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Experiment Station

The European Earwig

By

B. B. Fulton

CORVALLIS, OREGON

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SUMMARY

The European earwig has been present in Oregon since 1909 but did not attract much attention until several years later. It is a pest chiefly on account of its disagreeable habit of concealing itself in or about houses. It is also destructive to garden vegetables and flowers, and is occasionally a pest of bush and tree fruits.

The best method of control is by means of a poison bran bait scattered about in the evening. Sodium fluoride is recommended as the best poison, from the standpoint of both effectiveness and economy. For bait to be scattered over the ground clear wheat bran is recommended; for bait to be applied to trees, buildings, and other objects, ground oat hulls are recommended.

It is essential that all property in the same neighborhood be treated on the same evening. For this reason control work is most effective when carried on as an organized community effort.

No effective parasitic or predatory enemies of the earwig have yet been found in Oregon. An effort will be made to introduce parasites from Europe.

The European earwig lives over winter in the ground in small cavities a few inches beneath the surface. The eggs are laid in the cavity during the fall or early in spring, usually forty to sixty in number. The female guards and cares for the eggs and for the young earwigs until they leave the nest. Hatching takes place in April sometime between the blossoming periods of the cherry and apple. The young earwigs remain in the nest until after the first moult. Later they wander away from the nest and in the later stages are strongly inclined to climb up on objects of any kind during the night. After the young earwigs leave the nest the female continues to feed for a period and then goes into the ground to deposit a second lot of eggs.

If control measures are applied when the majority of young earwigs begin to feed at night it is believed that this brood and the adults can be poisoned before the second lot of eggs is deposited. The young of the second brood do not appear above ground until the first brood is nearly or quite matured.

There are four nymphal instars, which can be distinguished by differences in the thorax, forceps, and the number of antennal segments.

The European Earwig

By

B. B. Fulton

The earwig has been recognized as a distinct form of insect life since the middle ages. The name is descended from the Anglo-Saxon word *earwicga* which literally meant "ear creature." It is an interesting fact that in nearly all European languages the popular name given to this insect has similar significance.* In German, Dutch, Swedish, Spanish, and Italian the earwig is known literally as an ear worm. The Germans also call it an "ear-borer," the Danish "ear-twister," and the French and Portugese a "pierce-ear." All of these names refer to a widespread superstition that earwigs crawl into the ears of sleeping persons. Since this idea is not known to be substantiated by fact, it seems improbable that it could have arisen independently among so many different peoples. This suggests the possible antiquity of its origin.

By far the best known species of earwig, the one which is largely responsible for popular recognition of its kind, is the common European earwig, *Forficula auricularia* Linné. It has gained fame by making itself obnoxious.

Some four hundred other species have been described but the majority of them inhabit warm or tropical countries. Most of them are inconspicuous in appearance and live by day in concealed situations and so are seldom noticed. Fifteen species of earwigs are known to inhabit the United States. Several of them are introduced forms. Seven species have been found in the Northern states; five have been taken in the Pacific Coast states and only two are known in Oregon. These are the European earwig and the Little earwig, *Labia minor* (Linné), which can be distinguished from each other by the great difference in size; the length of the former is ⅝ to ¾ of an inch while the latter measures only about ¼ of an inch.

Except for a few species, little is known of the life of earwigs. They have been found under stones or bark or under litter on the ground. The maritime earwig, *Anisolaba maritima* (Géné) is partial to the decaying drift of sea beaches. The little earwig, *Labia minor* (Linné), is commonly found in manure piles. A species of the Southwest lives in dead giant cactus; two species have been found among the filth of slaughter houses; three species are known to live among the rank growth of grass and vegetation in low places.

The earwigs form a distinct group of insects which are characterized by their wings and their forceps. They were formerly classified as close relatives of the grasshoppers, crickets, and roaches but are now usually considered as a distinct order under the name "Dermaptera." The fore wings are represented by small leathery wing covers which meet at the median line and resemble abbreviated elytra of a beetle. The hind wings are large and when at rest are folded both radially and

*In the Century Dictionary and Cyclopedia the following names are given for various languages. Dutch, *oorworm;* German, *ohrwurm,* and *ohrbohrer;* Swedish, *ormask;* Danish, *orentvist;* French, *perce-oreille;* Portugese; *fura-orelhas;* Spanish, *Gusano del oido;* Italian, *verme auricolare.*

transversely and lie mostly concealed under the wing covers. Some of the species of earwigs are devoid of wings, and those which have them are seldom seen flying.

All earwigs have a pair of forceps or "pinchers" at the hind end of the body, an organ found only in one other group of insects, the genus *Japyx* of the Thysanura, which are small primitive insects in no way resembling earwigs. The forceps of the males are of different form and more highly developed than those of the females, and in some exotic species they attain remarkable size and peculiar form.

