did it rise above 44° F.

On March 2 the puparia were removed from the concrete cellar and placed in a small cage arranged for such work and situated on the roof of the Agricultural Building.

In the meantime other shipments of puparia were received from Dr. Thompson in France. None of these were stored in the concrete cellar. Instead, they were placed on top of sterilized sand contained in the two-inch clay flower pots, which also had been sterilized, and which was moistened throughout with distilled water. Care was taken not to provide an excess of water.

Glass vials, three inches long, three quarters of an inch in diameter; and open at both ends were used throughout the season to catch the flies as they emerged (Fig. 6). These were provided on one end with a small piece of gauze held securely over the opening with a rubber band. The open end was tuck deep in the most sand. Such arrangement is very convenient. The puparia can easily be observed through the clear glass vials and the flies when they emerge are unable to escape. Usually they go to the top of the vial and rest on the gauze. Here they become dry and their wings unfold. It is necessary to have the gauze or some such covers on the vials because it permits proper ventilation of the tube and goes far toward preventing moulds occuring on the puparia. Such need was exemplified plainly, when glass vials were inserted bottom side up, into the moist sand and inclosing the puparia. Moisture collected on the sides of the vial and within two days many of the puparia had developed a mould. The vials were removed immediately and the regulation ventilated tubes were used to replace them. The fungus soon disappeared and apparently caused little harm to the puparia, for most of them afterward gave rise to flies.

However, in a few instances (three or four) the fungus penetrated the puparium and grew abundantly within. It is impossible, even probable, that in these cases the flies had begun to emerge, but died after the cap of the puparium was cracked open, thus allowing free entrance of fungus spores to the fly's body. In those puparia opened for inspection this had happened. In one that was examined the inside of the puparium had been transformed into a dirty mass of brown frass and fungus mycelium. Only a trace of the insect's body remained.

It became necessary occasionally to add water to the sand. The length of time between applications of water naturally depends upon the humidity and temperature. On warm days the water evaporates from the sand and sides of the pots rapidly, so that water might have to be added every other day, or possibly every day during such weather. On the other hand, during very cold weather, or rainy spells, no water seemed to be required. It is necessary in such work to be careful not to add too much because of its beneficial effect on the growth of fungi.

All material received from Europe prior to March 2, save the first lot, was placed in Room 304 of Agricultural Building. The windows were always left wide open and no heat was permitted in the room. Hence, quite natural conditions prevailed for the puparia. A recording thermometer was installed and a daily temperature record kept (Fig. 7).

On March 2 all the pots containing the puparia were removed to a small breeding cage, previously mentioned, which was situated on the roof of the Agricultural Building (Fig. 8). The breeding cage was a simple structure, but served adequately to shelter the pots from wind, rain and frost, and yet allow of normal out-of-doors temperature. It was eight feet long, six feet wide, and seven feet high to the gables. The roof was cedar-shingles, while the floor was made of three-quarter inch rough planking. Common door screen was fitted tightly around the sides and covered the door so as to prevent entrance of birds and to break the wind. There was no need to guard against possible insect enemies of the live puparia or flies, because these were carefully placed under the insect-proof vials. Muslin curtains hung from the side, prevented sunlight from

striking the puparia.

After the flies began to emerge observations were made two or three times daily to take them from the vials. The usual and best times to make the rounds of the vials are about 8 A.M., 11 A.M. and 5 P.M. Most of the flies seem to emerge early in the morning, though a few come out during the day. It has been found quite necessary to make the early morning observation, for often the flies, with their wings sometimes yet folded, fall from the sides of the vials and lie upon the sand, legs waving in the air frantically, until they become virtually exhausted. Several have been found in this plight, but all were discovered in ample time to prevent serious results.

Upon finding flies emerged in the vial, it becomes necessary to determine their respective sexes and in order to do this, they must be examined under a lens. The glass vial is carefully pulled from the sand and any sand remaining in it is also removed, though caution need be exercised in this, else the fly will escape. A 15 X hand lens may be used in examining the genital parts on the abdomen, but a binocular microscope is much better. A cork inserted into the open end of the vial facilita-

tes handling and reduces the chances of escape for the fly. Vial and all is placed under the microscope and when the insect stands on the top side of the vial, the genital parts are easily determined.

Investigators working on Dignochaeta setipennis at the Rothamsted, England Experimental Station found that it is much better to confine the flies to small mating cages situated in well lighted places for three weeks or a month in order to get the best mating results. Their practice is to confine six or seven females with one male and that policy was followed out quite generally on work done at Corvallis. The breeding cages used at Rothamsted were glass cylinders about 8 in. high and 4 or 5 in. broad, with a perforated zinc lid and base. Umbelliferous flowers of some kind were kept growing in a small pot for the flies to feed on and sweetened cotton wool was provided for the same purpose.

A similar cage was at first tried out at the Oregon Experiment Station, but it was found to be very unsatisfactory as far as introducing and withdrawing flies was concerned. The apparatus used was a medium sized lantern globe, covered with fine gauze, and resting on a crepe paper mat which provided ample ventilation. Flowers and

sweetened water were kept on hand at all times. In addition to difficulty encountered introducing the flies as they emerged, and of placing fresh flowers occasionally without allowing the flies to escape, the insects appeared rather discontented and would exhaust themselves by crawling up and down the sides of the globe, occasionally losing foothold and falling to the paper.

Hence, a different type of cage was sought for and one closely patterned after those used in the Gypsy Moth Parasite Laboratories in New England was chosen. They (Fig. 9) are 12" x 12" x 4" in diameter when set up and are provided with a removable glass top and covered with fine gauze on the bottom. On the front end are three holes of the right size to accommodate the vials used to inclose the puparia resting on the sand in the pots and one hole is located on the rear board. One of the holes in the front is bored in a heavier, removable piece, 3 in. in diameter. This piece may be taken out when it is wished at any time to insert flowers or such material. Flowers were placed in vials with moist cotton about the stem tips and so that it quite filled the vial and protruded over the edge. These were inserted through one of the holes and the open end of the vial corked up. It is necessary at least once each day to soak the cotton with water.

The flies get their moisture from the cotton protruding from the inside end of the vial and incidentally the flowers are kept fresh longer.

A cotton plug, soaked meagerly with sweetened water and hung from a vial inserted in another hole on the front board provided a suitable place for the flies to get their nourishment. In the beginning of the work a saturated sugar solution was used as food for the flies. They seemed to relish it well enough, but two or three died prematurely. These were all males. Attention was called to the writer of the fact that a similar difficulty occurred in the New England tachinid work. Investigators at Melrose Highlands, Mass. found that the sugar solution was not heavy enough for the flies. They substituted a solution consisting of one part honey to three parts water and found the change very beneficial to the insects. Incidentally, the change was inaugurated at Corvallis. The flies appreciated the change as evidenced by more often feeding and no radical premature deaths have since been noticed. A black mould often developed on the sugar-water solution which was often not noticeable, until it attained extensive growth. Possibly toxins secreted by it proved deleterious to the flies.

EMERGENCES OF D. setipennis- MATING AND INTRODUCTION TO EARWIGS.

The tachinid flies belong to that suborder of Diptera known as the Cyclorrapha and which escape from the puparium through a round hole made by pushing off the head end (Fig. 5). D. setipennis, like other members of this group, possesses a frontal lunule on the head through which is projected an inflated membrane called the ptilinum. When the adult is ready to emerge, it inflates this organ and forces the head to pop off the puparium. Mr. L.P. Rockwood, who raised some of the flies at the Federal station located at Forest Grove, Oregon, stated that by the use of this ptilinum three of his flies made their way through heavy cotton plugs used on the vials inclosing the puparia. After this experience he quit the use of cotton plugs and substituted fine gauze as a covering.

Just what time in the spring the adults of Digonochaeta will emerge when under natural conditions is not known. Of course it will depend largely upon weather conditions. The material being worked with at the present time has been placed under severely abnormal conditions. The puparia were subject to field conditions in Europe for a while, were then collected and subjected to a drying

journey of nearly six thousand miles during which time they undoubtedly met with varying conditions of temperature, after which they were cared for in a climate different in certain respects from that they were collected in. It is believed that the severe shaking undergone during transportation from Europe to Oregon caused early emergence of some of the flies.

A complete record of all emergences of the flies has been kept. It has been observed that the males emerge in greater numbers early in the season than do the females (Fig.10). The first fly to emerge was a male on February 10. The puparium had been buried one inch in the sand and worked his way to the top. It was dead when found. Then on February 24 two more were found dead on top of the sand. Both were males. From then on (up to May 17 after which date is not included) the males emerged quite steadily ranging in number daily from one to eight. Of one lot of puparia received on February 17 one male fly had emerged and died during transit.

Up to and including May 17, 119 flies had emerged from the 333 Digonochaeta puparia received from Europe and cared for at Corvallis. Of this number 77 were males and 42 were females. Most of the flies were constitutionally

well formed when emerged. Only four of them were malformed, one with a misshapen abdomen and three each with a wing not fully developed. Two of these last were females and have been alive and active for six weeks.

Mr. L.P. Rockwood has had about the same per cent emergence up to this date as that obtained by the writer. He finds also that males emerge in greater number than females during the early part of the season.

Various flowers were supplied the flies in the mating cages. Wild flowering carrot was advised by Dr. Imms of Rothamsted, though he stated that other umbelliferous flowers would be satisfactory. It was often difficult to find suitable flowers for the flies early in the season, though dandelion, apple, wild parsnip, scotch broom, wild carrot, thimble berry, lilac, and dogwood blooms had been supplied right along as they blossom. The flies seem to enjoy resting on the flowers and in some instances, especially with wild parsnip, they apparently feed on them. Flowers must be changed after every day or so.

What length of time it is really necessary to confine the flies to small breeding cages to insure mating has not been decided for Oregon conditions. Dr. Imms confines them from three weeks to a month in England, though he suggests that two weeks may be sufficient in the warmer

weather of Oregon. The writer kept the first lot confined about 26 days before liberating them in the larger earwig-stocked insectaries, though in no case had mating of the flies been observed. Mr. Rockwood had the good fortune to find two flies mating very shortly after they had emerged from the puparia. Indeed, the male had just been placed in the cage. They copulated for at least an hour. This is the only case of the flies mating in Oregon that has been seen, though it is quite likely that they have been mating right along.

For the most part, one male has been confined to six or seven females, as suggested by English investigators. Occasionally, though, in a few of the cages one male to four or five females was tried - this because of a large supply of idle males on hand.