DISTRIBUTION

Like the cockroaches, a number of species of earwigs have followed the trade routes of man and have become nearly world-wide in their distribution. The European earwig is rapidly extending its range and may soon be known as a cosmopolitan species. Its native home includes the greater part of the continent of Europe, and at present this insect has outposts in North America, South America, New Zealand, and Tasmania. The South American record is assumed from the fact that a shipment of fertilizer from Buenos Aires and Santos was thoroughly infested with European earwig. The first extensive outbreak in North America, was at Newport, R. I., where earwigs attracted attention in 1911; since then they have multiplied and become a pest over a considerable area. Records show that the earwig has been present in Oregon since 1909. A specimen which was identified as an earwig was sent to this Experiment Station in 1910 from Albany, Oregon, accompanied by a letter in which the writer claimed that the insect had been a pest during the previous summer also. Little more was heard of the earwig until 1915, when it attracted much attention in Seattle, Washington, by its numbers and disagreeable habits. Afterwards, letters from both Portland and Albany, Oregon, began to call attention to the pest. By 1919, it had become established in Vancouver and New Westminster in British Columbia. In 1923, the earwig was known to occur in the following additional localities: Astoria, Salem, Eugene, Corvallis, Forest Grove, Gresham, Roseburg, Dayton, Mill City, Colton, and Blodgett, in Oregon; Vancouver, Camas, and Anacortes, in Washington; and Berkeley, in California. We also had unconfirmed reports of its occurrence in Edmonds and Everett, Washington.

MEANS OF DISPERSION

It is impossible to say how the original ancestors of the earwig in the various infested areas were imported into America. We know that earwigs have been intercepted from time to time on nursery trees and bulbs from Europe and this seems the most plausible explanation of their entrance into this country. Their spread from place to place is a simple matter, due to their habit of concealment in any object which offers a narrow, dark hiding place. When such objects are transported from an infested district, there is always danger that some earwigs will be carried away also. We received a specimen of earwig from Ontario, Oregon, found in a package of daily papers arriving from Portland after a journey of over four hundred miles. Flowers are common hiding places for earwigs, especially those with many petals such as roses.

Such flowers should never be removed from an infested area without being thoroughly inspected.

The main earwig-infested area in Portland, which covered a few city blocks in 1915, spread until it included an area in 1923 estimated at eight hundred blocks. How much of this spread has been due to the natural migrations of the insects has not been determined, but we believe that city streets serve to some extent as barriers and that without human aid in transporting the earwigs their dispersion from block to block would be slow. The fact that the infestation at the border of the main area is patchy and disconnected is evidence that the insects are disseminated largely by human agency.

DISAGREEABLE HABITS

At the present stage of infestation, confined mostly to cities, earwigs are a pest chiefly on account of their disagreeable habit of concealing themselves in or about houses. At night they swarm over porches in such numbers that many people prefer to remain inside on a summer evening rather than spend it with such unwelcome guests.

In the morning earwigs are found by the handful under rugs and cushions which have been left outside. They crawl into basements and hide in the laundry which is waiting to be ironed. In the bedrooms they sometimes find their way into the clothing hanging in closets. A man reported that he pulled on a sock one morning which contained three earwigs. A correspondent in a letter appealing for information describes the situation as follows: "Literally thousands and thousands of these bugs inhabited my premises last summer. They made it almost impossible to live in my home; they inhabited the sleeping porch till we had to leave it. They work mostly at night but in daytime might be found in kitchen drawers and often burrow an inch into a loaf of bread. They crawl over ceilings at night and drop on the bed, or inhabit themselves in a person's clothing during the night, and while their bite has never proved serious it is entirely uncomfortable." No part of the house seems to be entirely free from earwigs, not even the roof, and it is almost impossible to keep them out by the use of screens. The pests have become so annoying in some districts that property values have depreciated considerably.

As disseminators of filth and disease the earwig probably stands about in the same class with the cockroach. The body of the cockroach is known to teem with bacteria inside and out, and in its nightly foraging expedition it scatters these germs in its path. The habits of earwigs are such that we would expect them to be equally effective as carriers of disease. They are prone to crawl about over sidewalks, where if anywhere the germs of human diseases should be found, and later they may find their way into the house and nibble our food.

FOOD

The European earwig is one of the most omnivorous of insects, and will eat almost anything that can be considered edible. Their normal diet consists mainly of green plants, but they will pass by leaves and flowers for any occasional morsel of a more nourishing quality that they may happen to find. Sugar, starch, vegetable oils, fat or lean meat, are

all eagerly devoured. They eat dead insects and such live ones as they are able to capture and overpower. Littler[20] says that in Tasmania the European earwig destroys codling-moth larvae under tree bands. Brindley[7] gives a large number of references to European literature in which the earwig is recorded as feeding on various caterpillars, pupae, and scale insects. The author has fed living blow-fly maggots to both adults and nymphs. The nymphs in this case were in the second instar and no larger than the maggot, but several of them took hold of the victim at once and within ten minutes there was nothing left. Earwigs do not hesitate to eat each other when confined without food, but it is not known whether they kill weakened individuals or wait until they die. They devour the dead of their own kind even out of doors, but cannibalism would not be likely to occur where there is an abundance of food. There was a rather high mortality among the families reared in the Station laboratory, but here the conditions of food and moisture were not always ideal.

The plant food of the earwig includes a long list of garden vegetables, flowers, fruits, and wild plants. They exhibit certain preferences. The kind of plants attacked depends to some extent on what is available. If a favorite food is not at hand they will select the next best, and one cannot say positively that any plant is safe from earwig attack. Among the common plants which to the author's knowledge are subject to severe injury to the foliage are bean, potato, beet, cabbage, cauliflower, pea, dahlia, zinnia, sweet-william, and fig. A great many flowers are more or less injured by earwigs feeding on the petals and stamens. Dandelion flowers are a favorite food for the young nymphs. Earwigs eat numerous holes in the leaves of orchard trees and berry bushes, but the author has never seen any of these plants seriously defoliated. Strawberries have been observed with a cavity in the heart full of half-grown earwigs, and the adults are said to tunnel into ripe apples, prunes, and peaches. Brindley[8] gives a list of seventy-four species of plants including most of the common garden vegetables, flowers, fruits, and weeds on which caged earwigs fed on some part of the plant. In reviewing economic literature we find that in Europe earwigs have caused serious injury to the following crops: in Denmark, cauliflower (completely destroyed), beets, clover, dahlias; in Sweden, barley, wheat, cabbage, ornamental plants; in Norway, cabbage and other vegetables; in England, hops; in Austria, vegetables; in Russia, beets, potatoes, chrysanthemum stems; in Switzerland, pear foliage. Apparently the original home of the earwig is in no sense free from its depredations.

CHARACTER OF INJURY

The typical injury by earwigs appears as numerous small irregular holes in the leaves (Fig. 1). Tender foliage such as dahlia leaves are often completely devoured except the midrib and a few large veins. In the case of many other plants the smaller veins are left and the leaf is finally skeletonized. The work often appears like that of garden slugs, but the absence of any trace of slime on the leaves will serve to distinguish it. Earwigs will usually be found hiding in the ground near plants injured by them.

CONTROL MEASURES

Trapping. The oldest control method and the one commonly used in Europe is trapping. A flower-pot half full of excelsior is inverted over a short stake in the ground. Earwigs hide in the excelsior, which is removed and shaken over hot water or water with a film of oil on top. Burlap sacks or pieces of old garden hose about a foot long also make good traps. Traps should be placed among plants, near buildings or fences, or in tree crotches. Literally thousands of earwigs can be killed in this way during the course of a summer, and the trapper may gain considerable mental satisfaction from his labors, but unless some other control measures are used he will still have plenty of earwigs.

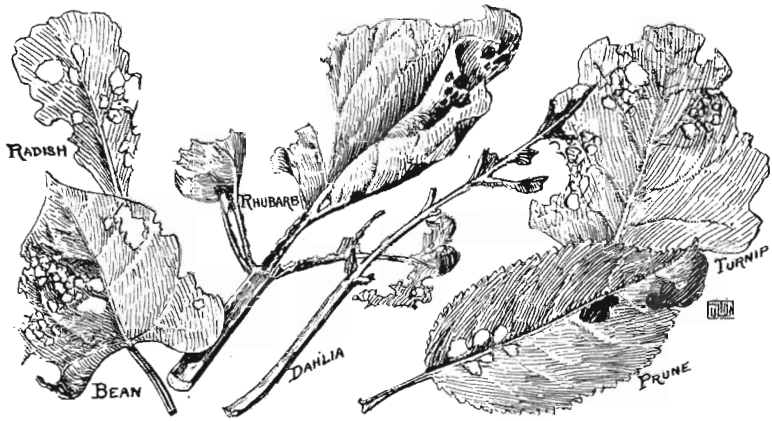

Fig. 1. Specimens of typical injury to foliage by earwigs.

Poison baits. During the summers of 1921 and 1922, the writer experimented with various poisons and attractants. The materials were placed at night in traps which the earwigs could enter but not leave and each morning the insects were removed and caged and a daily mortality record kept. The results of these experiments, which were published in a technical paper,[17] can be summarized as follows:

1. Wheat bran sweetened with molasses is sufficiently attractive to earwigs for all practical purposes, and clear wheat bran free from shorts is superior to all other substances tried for scattering over the ground.

2. Ground oat hulls are slightly more attractive than wheat bran. The fibrous quality of the former makes this material especially desirable for a bait to be applied to objects as a poison for climbing earwigs. Rice bran could also be used for this purpose but not for scattering on the ground.

3. The addition of amyl acetate (banana oil), anise oil, or meat extract does not materially increase the attractiveness.

4. Glycerin does not lessen the attractiveness of a bait and increases the length of time during which the bait is attractive.

5. When used in a poison bait for European earwig, in equal proportions by weight, sodium fluoride has an equal or greater amount of toxicity than arsenious oxide (white arsenic) and acts more rapidly. Sodium fluoride is slightly more toxic than sodium arsenate. Calcium fluoride is only slightly toxic.

Sodium fluoride has certain other advantages which make it more desirable as a poison for earwig bait than white arsenic or paris green, substances which are commonly used in poison baits for insects. (1) At present the cost is less than for the arsenicals. (2) It is soluble in water and thus easier to incorporate in a poison bait than either white arsenic or paris green. (3) It is less toxic to humans than arsenicals. According to H. B. Baldwin* sodium fluoride has been accidentally taken in doses of five, six, and nine grams without causing death, although severe sickness resulted. The same author took .03 gram without any noticeable effect, but .25 gram in two minutes produced nausea which lasted several hours. The last amount would be contained in about a tablespoonful of mixed bait. According to the above figures an adult person might eat as much as a quarter pound of the mixed bait without causing death, since at the recommended strength it would contain only about three grams of sodium fluoride. In the case of arsenious oxide much less than a gram is said to cause death.