May 3, 1925 all of the material was removed from the Oregon Experiment Station at Corvallis to Portland, where the State Board of Horticulture has constructed an insectary consisting of five small buildings (Fig. 11). Four of these are earwig and fly-proof and are used as places to inclose the parasitic flies with the earwigs. They were stocked with earwigs by the writer during the spring and summer of 1924. Fine gauze cloth is stretched

tightly on close fitting frames on the sides, which permit ample light to enter, yet prevent entrance of possible tiny hymenopterous hyerparasites of the fly larvae which are thought to be present in the vicinity. An oil mote fitted around the entire inclosure on the inside prevents the escape of any earwigs. Ample ventilation is obtained through a screened 2' x 2' opening in the roof, which may be closed during stormy weather, and by the gauze covered windows. The buildings are 6' x 6' square and about 8' high with a slanting roof covered with water-proofed roofing paper. A two-door vestibule permits one to enter and leave without allowing the flies to escape. The buildings were designed by Professor B. B. Fulton of the Oregon Experiment Station.

Another larger building is used to house the pots containing puparia and to shelter the flies being confined to the mating cages. A special rack has been constructed to support 12 of the mating cages. This permits them to be off the ground and affords ample ventilation.

On May 7, 1925 11 female Digonochaeta and 6 males were liberated in one of the earwig-stocked houses. Care had previously been taken to eliminate all spiders from the interior and to place a screen over the oil motes to

prevent the flies from dashing into them. In addition, two or three large carabid beetles were removed, for it is possible that they might capture a fly resting during the night time. The morning was murky, with no sun, and the temperature stood at 50 degrees F. The flies were rather morbid and had to be assisted from the cage to the ground. Earwigs were crawling in all directions. At first the flies appeared listless, but soon they seemed to sense the importance of their change from the mating cages and began to exhibit more action. They ran about over the ground, searching in the debris. Some flew to the cloth windows and the males made several unsuccessful attempts to mate with the females. The writer watched them for more than an hour in the hope of observing them ovipositing, but without success. However, they appeared increasingly nervous and sought out the earwigs hiding under the leaves and boards. They are carefully watched daily to see what they are doing, but as yet no eggs or larvae have been discovered, though it would be rather difficult to find them in the debris existing on the insectary floor, which is earthen. Several additional males were put into the pen with the first lot with the purpose of increasing mating chances in case mating

had not already taken place. In all, 10 males were put in with the females, though 3 of these were found dead afterward. It is likely they had lived their normal lives out.

On the same date (May 7) one of the small mating cages was stocked with about 100 nymphal earwigs and 25 adults. Three female and two male tachinids, reared by Mr. Rockwood at Forest Grove were inserted. The small cage was used because it was desired to confine the flies in an area sufficiently small to permit any eggs or larvae of the flies to be easily seen in case they were produced. The nymph earwigs were mostly in the second instar, a few in the third. The flies appeared greatly excited, followed the earwigs about, and even crawled over them when they congregated in masses. One of the females protruded her ovipositor, yet no eggs were seen to be laid. The two males either were killed by the earwigs, or died of natural causes, for on May 11 only a trace of them could be found.

In the belief that it was too precarious to cage the flies in such a small compartment with the earwigs, they were transferred to the large cage after the death of the males. A similar tragedy occurred in Corvallis

during March, when one female and two males were placed in a mating cage with earwigs. The males could not be found on the second day, and on the third day the female was dead and had one wing chewed off. It is not unlikely that she had been attacked while resting at night and that the males suffered similarly.

Another chance was taken with the smaller cage, when on May 14, were placed 6 female and three male flies that had been mated about 18 days in with at least 100 third instar earwigs and 12 adults, As in the previous trials, green feed was added for the earwigs and a supply of honey-soaked cotton placed for the flies to feed on. Moisture was provided in a water-soaked piece of cotton. Following a practice of investigators in New England who have reared quantities of tachinid flies in confinement, a fine spray of honey solution was projected onto one side of the cage. The flies seemed to enjoy indulging in the fine droplets, so the practice has been continued.

This last introduction has proved the most promising of all. Most of the females protruded their ovipositors and attempted to deposit eggs near the earwigs. None, however, could be seen to come forth. Each day since being placed in with the earwigs, the flies seem to be working

around over them all the time. So far none have been lost, so probably it is not hazardous to place them in small cages for special observation.

Ample flowers and honey solution are kept in both the large and small cages where earwigs are mingled with the parasites. It is very likely, judging from the business-like attitude the flies have assumed, that parasitism is now going on, but that the eggs and larvae have not yet been sought for at the proper time. Time will tell. There are yet many more flies being mated and many more are likely to emerge from the puparia now on hand, so that the chances for establishing the species this year seem very favorable.

LIFE HISTORY OF DIGONOCHAETA setipennis

It is impossible as yet to know just what the life history of this species will be under Oregon conditions, in case it becomes well established. What we know of its life history is based entirely upon observations of English investigators, though Mr. W. R. Thompson of the U. S. Bureau of Entomology, stationed in France, has done some work upon the flies. There appears to be only one generation annually in Europe.

The following is a transcript from an article by Mr. A. M. Altson who studied the insects at the Rothamsted Experimental Station, which bears upon the laval habits: "There are two parasites, both species of Tachinidae (Diptera). The one, Digonochaeta setipennis Fall, obtains penetration of its host by depositing its egg, containing a fully developed embryo in the immediate vicinity of resting earwigs. The egg hatches instantly, and a small, heavily armoured larva appears, which rapidly moves off towards the earwigs; these it mounts by way of the legs, and having discovered a soft area in the integument (in the neck or between the thoracic sclerites) it proceeds to bore in until its anal segment blocks the point of penetration. Gradully the fractured hypodermal cells begin growing, and owing to the obstruction caused by the larva, they grow around it forming a sheath or a funnel in which the greater part of the larva is enveloped for the whole of its parasitic life. By means of this sheath, it maintains direct contact with the air. The length of larval and pupal life varies considerably, and is primarily dependant upon the time of year when penetration of the host takes place. This Tachinid has been recorded from other hosts of no less than four orders,

including Lepidopterous Larvae; this may be explained by the fact that earwigs hide away in an endless variety of situations during the day, and the Tachinid larva in search for its host has happened upon an accidental one that has had the misfortune to cross its path."

Following is an extract concerning D. setipennis from "Die Tachinen," Vol. 7, page 370, 1921 (By W. Baer):

"Not rare from April to August, occasionally also up to late autumn. It is chiefly an earwig parasite and has been bred many times from Forficula auricularia Linn. (Neilsen, Pantel, Kramer, etc.) but also has a varied list of other hosts; Pheosia tremula Cl., Lasiocampa quercus L., Euproctis chrysorrhoea Linn., Notodonta trepida Esp., Panolis griseovariegata Goeze, and particularly also from caterpillars of injurious microlepidoptera:- Dioryctria abietella Fab. Trapholitha strobillella Linn., and Carpocapsa pommella Linn.

"The larvae are of very peculiar structure. In the first stage they are armoured with longitudinal group of little scales; in the third stage, on the contrary, the larvae elevated tubes bearing numerous straight or curved

slits and contrasting by their coal black color with the white body of the maggot. The shining black puparium shows the spiracles in the form of two diverging protuberances, grown together at the base. They belong to the fifty group on reproduction characters (depositing small larvae in the vicinity of the host but not in excessive numbers). The armored young larvae search out the hosts for themselves. In the earwigs they penetrate through the inter-segmental membrane and usually in the thorax. Here they are found in a funnel with primary respiratory opening in the third stage in September. In October they bore out, usually at the apex of the abdomen of the host, and pupate in the same place. The flies come out, partly in the same year, but mostly in April of the following. It appears without doubt that there must be an intermediate host to carry them over until there are mature earwigs again."

The foregoing suggestion by Baer that there must be an intermediate host to tide them over until there are mature earwigs does not tally with the assertion of Dr. Imms that the maggots prever nymphal earwigs. Mr. J. M. Aldrich also states that there must be an intermediate host between April and the time they attack earwigs. It is true that earwigs in Oregon usually hatch

during the month of April and that the tiny earwigs are not large enough to support a maggot. Possibly an intermediate host will be required in this country.

Little data could be gathered on the appearance of the egg of D. setipennis. On April 27 one of the females that had been in the mating cage for about 14 days died. Dissection of the abdomen showed about 50 to 75 long light-colored, rather undeveloped eggs in the uterine duct. Jose Pantel described them as "Elongate sub-cylindrical, macrotype eggs hatching to colored maggots in coiled, very long and slender to fat gut-like uterus."

The insects over winter as puparia under leaf mould, moss, bark or in whatever suitable secluded place they might find.

It is not improbable that the life history will differ somewhat in Oregon and that we might even expect two generations, because of the apparent earliness of earwig hatching here as compared with parts of Europe.

It is note-worthy that of the first shipment containing 47 puparia, all but eight have emerged. In number two shipment received shortly afterward, only five puparia have not so far yielded flies or hyperparasites.

The third shipment has had a greater per cent of emergences than the fourth; the fourth greater than the fifth, which is greater then the sixth. The seventh shipment of seventy puparia has produced only three Digonochaeta, but twenty three Ichneumon hyperparasites. Most of the puparia are yet intact. Apparently, these last gathered were of maggots that pupated late, or else they have undergone conditions which have uniformly retarded them.

Rhacodineura antiqua Fall (Fig. 2).

Transportation of Rhacodineura antiqua material from Europe to Oregon presented much more of a problem than did the transporting of Digonochaeta setipennis puparia, because the life histories of the two species differ radically. The pupal period of R. antiqua is much shorter than that of D. setipennis and comes in early spring.

Consequently, it became necessary for Dr. Thompson in Europe to collect living earwigs from an area known to harbor the desired parasite and ship them to Oregon in late winter. The first lot containing about 300 living earwigs arrived on March 19. They came in small individual boxes, about 100 insects to the box. The packing was exceedingly secure. The earwigs, together

with a few pieces of cut white potato for food, were sowed securely in a stout linen bag. In turn the bag was inclosed in a small but strong wooden box which was sealed tightly with wax and covered with a cloth pasted securely over the entire surface. Then the entire parcel was securely wrapped with two thicknesses of paper and tightly sealed for mailing. It is a wonder the earwigs could exist, for virtually no air could enter the sack inclosing them. However, most of them were alive. About 50 were found dead and several had been devoured, as evidenced by the scraps of chitin and forceps remaining in the bag.

At least 3 of the parasites had left the earwigs and pupated and one had either emerged and been eaten, or the puparium had been broken into by the earwigs and the contents devoured, for it was quite empty and shattered. Two puparia were adhering to the linen bag. One was a dark reddish brown in color, the other colorless and opaque. Both were placed in moist sand in vials and set away fro observation. The vials were covered with a gauze held in place by rubber bands. The developing fly could readily be seen through the walls

of the light puparium, even to the developing wings and head pieces.

The earwigs were placed in large glass battery jars containing moist sand. Potato and dandelion were put in for them to feed upon. A gauze cloth was placed over the top of each. The jars permitted easy observation of the earwigs and daily care was administered them in the hope of securing puparia of the flies. The sand was always kept rather moist and abundant feed supplied them. They were kept in an unheated room.

April 28 a second shipment of live earwigs was received from Europe and they were cared for in a like manner. As in the first lot a number had died and a few had been eaten. Of the one hundred originally sent, about seventy were alive. No puparia had been formed enroute.

In examining the jars on April 20 one light colored puparium of R. antiqua was found lying on top of the sand. Nearby were two dead earwigs, each with a ragged hole at the base of the abdomen, from which the maggots undoubtedly made when leaving the host (Fig.12). As only puparium could be found, it is likely that the other maggot perished at the hands of the predaceous

earwigs. The puparium was added to the others in an individual vial with a little most sand.

On April 21 the reddish colored puparium found in the first shipment gave rise to a male Rhacodineura. It emerged about 10 A.M., was very nervoursly disposed and its wings did not unfold until 2 P.M. For a few days it was kept under a lantem globe fitted with a gauze cover and supplied with a honey-water colution on cotton and a small jar of lilac flowers, but later it was transferred to one of the standard mating cages.

Adults of Rhacodineura antiqua are about the same size as Digonochaeta setipennis. They are lighter in color generally than Digonochaeta, usually an ashen gray, with dark red compound eyes. Arista are heavier at the base and quite narrowed toward the tip of the third joint. The genital parts of both male and female greatly resemble those of Digonochaeta, save that the abdominal genital claspers are heavier than those of the latter, broader, and not capped with the characteristic yellow pubescence.

The chief distinguishing mark between the two species lies in the difference in wing venation. Vein III 5 of R. antiqua disappears before it reaches the border,

leaving cell III 5 before it reaches the border, entirely open; whereas, in D setipennis this vein extends to the border and cuts in toward Vein III 4-5 and almost closes cell III-5. Vein VII-2, which runs out in cell VII-2 of Digonochaeta, is not found in Rhacodineura.

Generally the fly is stout and well covered with bristles. The abdomen has a rather convex appearance when viewed laterally. Squamae are very large, whittish, and well developed.

Following is the original description of R. antiqua as given by Fallen in German:

"300 Tach. antiqua.

Aschgrau; Beine rostgeln; Spizzenquerader der Flügel fehlt. Cinera: Pedibus ferrugineis; nervo transversali apicali alarum nullo.

Fallen Musc. 22,44: Tachina pallipes Variet. Monstrossa.

Weibohen: Undergesicht perlgrau mit schwarzem Schiller. Knebelborsten bis zur Mitte hinaufreichend; Taster rostgelb; Stern breit, perlgrau, mit breiter, rostbrauner Streime: Borsten gehen begenformig aufs Untergesicht herab. Fühler so lang als das Untergesicht: beide Wurzelglieder weissliche; das dritte

braun; Borste bis zur Mitte verdikt. Leib aschgrau; Rukkenschild vorne mit vier braunen Linien; Hinterleib eirund, hochgewolbt. Beine rostgelb, mit braunen Füssen. Schüppchen weise; Flügel etwas grau, mit gelblicher Wurzel, und einen Randdorne: Spizzenquerader fehlt durchas. Mehrmalen in Sommer In Hekken, auch mehre Exemplare aus der Saumhauerischen Sammlung. - 3 Linien.

Prof. Fallen halt die gegenwartige Art für eine Ausartung der vorigen. Ob dieses wahr ist, kann ich nicht entscheiden. Ich habe die T. pallipes in seiner Sammlung nicht bemerkt. ++ Augen haarig.

Meigen, J.W. Systematische Beschreibung der bekannten europischeu zweiflugeligen Insekten. Th. 4 Hamm. 1924, p. 412, no. 300."

On April 27 another rather large, light-colored puparium of R. antiqua was found lying on the sand and was placed in a vial and put with the others in the breeding cage situated on top of the Agricultural Building at Corvallis. That made a total of three puparia and one emerged male of this species that had been obtained so far from the living earwigs.

The puparia of R. antiqua are about the same size as those of D. setipennis, though they are blunter at

the ends and the posterior spiracles are not prominent, (Fig. 13).

It was feared that the living male Rhacodineura could not be kept alive until a female might emerge from one of the puparia on hand. That is what happened. On May 11 his demise was duly registered and he was added to the collection of Digonochaeta males in a St. Louis Box. His loss proved a serious one, for on May 16, emerged two females of the species too late to inspire recuperation of the male. One puparium has yet to yield a fly. Possibly it may be a male. It is one of those discovered in the shipment of live earwigs on March 19. The ones which emerged on May 11 pupated on April 20 and April 27. That made their pupal period 21 days and 14 days respectively.

On May 9 the puparium yet intact was examined under a binocular miscroscope to ascertain its stage of development. The fly showed up plainly under the glass - virtually all parts could be made out. The spines of the body were quite evident; the wings appeared black and were folded evenly down the sides of the thorax and abdomen, the distal ends nearly meeting on the ventral side of the abdomen. The head and mouth parts were plainly in evidence, the head bent downward slightly and directed posteriorly.

Legs were all protruded backward quite parallel to the body.

Life History of R. antiqua

As in the case of D. setipennis, no opportunity has been available to secure the life history of R. antiqua in Oregon. It differs radically from D. setipennis in certain phases of its early history and in method of over-wintering. In his discussion of D. setipennis and R.antiqua Mr. A.M. Altson says of the latter:

"The other parasite is Rhacodineura antiqua Meig., which was found to lay a minute egg containing a fully developed larva on anything that earwigs have fed upon the previous night. The eggs are then swallowed by earwigs coming out to continue their unfinished meal. In the experiments, flowers, foliage, cut fruits, and vegetables were available for the flies to oviposit on. The egg hatches in the alimentary tract on its way through. Egg cases were found in the pellets about twenty-four hours after being swallowed. The larvae, so minute as to have escaped detection so far, apparently bores through the walls of the alimentary tract into the body cavity. There it was found to have reached the second

instar in forty days after the egg was swallowed, and to have increased itself to nearly ten times its length as an embryo. The second instar larva passes the winter in the host, free in the body cavity, moving in spring to the host's neck, which it punctures; it then turns and by some means fixes its anal plate against the fractured integument. The broken hypodermal cells, as in D. setipennis for an enveloping sheath around it, This species takes in most cases ten to twelve months to complete its life cycle."

It is not likely that puparia of this species will be regained this year, though there is a bare possibility. Plans are being made to care for a large number of live earwigs to be shipped from England to Portland in the fall and winter of 1925. The species is heavily hyperparasitized by the ubiquitous hyperparasitic Chalcid, Dibrachys bourcheanus Ratz. It case it becomes established in Oregon, we will have the same difficulty to contend with, for Dibrachys is present here, also.

Hyperparsites of R. antiqua and D. setipennis

Primary parasites would often be extremely more effective in controlling their hosts if it were not for the insects which in turn parasitize them.

Both R antiqua and D setipennis have two very serious such hyperparasites to contend with in England. These, as given by A.M. Altson are Dibrachys boucheanus Ratz, a Chalcid, and Phygadenon scaposus Thoms. They often go far toward nullifying the possibilities of the two species in England.

Two species of hyperparasites have been obtained from the puparia of Digonochaeta sent from England to Oregon (Fig 14). One is a Chalcid and one an Ichneumonid. Mr. Cushman of U.S. Bureau of Entomology identified the Ichneumon as Plesignathus variabilis (Grav.) and the Chalcid, by Gahan, as Dibrachys near cavus Walker. However, D. cavus and D boucheanus are believed to be nearly identical species, if not synonoumous Probably the species obtained here and called D. cavus is recognized by England workers as D. boucheanus. Specimens of this species are being forwarded to Dr. Jas. Waterston of the British Museum to be compared with Walkers's type of D. cavus which is located there.

It is not improbable that the Ichneumon obtained in Oregon from the material is the same species commonly occuring in England but listed under a different genus.

What appears to be an entirely different species of Chalcid was recently obtained from one of the Digonochaeta puparia. The body is much blacker than the previously obtained Chalcids and the decided extension of the ovispositor on the ventral side of the abdomen, middle segment, is different from any yet found.

In all, thirty-seven individuals of Plesignathus variabilis have emerged from the Digonachaeta material. They are generally dark. Head and thorax black. Abdomen, anterior dorsal orange, posterior black. Ventral surface of abdomen light orange anterior, but running into black at tip. Petiole very narrow and black. Antennae black, twenty-five segmented, and nearly as long as body. Compound eyes large. Ocelli three. Leg segments black with pale orange markings, tarsi five-jointed and black. Distal end of second and third tibia equipped with two stout spines, while distal end of first tibia has but one. The individuals are rangy in appearance and average three mm. in length.

The original description of Phygadeuon scaposus Thoms is given as follows:

Phygadeuon scaposus Thoms.

Opuscula Entomologica, P. 10, 1884, p. 961.

P. scaposus m: Niger, abdominis medio, antennis basi pedibusque rufis, postannello scapo cylindrico brevoire, terebra petiolo fere duplo brevoiore. Long. 1-1/2-2 lin.

(p.962) Species ab affinibus, peristomio lato, mandibulis longis et validis, antennis brevibus, postannello scapo cylindrico vix longiore, feminae evidenter brevoiore mox discedens.

Funnen vid Palsio" nära Helsingborg samt vid Arrie och Ringsien i Skane."

The first one of this species to emerge did so on January 24. They have been coming out at intervals regularly since then. Often many would emerge in the gelatine capsules during the Journey from Europe and from one shipment of seventy puparia sent, sixteen individuals of Plesignathus were found to have emerged during transit. One of the insects was seen to emerge and the process proved very interesting to witness. It required sixteen minutes for him to complete the operation. Emergence occured abdomen foremost. A fierce struggle seemed to ensue within the pupal case, then out came one of the third legs. Another soon followed. Finally the

middle legs were extricated, and with these braced against the puparium the struggle continued. It was not an easy matter to induce the rigid wings to leave the case, but finally, by dint of much effort, the pupal case split down the middle and the hyperparasite shook himself free.