RECOMMENDATIONS FOR CONTROL

Poison bran bait should be scattered over the ground in the evening just before dark. This should be done on warm nights after most of the young earwigs are old enough to feed above ground or when most of them are in the second instar or older. In Portland the best time to begin poisoning usually comes sometime in May. One year the young earwigs did not come out in large numbers until after June first. An unusually early season might bring them out by the last of April. This point can be determined only by observation.

The poison bran should be scattered over every foot of ground. By throwing it hard with a wide swing of the arm it can be scattered more evenly and quickly than by simply dropping it or shaking it through the fingers. On open lawns a very thin scattering is sufficient. More material should be applied along walks, curbs, fences, walls and buildings and around trees, bushes and thick vegetation (Fig. 2). The work should be done during clear weather and the grounds should not be watered for a few days, for this washes out the poison.

FORMULA FOR POISON BRAN

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

Dissolve the sodium fluoride and then the molasses in the water. Stir well and add this solution to the desired amount of bran to be used and mix thoroughly. The bran should be wet but not enough to make it ball up nor wet enough to drip without being pressed. Only clear

*Baldwin, H. B. The toxic action of sodium fluoride. Journal American Chem. Soc. 21, pp. 517-521, 1899.

wheat bran free of shorts is advised, and the above formula is based on this material. If mill-run is used great care must be employed not to leave large lumps on the ground. The amount of molasses in the above formula is given in a convenient amount for a small batch of poison bait. For large scale production see formula on page 13.

Late summer poisoning. It is well to follow up the general application of poison bran bait by the use of small amounts of poison bait applied to trees, walls, and other objects several times during the summer, to catch the earwigs after they begin to climb at night.

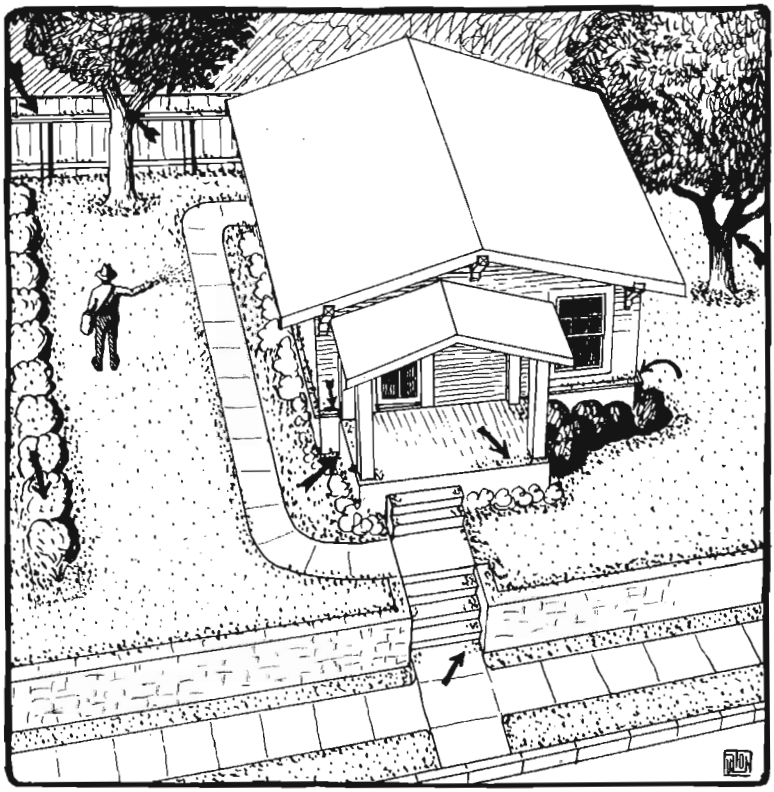

Fig. 2. Diagram showing proper distribution of poison bran bait as indicated by dots.

For this purpose it is well to have a mixture which will not dry for several days. This may be accomplished by substituting glycerin for a third of the amount of liquid used. Oat hulls will make a mixture which will stick to objects better than wheat bran. The following mixture is recommended:

Sodium fluoride	1 ounce
Molasses	5 ounces (⅓ pint)
Glycerin	5 ounces
Water	5 ounces
Ground oat hulls, about	1 pound

Mix by first dissolving sodium fluoride in the water, add molasses and glycerin, and mix with enough ground oat hulls to make a wet mash. Smear pinches of this in the crotches of all trees or around the trunk; leave pellets of it at intervals of about six feet along all fences and walls, and along the top of the house foundation, in cracks of barns and other buildings, or anywhere that the earwigs are seen crawling.

It is very probable that no dead earwigs will be found on the day after an application of poison bran. In experiments in which the recommended strength of poison was used, none of the earwigs which had fed on the bait were found dead on the first morning, and only about one-third of them were dead on the second morning. It was not until the fourth morning that most of them were dead. Poisons act more rapidly on insects during warm weather. Earwigs which have eaten a very small amount of poison may live as long as a week, but during that time they remain quiet and do not eat.