In all cases of emergence of this species observed by the writer, the insect always leaves the puparium from the head end, but tears a characteristic ragged hole (Fig. 15).

Dibrachys cavus Walker (D boucheanua (?))

Four puparia have given rise to Chalcid hyperparasites. On February 14 six emerged from one puparium. It is likely that all developed from one egg, for Chalcids are often polyembryonic. Again, on April 10, five Chalcids emerged from a single puparium, and on April 24 another gave rise to two individuals. Then on May 15 five Chalcids emerged from a puparium and two days later two more came from the same puparium. These last may not be D. cavus.

One must be very cautious in handling the puparia, for it might prove disastrous to the experiment of introducing the tachnid parasites, if their hyperparasites

were also brought in. They must be kept under cover constantly, for the hyperparasites can emerge quickly, mate and fly away. On one occasion two of the small chalcids, emerged from the same puparium, were seen to mate as quickly as the female extricated herself from the pupal case. Even after several of them have emerged, it is necessary to keep the puparium under cover, because others may follow in a couple of days. This has happened more than once in the writer's experience with them.

One broken puparium received in a shipment from France was left in the original gelatine capsule it came in and set to one side. It is fortune that it was not left open, for two weeks later a male and female chalcid emerged from it. They immediately were treated to a dose of cyanide. Unlike Pleisignathus variabilis, Dibrachys cavus may emerge from any part of the pupal case (Fig.).

Dibrachys cavus (Fig.) are very small, generally black insects - though when viewed under lens, they have a decidedly dark green tinge and the exoskeleton of the head and thorax appears minutely pitted. Compound eyes large, black and situated laterally on head. Anterior vertex of head rather depressed. Ocelli three. Antennae

bead-like, arising form center of frons, 10-segmented, the first segment very long and reaching to the top of the head. The remaining segments from a straight chain which branches nearly at right angles to the medium line of the body. Mandibles rather prominent. Thorax much heavier than abdomen and longer. It is deeply grooved and irregular on lateral surfaces, showing many false sutures. Metanotum humped slightly and shield shape. Fore wings longer than hind pair and heavier. All wings virtually without supporting veins save for an irregular, rather indefinite costal vein which runs along wing about two-thirds total distance, branches slightly then disappears. Petiole arises from under side of thorax. Abdomen glossy, six-segmented, though indistinctly so, and quite pointed.

Following is the original German description of Dibrachys boucheanus, which virtually fits D. cavus and may be identical:

Dibrachys boucheanus Ratz,

Die Ichenumonen der Forstinsecten v. I, 1844 p.196-197

Pteromalus Boucheanus. 1-1/6 - 1-1/4 ''' lang, Schlank ( ).

Metathorax punktirt, gehielt, seitwärts ziemlich stark behaart, Rn. sehr fein und klein, graubraun, mit kleinem, Torymus sehr ähnlichem Knopfshen, viel kürzer also Dn. Hinterleib so lang, wie Rumpf, oder kaum länger, langlich, wenig zugespitz, oben stark gehöhlt, unten nicht gekielt. Fuhrlergeifsel ziemlich kurz, gegen das Ende allmählich etwas verdickt, oder fast fädenformig. Rumpf ziemlich fein punktirt, blaulichschwarz. Fuhlerschaft nur an der Basalhälfts der Underseite +) und die hier und da leicht angeräucherten Beine (mit Ausschlufs der Füften) die Hinterschenkel zuweilen dunkler, als die übrigen.

Ich have diese Art, wie die vorige, als Schmarotzer-Schmarotzer im J. 1842 heim Aufhören des Schwammraupen-Fragses im mehreren Execplaren gezogen. Sie war nebst Eurytoma Abrotani(s. bei Eur.) die häufigste Art, und Eupelmus azureus, den ich zuglich erzog, sie seltenste. In manchen Gruppen der Mircrogasteren Tönnchen, welche ich im Juli des Jahres 1842 von den an den.

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+) Wenn dies Thier, wie ich vermuth, das zu tennuis ist, so würde sich hier die Färbung des Fuhlerschaftes heider Geschlechter gerade umgekehrt verhalten, wie bein andern Arten, indem z. B. von P. Cecidomyiae das dunklere Fühler, also das hat. Es fände sich hier auch ein merwürdiges Beispiel von Mangel und Gegenwart Metathorax Kiels bei Einer und derselben Art. Bäumen gestorbenen dispar Raupen abgenommen hatte, kam kaum die Halfte des Microgaster aus, was man, auch ohne die Thiere zu haven, an den kreisrund abgeschnitten Deckeln erhennen konnte, während die von einem Schmarotzer-Schmarotzer verlassenen Tönchen wie mit einer Nadel gestochen waren.

Uber die Entwichelung dieser Art habe ich mehrere interessante Erfahrungen machen können.

Es zeigt sich hier von Neuem ein Seitenstück zur Ernährungsweise des Anomalon circumflexum, wie ich es schon bei P. Cecidomyiae (No. 13) erwähnte, jedock mit dem Unterschiede, dass gegenwärtiger Schmarotzer, gerade wie grosse Ichneumon, (vielleicht nur ausnahmsweise) in der Larve und Puppe von Mircrogaster sich ausbildet. Ich bewahre noch die Exuivien mehrerer Larven und Puppen, welche ich beim Zerschneiden noch geschlossener Tönnchen des Microgaster fand und die unverkennbar diesem

geselligen Schwammraupen-Schmarotzer angehören. Die Puppen des kleinen Pteromalus, welche ich todt aus denselben hervorzog, sind daneben ausgekelbt. Also kann einmal schon die Larve des Microgaster ganz von seinem Gaste ausgefressen und an der Verpuppung gehindert werden; ein andres Mal behält sie aber noch so viele Kräfte und Masse, das die sich noch verwandelt und erst als Puppe gänzlich unterliegt. Eine noch wunderbarere Erscheinung ist folgende. In einem (jedoch mit auffalend Kleinem Löchelchen) geöffneten Microgastern-Tönnchen finde ich eine zerstörte Pteromalus Puppe, aus welcher augenscheinlich ein andres Thier, als P. Boucheanus hervorging, also wahrscheinlich ein Schmarotzer in der dritten Potenz!

(p.197) Die Entwickelung dieser Thierchen erfolgt aber ziemlich spät; denn ich hatte noch den 18. September lebendo Puppen und Wespen, ja sogar noch eine lebende Larve, obleich die Schwammraupen schon im Monat Juli durch die aus ihrer Haut sich herausfressenden Microgaster-Larven getödtet worden Waren. Wenn dieser Act des Herausfressens, bei welchem die kleinen Pteromalen wahrescheinlich den Augenblick, da die M-Larven noch nicht eingesponnen sind, benutzen, sich aush hier und da bis

in den August verspäten sollte, so würde doch wenigstens eine vierwöchentliche nier nöthig sein, wie ich sie bei P. Puparum bestimmt nachgewiesen habe. Ferner muss ich bei dieser Art noch Erscheinung Erwähung thus, die ich mir gar nicht have erlären können. An einer braunen, halbtrocknen Microgaster-Larve,in welcher eine fertige Puppe des Kleinen Pteromalus steckte, fand ich eine eirunde, geplatzte, unter dem Mikrospope borstig erscheinende Hülle klebend. Ob dieser brostige Körper das Ei war, aus welchem die Pteromalenlarve hervorkroch und sich ~~xxx~~ gleich in ihr Schlachtopfer hineinbohrte? (s. das Allgem. p.9)

Wie vielle Fragen giebt es hier, obgleich doch etwas geschehen ist, noch zu Beantworten! Wem wird glücken, einmal den Moment abzupassen, wo beide Schmarotzer bei den Migrogastern-Larven zusammentreffen und sich die Erhaltung ihrer Art streitig machen?

Hr. Bouche (Naturgesch. der Insect.p.168). bescreibt einen P. Microgastri, welcher bis auf die geringere Grösse (3/4-1) "die schwarzbraunen Fühler und die braunen Beine", mit meinem Boucheanus ubereinstimmt. Auch ist das Vorkommen in den Puppen von Microgaster dasselbe, jedoch wieder verschieden, das sie zu 3-4 in den Puppen (Concons?) und im Monat April auskommen

sollen. Wen also auch eine übereinstimmung in der Körperform anzenehmen wäre, so würde doch eine solche Verschiedenheit beider hinsichlich der Lebensweise herauskommen, dass sie schon dieserhalf als specie diversi anzunehmen wären; oder es würde sich hier uns ein Fall von Abwäichung in der gewöhnlichen Lebensordnung darstellen, wir wir wenige kennen. Die angegebene Flugzeit (April) giebt auch zu mancherlei Betrachtungen Anlafs; zunächst erscheint es wunderbar, das die Thiere so lange in ihrem Verstecke blieben, nachdem ihre Wohnungsthiere längst gestorben waren.

Bermerken muss ich dock noch, dass ich im J. 1840 aus den Raupen von Gastropacha pinivora (s. Forstinsecten Bd. II, p.128) einen volkommen mit P.Boucheanus ubereinstimmenden - Pteromalus erzog, an welchem nur der Kopf verloren gegangen ist. Warum sollte das Thier sich auch vor jener haarigen Raupe furchten, da es doch an die Schwammraupen geht? Ob es hier nur erster oder zweiter Schmarotzer war?

Endlich habe ich noch nachzutragen, das Herr Graff aus Bombyz vinula einen Kleinen Hemiteles erhielt, mit welchem zusammen viele Exemplare unsres Pter. Boucheanus erschienen.

Auch die 10 individuen, welche Hr. Graff aus einem Tachinen-Tönnchen erzog, gehören dieser Art an."

The Green Muscardine Fungus

Oospora destructor (Metchinoff)Delacroix .

During the spring of 1924 the writer discovered that some of the earwigs sheltered in breeding jars at the Portland Laboratory of the State Board of Horticulture were dying from a fungus attack. Soon after death overtook them, the fungus appeared in white tufts all over the thorax and head and soon spread to other parts of the body.

A few specimens were sent to Professor H. P. Barss of the Oregon Experiment Station for study. Professor Barss, after perusing all available literature and examining the morphology of the fungus, stated that he believed it to be the fungus known in Europe as the green muscardine, or Oospora destructor (Metchinoff) Delacroix. Further researches have substantiated his contention.

Earwigs affected by the fungus walk with a swaggering of the body and a cramping of the body close to the ground. At times they have been observed to indulge in hectic spasms, when they would twist the abdomen sharply up and down and from side to side, losing all control of their organs of locomotion and fall upon their sides.