Caution. Sodium fluoride is poisonous to human beings, but death from its use is rare. Wherever small children are present care should be used to prevent them from eating any of the poison bran. It should be scattered so that no large lumps remain on the ground. It is safe to treat poultry yards if the above precautions are taken and not too liberal amounts used. Material applied to trees and other objects should be placed beyond children's reach. A thorough sprinkling of the grounds with water after the bran has been on a couple of nights will wash out the poison. Calcium lactate or other soluble calcium salts may be given as an antidote—dosage 1 gm. (15 grains) or a few spoonfuls of lime water may be substituted. Milk is said to aid in recovery.*

Cooperative poisoning. Earwigs crawl about at night and do not respect line fences. It is essential that neighboring property be treated at about the same time, preferably on the same night. If cooperation is possible it is desirable to have everyone in the same block scatter poison on the same evening. Parkings and alleys should not be neglected. Without cooperative action on neighboring property, treated grounds may become thoroughly reinfested during the course of a summer.

Community earwig poisoning. The ideal method of controlling earwigs is an organized community-wide campaign, leaving the preparation and application of the poison in the hands of a county agent, horticulturist, or other official competent to carry on the work. He should have full power by law to carry on the work on any property in a district known to be infested, without having to inspect each holding individually. This plan of control eliminates the effect of the minority who may be unwilling to cooperate or of some individual who may have some untested pet remedy which he insists on using. The campaign is valuable also in educating the public in control methods and their possibilities.

The Portland earwig campaign of 1923. The administration of an earwig campaign in Portland, 1923, was placed in the hands of the State

*DeOng, E. R. Jour. Econ. Entomology. Vol. 17, p. 343, 1924. Toxicity of Sodium Fluoride to Man.

Board of Horticulture,* whose powers under the state law made it possible for them to carry on the work wherever necessary without interruption. The various phases of the work included: (1) scouting for earwigs and mapping of infested territory, (2) manufacture of poison baits, (3) transportation of poison bait to territory to be treated, (4) scattering of poison bran bait over the ground, (5) application of adhesive poison bait to tree trunks, fences, buildings, etc.

(1) *Scouting.* The easiest and most rapid method of making a general survey of infested territory is that of setting out non-poisonous, attractive bait along a line of travel and then going back over the same route after a time and examining the baits with a flashlight for the presence of earwigs. Scouts were given small quarter-section maps of the territory to be covered. They would travel only on streets lying in one direction; that is, they would go west a half mile on one street, and cast on the next until the whole quarter section had been covered. Bait was dropped in small piles on the grass at the edge of the sidewalks, one near each corner and one at the middle of each block, so that the location could be remembered. This necessitated crossing the street three times for each block traveled and left six deposits of bait on each block. If earwigs were found at any one of the six places the block was considered infested. Each scout kept a record of observations in a note-book which was turned in each day and the results were plotted on a map.

Reports of infestations by individuals in various parts of the city were very helpful in the survey work. They were verified whenever it seemed necessary.

(2) *Mixing poison bait.* A mixing platform for making poison bait was built in a city park within the infested district. The platform was twenty feet square, built of matched flooring, and had a twelve-inch plank as a retaining wall around the edge. There was a large shed beside it for storage of supplies of bran and other properties. An electric light overhead and a water tap with hose near at hand were essential parts of the equipment. Barrels were placed along two sides of the platform for storage of solutions. Other equipment consisted of shovels, rakes, pails, scales for weighing poison, and a long-handled stew-pan for handling molasses.

The barrels for storing the solution held about sixty gallons. They were marked at the forty-five gallon level and filled with water to that point. Twenty pounds of sodium fluoride was dissolved in each and then seven gallons of molasses. This amount of solution would wet to the proper consistency six sacks of bran or 360 pounds. The bran was dumped on the floor and one man poured on the solution with a pail while another mixed it with a shovel. The pile had to be turned over a few times to mix it thoroughly. A rake was found to be helpful in breaking the lumps as the material was being turned with a shovel. The mixed material was dumped into sacks and piled for delivery.

The adhesive poison bait was made wetter and was stored in five-gallon cans with the tops cut out.

*Mr. H. C. Atwell, Horticultural Commissioner of the First District in general charge of the campaign. Mr. J. E. Stansberry in charge of field work. B. B. Fulton, detailed by the experiment station in an advisory capacity.

(3) *Transportation.* Trucks were hired to deliver the poison bran bait to the territory to be poisoned. They loaded up at the mixing plant just before 7:00 p.m. and had part of the load delivered before the spreading crew arrived for work. The drivers had small maps of the territory to be covered, with arrows showing the route to take. The sacks of bait were dropped at the curb, two or three piles on opposite sides of the blocks to be treated. Later they went over the same route again and picked up the sacks and unused portion of the bait.

In the case of the adhesive bait which was applied during the day, the truck could haul the whole day's supply and followed the crew without unloading.

(4) *Spreading poison bran bait.* The work of scattering the poison bran over the ground began at 7:00 p.m. and continued until midnight. A spreading unit was divided into two gangs, which worked on the same block but on different streets. If the blocks were longest east and west, one gang would work the north half and the other the south half, and together they would work west on one tier of blocks and east on the next. A gang of ten spreaders, one foreman and one filler, was found to be about the best number for each half unit.

The spreaders carried the bait in canvas sacks with a shoulder strap. Army nose-bags served the purpose very well. The filler would dump the bait into the carrying sacks. A piece of canvas about four feet square was used to catch the spill. The foreman would assign one or two men to each lot, and they were expected to finish the work on that lot before starting on another one. On large vacant property the whole gang would line up along the street about four yards apart with full sacks and then move across the lot, keeping abreast and scattering the bait as they went.

It was found advisable to have a general supervisor over each unit to inspect the grounds after the work was done and see to it that no part was missed.

After dark each man carried a carbide miner's lamp. The filler was also provided with a light iron stake about three feet long, with a sharp point and a step near the bottom for pushing it into the ground. At the top it was fitted with a short piece of pipe which would receive the handle of a miner's lamp.

(5) *Adhesive poison bait.* Since adhesive poison bait was applied in day time and only to trees, buildings, fences, walls, and other objects, the work went much faster than that of scattering the bran bait. It should be used only when the earwigs are half grown or larger. The material was kept in a truck, and the driver had rather large-scale quarter-section maps with the prescribed route indicated on them. He would assign each man a block to work on and write the man's name on the map in that block. A gang of eight or ten was as many as could work together conveniently in one unit. The material is of the consistency of thin dough and is applied with the hands in about teaspoonful quantities.

Summary of campaign. In summing up the records of the campaign, we find that about eight hundred city blocks, averaging fifteen lots each, were treated with one application of poison bran, and about two-thirds of this area was also treated with adhesive bait. The total materials

used were as follows: sodium fluoride, 15,300 lbs.; wheat bran, 252,000 lbs.; molasses, 47,900 lbs.; glycerin, 858 lbs.; ground oat hulls and other carrier for adhesive bait, 3760 lbs.

The total cost of these materials was close to $6800, and the total cost for labor and all other expenses connected with the control work was $6200, making a grand total of $13,000. With these figures the total cost of one application can be computed at $16.25 per block or a little more than a dollar per lot. This would be a little higher if the adhesive bait had been applied over the entire area.

The Portland campaign of 1923 was carried on under very unfavorable weather conditions. Unusually warm weather in April caused the earwigs to hatch early. Later when control operations were under way the work was interrupted and retarded by frequent periods of cold or rainy weather. This condition continued until July, and by that time the earwigs were beginning to mature.

By continuing the campaign later than was originally planned, it was possible to treat the main infested area with one application of poison bran, and the adhesive bait was applied to trees, etc., over a large part of the area. Wherever the poisoning was done under reasonably favorable conditions, it so reduced the numbers of earwigs that they were no longer troublesome, but they could still be found by searching for them.

NATURAL CONTROL

The physical conditions of the environment probably modify the distribution of the earwig, but the limiting factors have not been studied. They demand considerable moisture, especially during the early stages, but do not live on land which has standing water during the winter. It has been noticed that they are more numerous on well kept, well watered grounds than on dry fields which are without trees or bushes.

Birds prove to be of little value in the control of earwigs, no doubt due to the nocturnal habits of the insects. Hens eat earwigs readily when they can find them. Brindley[1] has summarized the available data on earwigs as food for birds in England and finds that many of the most insectivorous birds are not reported as feeding on earwigs at all, and in only a few species did earwigs form an important part of stomach contents.

Jones states that toads eat earwigs readily. Since these animals are nocturnal in habits they would seem to be ideal enemies for reducing the number of earwigs. Unfortunately toads are almost unknown in most of the present earwig-infested areas, probably on account of the dry summer weather and scarcity of permanent ponds for breeding places. In the spring of 1924 a number of toads were found by Howard Stearns in an earwig-infested lot in St. Johns. He says that a dissection of three of them showed many unfortunate earwigs in the stomach of each.

Earwigs have a fungous disease in Europe. Brindley says that a disease of this kind caused heavy mortality among the earwigs which he kept in captivity and that in order to keep them alive he had to have dry sand in the glass dishes and supply water only with the food. The writer has had no instances of earwigs dying of fungous disease although some of the cages have been very wet and have even developed mold.

In the spring of 1924, working with the earwig control work in Portland, Mr. Howard Stearns found a few dead earwigs covered with a fungous growth. When live earwigs were confined with these specimens they acquired a disease which manifested itself by difficulty of locomotion, and by a whitish color about the pronotum. After death the diseased individuals became covered with a greenish fungous growth. This fungous was identified by Professor H. P. Barss as green muscardine, *Oospora destructor* (Metochnils) Delacroix, which has been found on white grubs in France and on the beet root weevil, *Bothynoderes (Cleonus) punctiventris* Germar, in Russia, where attempts have been made to disseminate the disease artificially.