Under proper conditions of temperature and moisture, death usually overtaken earwigs within four days from the time of infection. In two or three instances the fungus did the work within forty hours after the earwigs were subjected to the fungus chamber.

The fungus was first studied by Metchinoff and he named it Isaria destructor, but the study was completed by M. de C. Dr. Delacroix in 1893 who reported upon it to the Societe mycologigue de France. Because of certain corrections he made in the work of Metchinoff, his name take precedence. Delacroix experimented with several media, but found that cultures thrived best on potato.

After growing a number of cultures on potato, he contaminated specimens of Coleoptera and obtained a filamentous growth of yellow, saffron mycelium mingling with the characteristic white growth. The yellow mycelium threads were found to be true O. destructor, but were sterile. Vast, who also studied the fungus, found that it grows well on the barbs of feathers.

Oospora destructor belongs to the Fungus Imperfectus, falling within the Hyphomycetes in the group

Mucidineas. After death of an infected earwig, the fungus breaks out principally in the thoracis region, especially on the ventral surface, and progresses up on to the head parts. From each joint of the antennae - white tufts of mycelium appear and also from the joints of the legs. On the dorsal side the fungus soon crops out from under the wing covers and over the head until the eyes and mouth-parts are completely smothered by growth. As growth progresses, the white fungus protrudes from under the abdominal integuments and shows as even rings, giving the abdomen a striped, or ringed appearance. So far as observed, it is customary for the fungus to attack first the thoracic region, then progress up the head and neck and posterior along the abdomen. The hyphae penetrate all portions of the body and appendages.

On April 24 a male earwig was found with a small colony of the white fungus mycelium barely showing on the thorax. It was kept in a moist chamber and by April 25 the head and thorax were covered by a dense mycelial growth. This spread through the body until the entire earwig was covered by the fungus on April 28th. On April 27 the green fruiting bodies became apparent on the older growth of the thorax and on April 29 the head and thorax

were quite green, while the abdomen was nearly a solid pure white. Even the heavy chitinous forceps were covered with a white pubescent growth of mycelium.

It was very easy to trace the progress of the fungus growth on the earwig's body by the progressive coloration of the fruiting bodies as they developed and ripened. The spore layer on the thorax was a "deep dull yellow green" (Ridgway). From each integument of the abdomen a growth of mycelium emerged giving that part of the body a series of whitish rings that progressed more and more to a green as they neared the base of the abdomen. The proxinal ring of the abdomen was quite green, while the distal was nearly snow-white (Fig. 16).

Conidia are borne over the entire surface of the mycelium from simply or slightly branched conidiophores and are in chains. They are quite cylindrical and measure about 4 u in length, as observed from conidia cultured on F. auricularia. In mass on the earwig they present a gray-green appearance, but under the microscope they seem hyaline. The primary growth of hypae is white, but, as the conidia form, they turn greenish. The conidiophores are from 1 to 2 m m. long (Fig. 17).

Many trials were made to determine the approximate optimum conditions of moisture and temperature for germination of the pathogen on the earwig. On April 7 three nymphal earwigs (second instar) and one adult female were powdered directly with the spores of Oospora destructor and kept in a tight chamber with moist sand in a room where the temperature did not rise above 52°F. now below 40° F. for the seven days the earwigs were in it. After four days, one of the nymphs and the old female died and the characteristic fungus appeared on them. Neither of the others became infected, so were removed to a room where the temperature averaged about 60° F. throughout the whole day. Both died of the disease two days following the transfer.

Various other tests proved quite conclusive that the spores germinate with difficulty except under quite humid, warm conditions.

On April 19 two nymphs were placed in the chamber previously used for other inoculation tests and no additional spores were added. Small pieces of raw potato were kept in the Chamber for good, as they were in each of the foregoing reported tests. Within three days both were dead, one was covered with a host of tiny, white mites and exhibited no fungus, while the other supported a dense

growth of white mycelium about the thorax and head. On the fifth day it had not shown up on the abdomen, but was sprouting luxuriously from the antennal joints and the thorax was covered by a continuous mass of conidia of a "Kronberg's green"(Ridgeway).

Under conditions of the small insectaries in Portland where thousands of earwigs are confined in a small area, the fungus has reaped none too insignificant harvest this spring of 1925. Many are found daily with abundant mycelial growth covering them. In some of the specimens, where growth has continued for a considerable period, or possible subjected to excellent conditions for the fungus, the mycelium completely hides the earwig's body. Without doubt, it is of some economic importance, especially when the conditions of temperature and moisture favor the organism.

In order to determine what artificial media might be best for culturing the fungus and better understand the biology of the fungus, various media were inoculated with virile spores and the results observed daily.

Following is a resume of the appearance of the

cultures on April 22 - they were inoculated on April 15:

M 1 - Steamed turnip plug

Mycelium grew well in white-tufted colonies and gave rise to "deep dull-yellow green (1)"(Ridgway) conidia, though only in a light sprinkling.

M 2 - Carrot Plug steamed

Fair growth of white mycelium in tufts, but only a very small patch of conidia which were "turtle green" (Ridgway).

M 4 - Sweet clover stems - steamed

Two separated colonies of abundantly tufted mycelium, but without fruiting bodies.

M 5 - Canned sweet potato plug - steamed.

Good white mycelial growth, but no conidia in evidence.

M 6 - Steamed white potato plug.

Excellent white growth of mycelium and small patch of "Andover green" (Ridgway) conidia.

M -7 - Italian prune - steamed.

Failed to germinate.

M 8 - French prune - steamed

Failed to germinate.

M 9 - Canned string bean - steamed.

Fair growth of white mycelium - not long. Small patch of "Andover green" (Ridgway) conidia present.

M 10 - steamed parsnip dug.

Mycelium not long, nor growth extensive. Crust formed over surface of mycelium. No fruiting bodies evident.

M 12 - sterilized rice.

Medium growth of short hyphae and small patch of "Andover green" (Ridgway) conidia. Yellow coloration not deep, on surface of media.

M 13 - French prune juice decoction - steamed.

Very short, meager mycelial growth with no ripe fruiting bodies.

M 14 - Plain agar sterilized.

Faint growth - no fruiting bodies showing.

M 15 - Decoction of dried Italian prune - steamed.

Greyish-white mycelial growth with faint trace of yellow. Several patches of "Andover green" (Ridgway) conidia showing up, though not extensively.

M 17 - Steamed oat agar.

Poor growth of white mycelium - no green fruiting bodies.

M 18 - Standard potato dextrose - clarified.

Good growth of mycelium which ranged from snow-white tufts to "Marguerite yellow" (Ridgway) with very light sprinkling of "Andover green" (Ridgway) fruiting bodies.

M 19 - Potato dextrose agar - sterilized.

Abundant growth of white mycelium with generous sprinkling of "Andover green" (Ridgway) fruiting bodies.

M 20 - Standard synthetic medi (Fig. 20).

Produced a very dense growth of hyphae which appeared as cushions in places. Small patch of "Andover green" (Ridgway) conidia present.

M 21 - Italian prune agar - steamed.

Dense, but not long, growth of grayish white mycelium tending to form a continuous mat. No fruiting bodies developed.

M 22 - French prune agar - sterilized.

Dense, but short, growth of hyphae - mostly white with a faint trace of yellow. Fruiting bodies barely beginning to show.

M 24 - Beef peptone agar - steamed (Fig. 20)

The mycelium did not grow very heavily, but great amounts of fruiting bodies were present, due, very likely, to the N. present in the media. These were a "Kronberg's green" (Ridgway) and formed a continuous layer over the agar slope.

STERILE SLICED POTATO IN PETRI DISH (Fig.19)

After 16 days from time of inoculating there was a mat of hyphae fully one-half inch deep and covered with a continuous layer of conidia of a "deep olive color" (Ridgway) enmass over the entire potato slice.

OTHER ENEMIES OF THE EARWIGS

Toads

Toads eat earwigs readily. This has been reported from Europe and has been ovserved by the writer in earwig infested areas of Portland. In the summer of 1924 on a vacant lot in St. Johns, a suburb of Portland, a great many toads were found. Earwigs were plentiful in that region, so three of the amphibians were dissected and an examination made of their stomach contents. There were remains of many unfortunate earwigs in the stomachs of each.

Other toads were brought into the laboratory and confined with several earwigs. This was only for a short time, for a consolidation was brought about with the earwigs getting the worst of it.

Predaceous beetles.

Certain of the large carabid beetles prey on both adult and nymphal earwigs. These have been seen often at night prowling about in quest of other insects and have been seen to catch and run off with many earwigs. Both Carabid beetles and rove beetles have been caged with earwigs by the writer with the result that the latter were devoured.

Chickens.

Chickens keep the premises where they may be confined quite free of earwigs. Rarely have earwigs been found within a pen of these fowls in Portland, even when the adjacent lot might be abundantly infested with them.

Nematodes.

Many round worm parasites of the earwig have been reported from Europe and one is known to infest the earwigs in Rhode Island. A few are valuable in a minor way, but are not considered as major enemies of the earwig.

On April 1, 1925 a nematode fully three inches long was found in one of the cages where the earwigs being held to regain the puparia of R. Antiqua were. It had been badly chewed by the earwigs but was sufficiently whole that Dr. G. Steiner of the Bureau of Plant Industry in Washington, D.C. was able to recognize it as a Mermithid, one of the common earwig-infesting forms known in Europe.

No round worms have been discovered in earwigs of the Northwest, though it is not unlikely that they occur.

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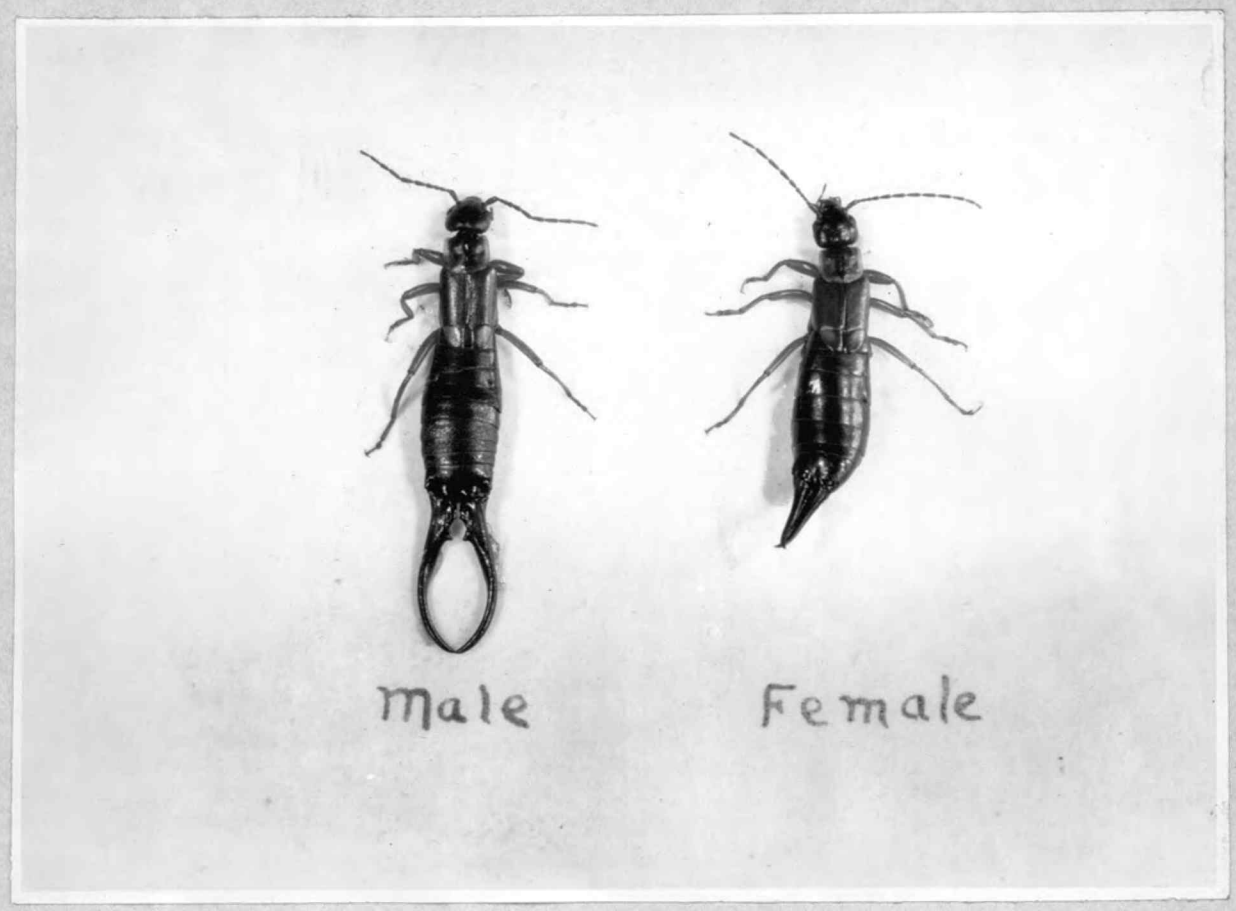
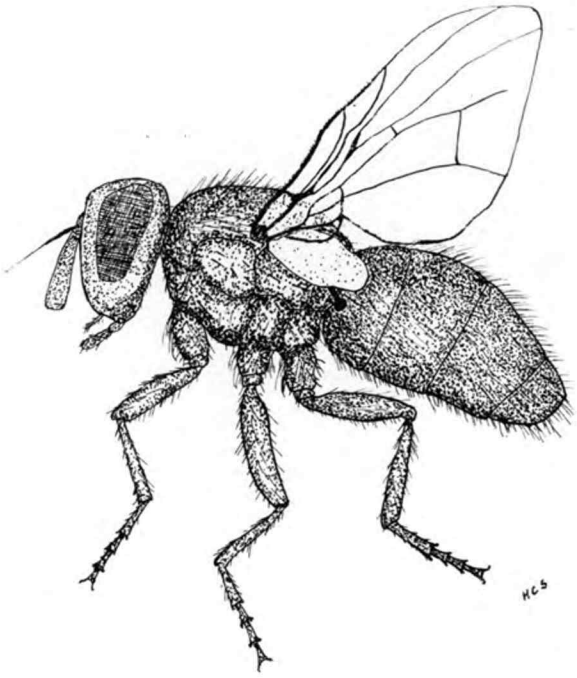
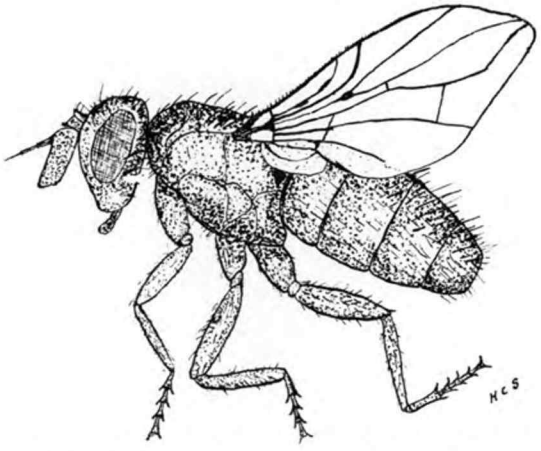


Figure I
Showing The Difference In The Forceps
Between Male And Female Earwigs



Rhacodineura antiqua - lateral view.
X10



Digonochaeta setipennis
lateral view. X10

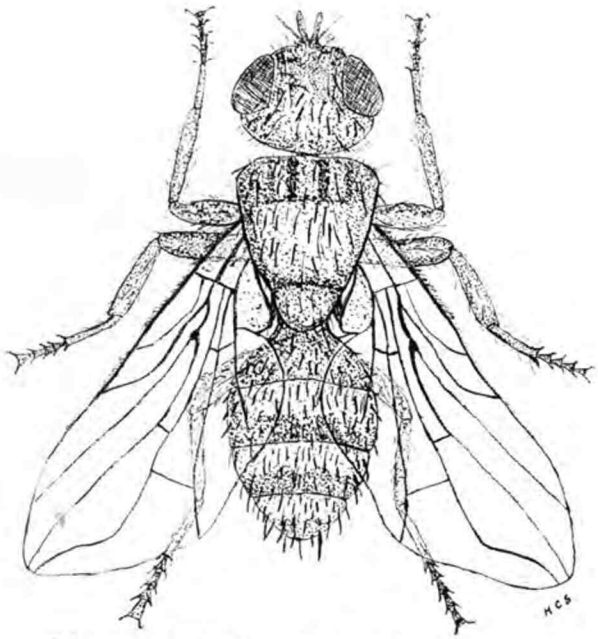
Figure 2.

Packages containing puparia
Received from Europe

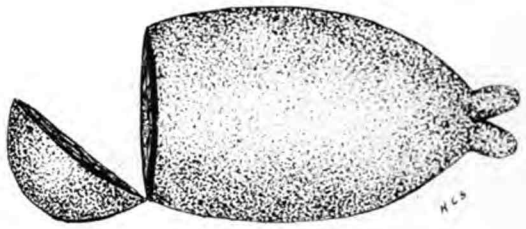
Figure 3.

Puparium of D. setipennis.

Figure 4.

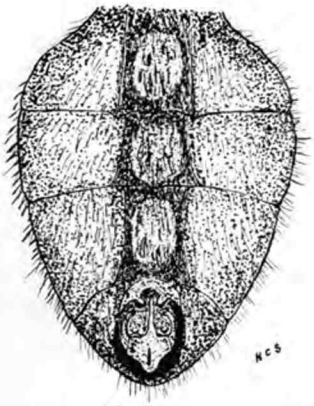


Digonochaeta setipennis
Dorsal view.

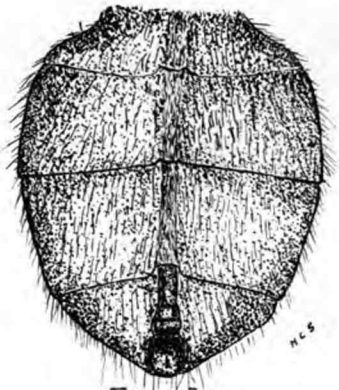


Puparium showing emergence
hole of Digonochaeta setipennis
X15

Genital parts of
D. setipennis
external - X10.



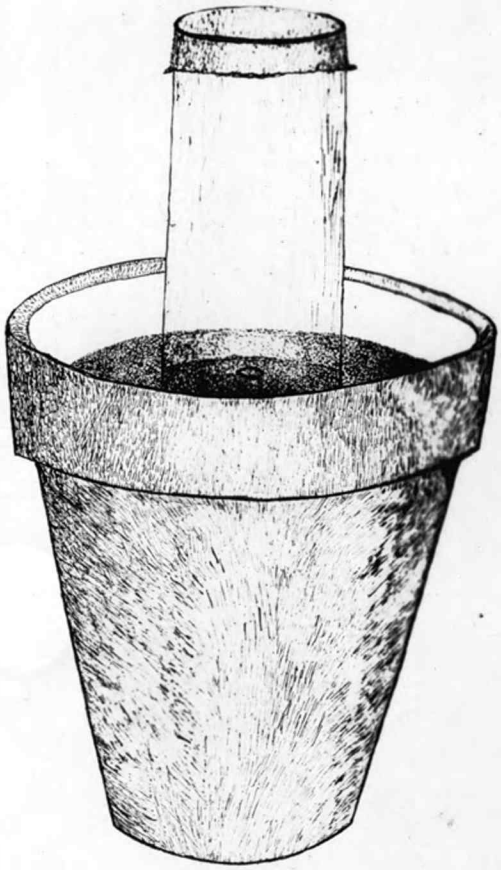
Male.