There are a number of parasites of the European earwig some of which may prove to be of economic value if introduced into the infested regions. Many earwigs harbor gregarines, protozoan parasites, in the alimentary canal, but these are not fatal to the insect. Lucas* reports scarlet acarine mite on the European earwig. Jones[10] reports that a parasitic, thread-like worm caused the death of ten percent of the earwigs confined in the laboratory at Newport, R. I. The worm (Filaria locustae) lives free in the body cavity of full-grown nymphs and adults. The average measurement of five of these parasites was 3¾ inches by 1/48 inch. So far we have not discovered this parasite in Oregon. A somewhat smaller thread worm was found by Brindley[7] parasitic on earwigs in England, but all the infected individuals seemed as active and healthy as those not infected.

In Europe the larvae of two species of flies (Tachnidae) live as internal parasites in the body of the earwig, and are fatal to it. These are *Digonochaeta setipennis* and *Rhacodineura antiqua.* Investigators at the Rothamsted Experiment Station in England have been engaged in exporting these Tachinid parasites, *Digonochaeta setipennis* and *Rhacodineura antiqua,* to New Zealand and recently arrangements have been made to have them shipped to the United States.†

LIFE-HISTORY AND HABITS OF THE EUROPEAN EARWIG

In Oregon earwigs can be found in midwinter under boards or stones on the ground or in cavities in the ground an inch or two under the surface, rarely deeper. They do not hide in clusters as they are found in summer, but each one has a small cell with just room enough to move about a little. Strictly speaking the earwigs do not hibernate but are more or less active all winter. Many of the females have a cluster of cream-colored oval eggs, while others are without eggs (Fig. 3). Observations made on January 15, 1923, showed that those with eggs in the cell had no developed eggs in the body, while those found without eggs had the abdomen full of them. One of the latter had 35 developed eggs in the body. The normal number found in the nests ranges from 40 to 60. Actual counts from some nests are as follows: 46, 46, 47, 48, 50, 59, 60.

*Lucas, W. J., Entomologist. 39, p. 213, 1904.

†No shipment of these parasites to Oregon can be made before the fall of 1924. These will not emerge as adult flies until the spring of 1925 and during that season it will be necessary to breed them in confinement. Under the most favorable circumstances, no parasites could be liberated before 1926, and the effect of their work would not be noticed for several years after that.

Presumably the over-wintering eggs are deposited in the fall or on warm winter days, while those females without eggs earlier deposit them early in spring. A female collected on January 19, 1924, and kept in a warm room was found nine days later with a pile of eggs which had been laid during the night.

The males leave their hibernating quarters very early in spring and seek convenient dark crevices above ground, where they often cluster together in large numbers.

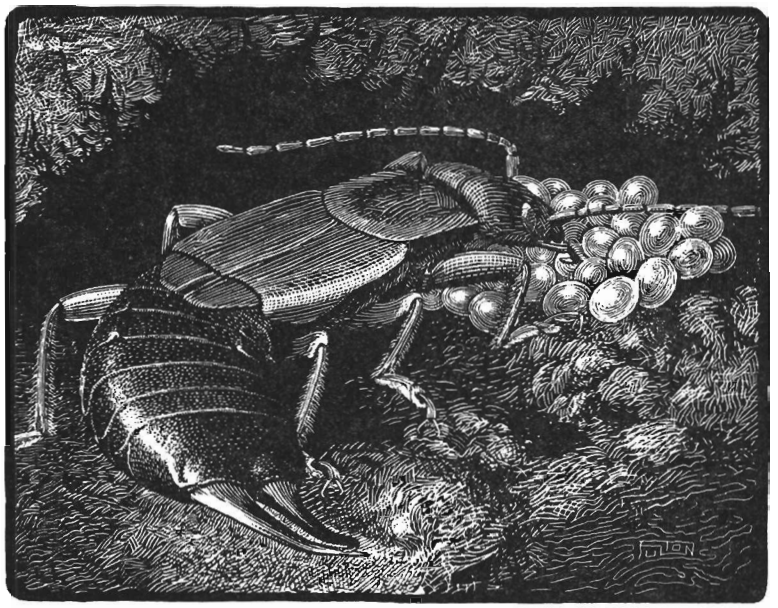

Fig. 3. Female earwig in winter quarters with eggs.

The egg. The eggs when first deposited are pale yellow or cream colored and opaque, broadly elliptical, a trifle over a millimeter (1/25 inch) long and slightly under a millimeter in width. The average of six from one lot was 1.085 mm. long by 0.975 mm. wide; three from another lot averaged 1.10 mm. by .84 mm. As the eggs develop they increase greatly in size, become whiter and more translucent. They begin to show watery patches among the general cloudy whiteness of the internal structure. At this stage some eggs measured 1.54 to 1.62 mm. in length by 1.22 to 1.32 mm. in width. When about to hatch the embryo can be dimly seen through the shell (Fig. 4, A). It is curled up with the head in one end and the abdomen doubled under and reaching nearly to the mouth. The dark red eyes, mandibles, antennæ, palps, and legs are plainly visible, and occasionally slight movements of the legs can be observed. At this stage the eggs are still larger and appear to be under pressure. Measurements of seven gave the following: length 1.59 to 1.71, average 1.65 mm.; width 1.22 to 1.32, average 1.27 mm. Something

of the internal pressure and the elasticity of the membrane of the developing earwig egg can be demonstrated by dropping one on a smooth hard surface. It will bounce like a new tennis-ball.