Female

Abdomens of D. setipennis showing difference between sexes.
X15

Fig. 5



Drawing showing type of pot and vial used in handling puparia

Figure 6

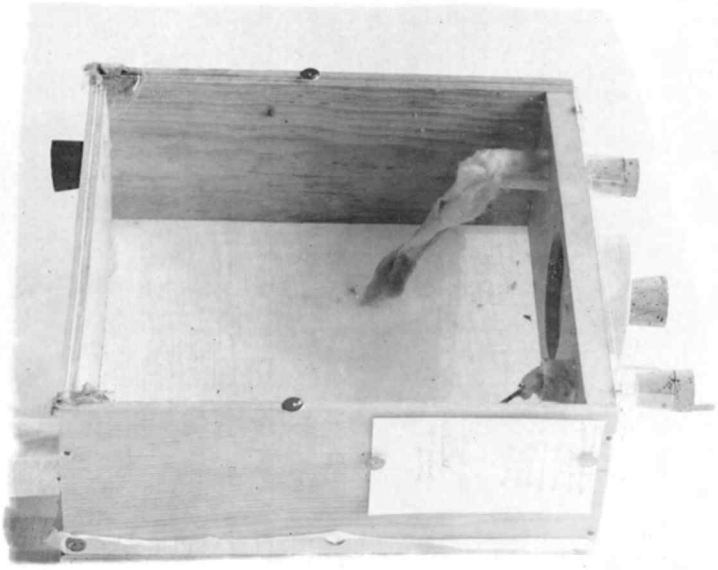
Feb.	Max	Min	Mar.	Max	Min	April	Max	Min
18	73	52	1	66	35	1	64	42
19	61	49	2	66	48	2	57	47
20	60	51	3	59	42	3	60	46
21	55	52	4	62	36	4	59	47
22	54	51	5	58	35	5	56	42
23	54	50	6	55	31	6	60	44
24	60	55	7	56	39	7	68	38
25	61	51	8	46	38	8	74	41
26	54	49	9	46	36	9	78	44
27	62	34	10	55	34	10	69	48
28	65	34	11	47	30	11	66	51
			12	55	30	12	74	42
			13	55	41	13	68	42
			14	56	41	14	74	50
			15	58	35	15	71	56
			16	59	43	16	65	49
			17	57	44	17	55	43
			18	59	35	18	53	43
			19	57	46	19	55	43
			20	62	48	20	58	39
			21	60	40	21	56	43
			22	58	40	22	57	39
			23	70	41	23	56	40
			24	72	36	24	63	42
			25	62	41	25	62	39
			26	67	35	26	66	39
			27	60	38	27	75	45
			28	55	36	28	78	46
			29	58	30	29	76	47
			30	60	42	30	68	46
			31	52	39			

Fig. 7

Table showing the maximum and minimum temperatures (degrees F.) surrounding Puparia from Feb. 18 to April 30.

Breeding cage used to House Pots with Puparia

Figure 8



Mating cage used in work

Figure 9.

Figure 10 not provided.

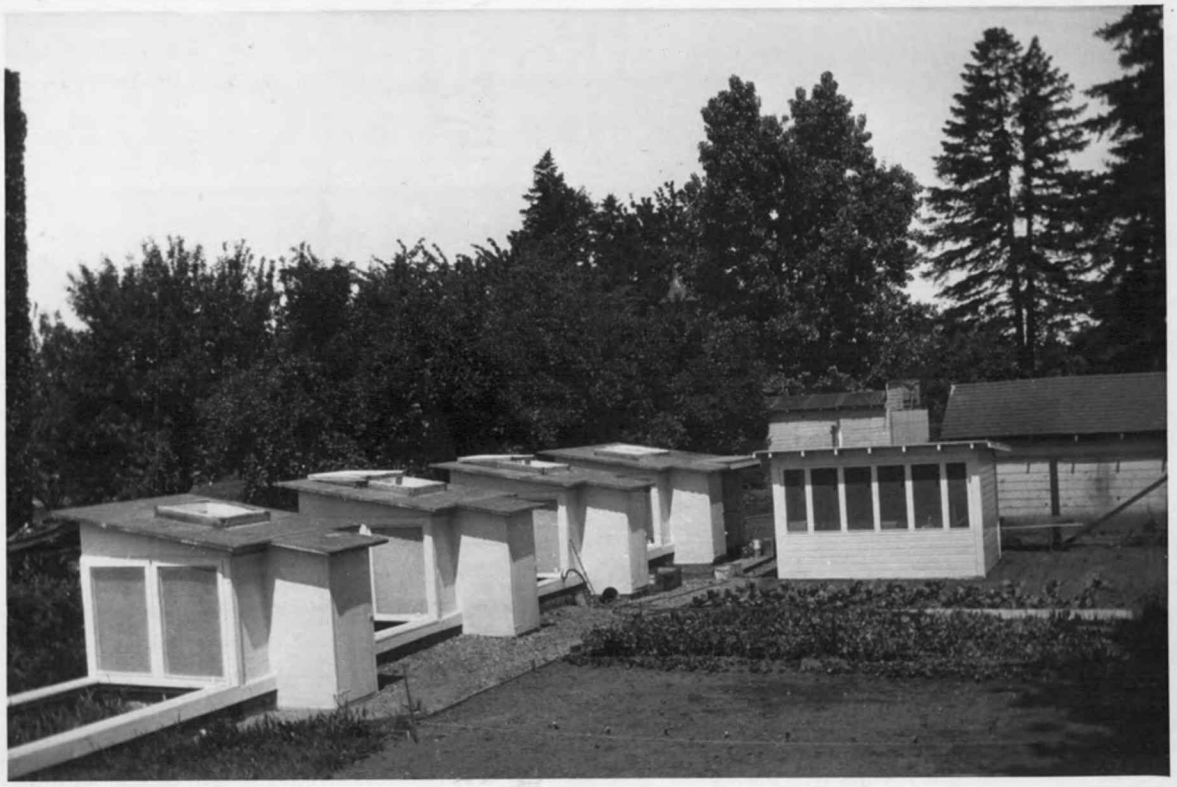
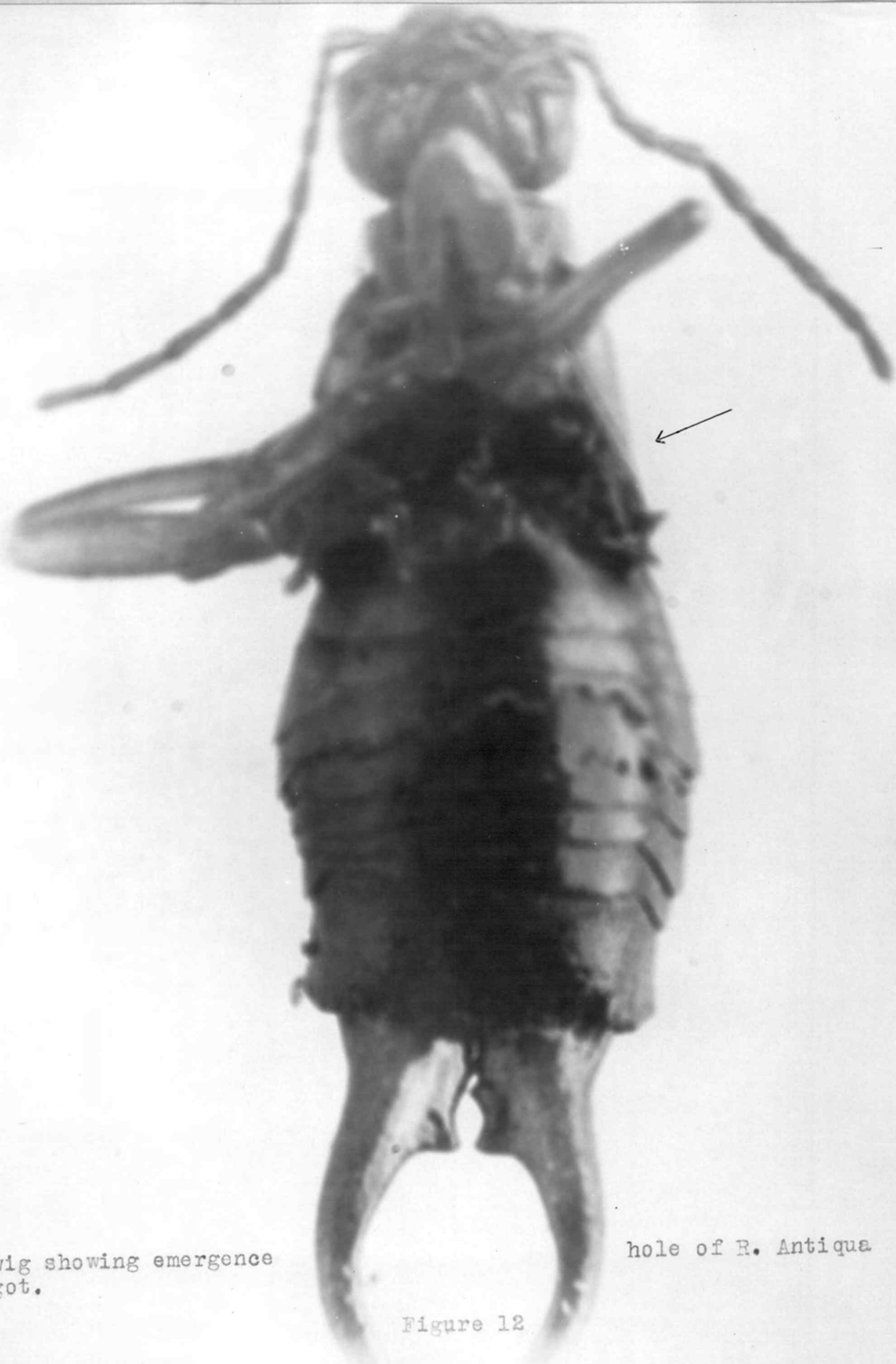


Fig. 11

Insectaries located at Portland, Ore.

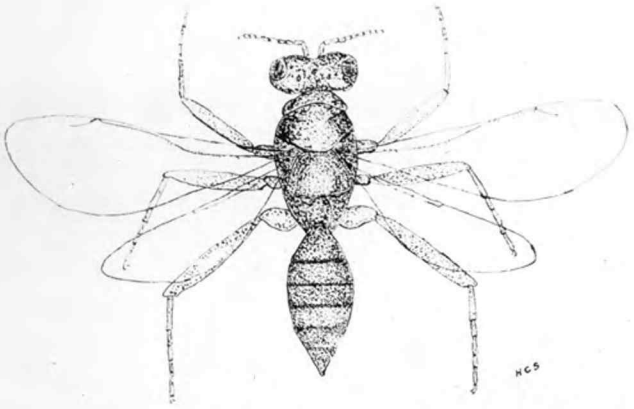


Earwig showing emergence hole of R. Antiqua maggot.

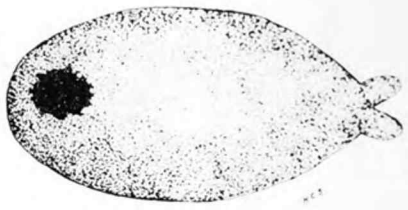
Figure 12

Puparium of R. antiqua after Emergence of Fly

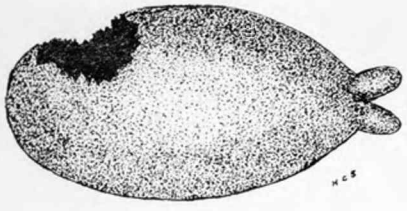
Fig. 13.



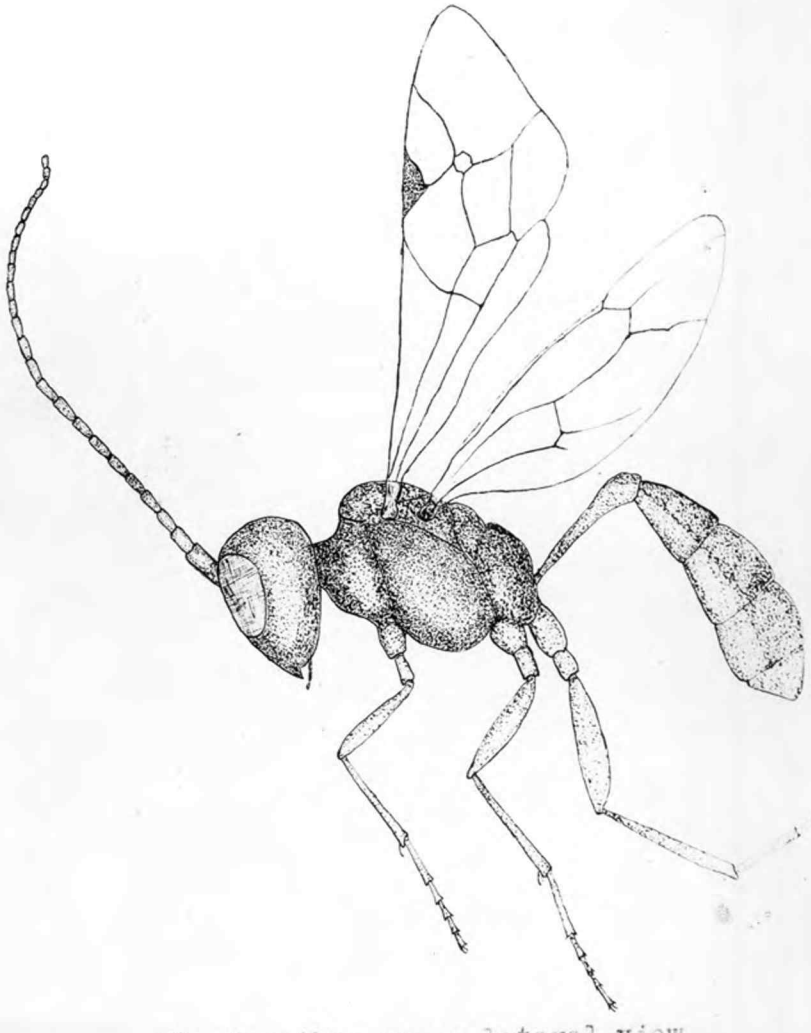
Dibrachys cavus - Dorsal view. X20



Puparium showing emergence hole of Dibrachys cavus. X15



Puparium showing emergence hole of Plesignathus sp. X15



Plesignathus sp. - lateral view X15

Fig. 14.

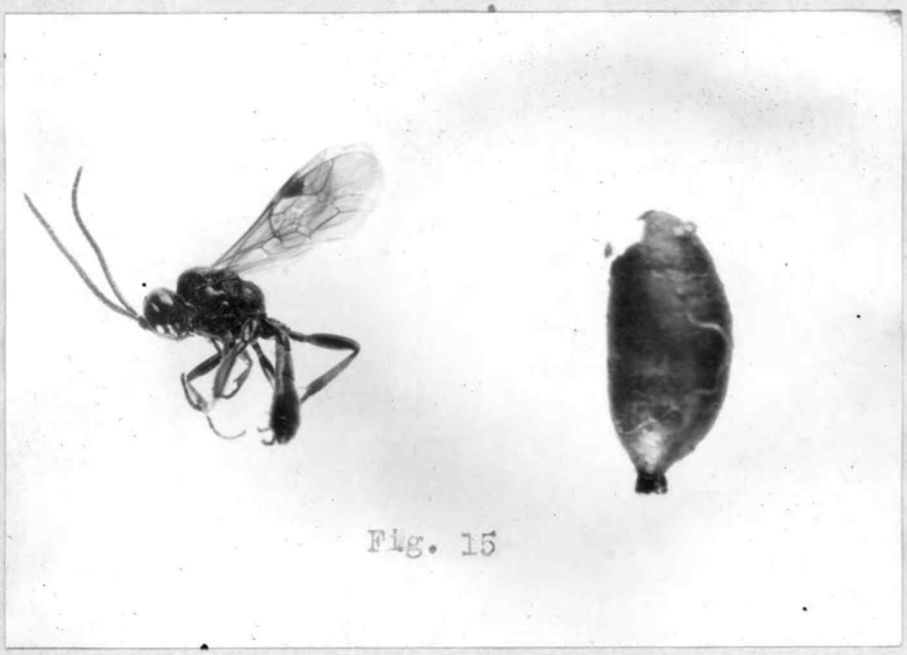


Fig. 15

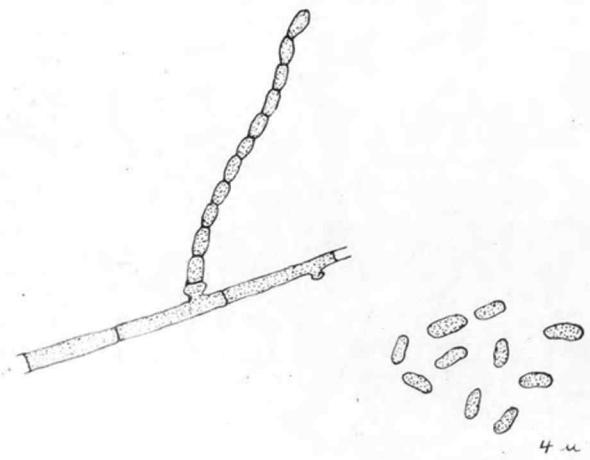
P. Variabilis and puparuim it Infested.

Fig. 16.

EUROPEAN EARWIG

Green Muscardine fungus growing out through segments of body of insect. Ventral view. The insect was one received in March 1925 by Dept. of Eutomology from England. The insect was kept in a moist chamber in Eut. Lab. O.A.C. and died April 24, 1925 when the fungus Regan to grow out. The insect was kept in moist chamber till April 29th,

Corvallis, Oregon.



Conidiophore and conidiospores of
Oospora destructor

Fig. 17

Produced on European Earwig.

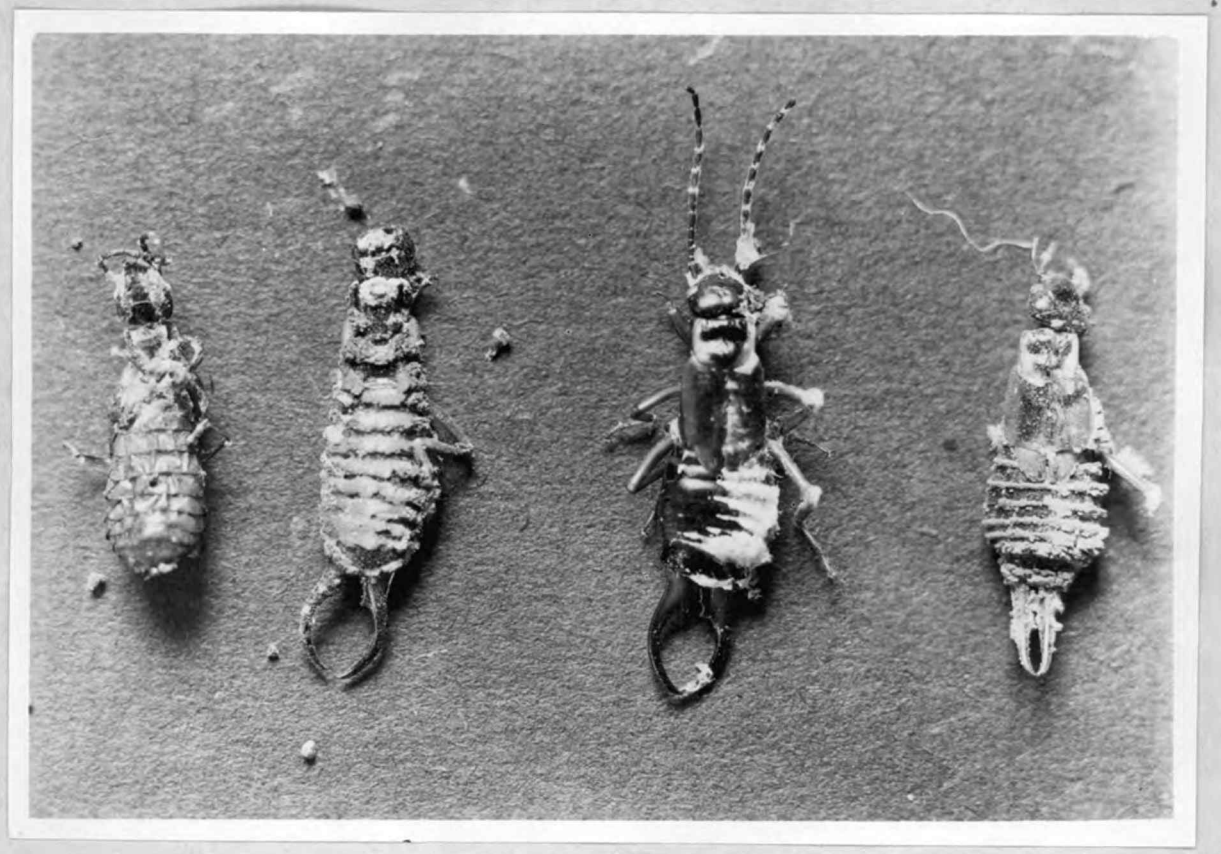


Fig. 18

ON EUROPEAN EARWIG

Earwigs infected with fungus showing natural outgrowth of spore-bearing hyphae.

From left to right:

No. 1. Artificially exposed to O. destructor spores on June 6, 1924 and died after July 29, 1924. H.P. Barss.

No. 2. Artificially exposed to fungus culture on June 6, 1924. Died July 29, 1924 (or sometime after) H.P. Barss

No. 3. Earwig showing results of infection with baspora destructor - Found dead about July 24, 1924. O.A.C Exp. Sta. H.P. Barss.

No. 4. Earwig inoculated artificially on April 18, 1925 - Died April 23, 1925. Was kept in a moist, warm glass cage - Stearns.

Fig. 19

FROM EUROPEAN EARWIG

Culture on sterilized potato slice inoculated April 8, 1924. (16 days old).

Fig. 20

EARWIG.

Photo of culture test tubes inoculated April 15. (9 days previously) reading from left to right, the media were

M 6 M 20 M 24
M 6 - Potato plug sterilized in autoclave
M 20 -Standard Synthetic medium
M 24 -Beef peptone agar (standard)