When placed dorsal side up under a microscope the heart beat of the embryo can be plainly observed and counted—138 per minute, at ordinary room temperature of 70 to 75° F.

Maternal care of eggs. The maternal care of the eggs and young by the female earwig has been described as long ago as the eighteenth century by the Swedish entomologist, DeGeer. He told how he placed a female with her eggs in a sand-box and watched her gather up the scattered eggs and place them in a pile. This is an experiment which

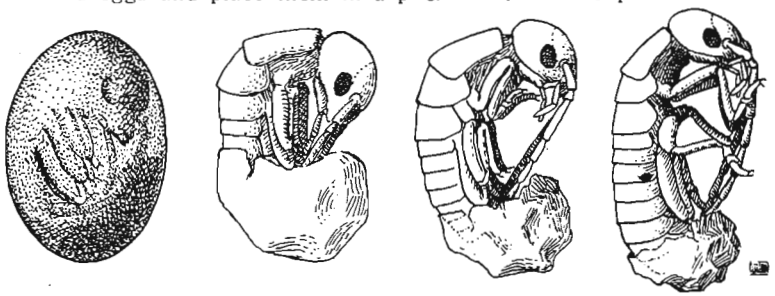

Fig. 4. *A*, Egg about ready to hatch (as seen by transmitted light); *B*, *C*, *D*, stages in the hatching process.

any one can easily perform. A flat dish covered with a piece of glass or a Petri dish partly filled with moist sand makes an ideal home for an earwig, where its habits can be observed.

After the female earwig has gathered the eggs into a pile she will dig a hole in the sand to store them in, or will make use of some ready-prepared cavity. From then on she stands over the eggs and guards them (Fig. 3).

Hatching. During the whole incubation period the eggs are moved about frequently from one part of the cell to another and at each handling the earwig rolls them about in her mouth, as if cleaning them. At hatching time this shifting about becomes more frequent and no doubt the process prevents any newly hatched earwig from being imprisoned under the pile of eggs.

The membrane of the egg becomes greatly stretched with the increase in size of the egg; its area increasing on the average about twice. It bursts at the end occupied by the head of the embryo, which immediately begins the struggle of freeing its parts from each other and from the membrane. The bursting of the membrane must take place very suddenly, for although the writer has observed the hatching of many eggs, he has never happened to be looking at one at the moment the process started. One emerging young was found with the egg membrane caught in the condensed moisture on the glass cover, 6 mm. above the spot where the egg had been a few seconds before, indicating that the hatching had started with something approaching explosive violence.

When the young earwig first appears, more than half the body protrudes from the shriveled egg membrane before it changes its embryonic

position. Then it straightens out, and one by one the legs are unfolded and moved about. The first two pairs of legs then push at the antennæ to free the distal end (Fig. 4). The egg membrane remains as a shriveled white thing, clinging to the tip of the forceps, and is finally knocked off by the movements of the young earwig. It takes about three to five minutes for the young to free its legs and antennæ. About two minutes later it can crawl feebly.

Time of hatching. Hatching usually begins in April, but it may be early or late according to the season. This applies to nests in warm situations not too deep in the ground. Eggs in shaded places do not hatch until the latter part of April or early in May. For the three years that the earwigs have been under the writer's observation, hatching has started during the blossoming period of the native broad-leaf maple and cherry trees and is practically completed by the time apples are in full blossom. In the spring of 1924 hatching began about the time pear trees were coming into blossom; cherries were in full bloom and the maples had flower clusters about two inches long.

The nymphs. The first few minutes of the young earwig's life, after freeing itself from the egg membrane, are concerned with the process of locomotion. It does not even stop to devour the remains of the egg as is customary with many young insects. Crawling is at first feeble and uncertain, but soon the mechanism of its body begins to work more smoothly and the movements become better coordinated. After a while the nymph settles down in a quiet part of the cell to develop hardness and color. It resembles the adult earwig closely except in the structure of the thorax, which has no trace of wings. The body is white and almost transparent. At times the nymph devours quantities of air, which can be seen as a series of bubbles passing through the esophagus. One or more large air vacuoles can be seen through the wall of the abdomen.

In a few hours the young nymph becomes a medium gray color with a slight brownish or olive tinge. The body becomes shorter and broader. The head of the newly hatched earwig measures about 0.9 mm. in width but later measures fully 1 mm. The body back of the head is at first 2½ mm. long but later shortens to 2 mm.

Maternal care of the young earwigs. For a few days after the young earwigs appear the female keeps the nest tightly closed to prevent their escape. A nest of young earwigs is a most interesting sight; they seem to fill the cavity, a squirming, writhing mass. The old earwig standing in their midst with the nymphs crawling under, over and about her, reminds one of an old hen with a brood of chicks (Plate I).

After a few days the nest is opened to the outside, but the female guards it against all intruders by using her forceps as a weapon. Occasionally she brings in some food for the young earwigs, who remain in or close to the nest until they have moulted.

Nymphal instars. There are four nymphal instars or immature stages of the earwigs. In other words, during the development of the earwig from hatching to maturity it sheds its skin four times. After each moult the nymph is pure white and has a decidedly inflated appearance. This is due to a large quantity of air in the alimentary canal,

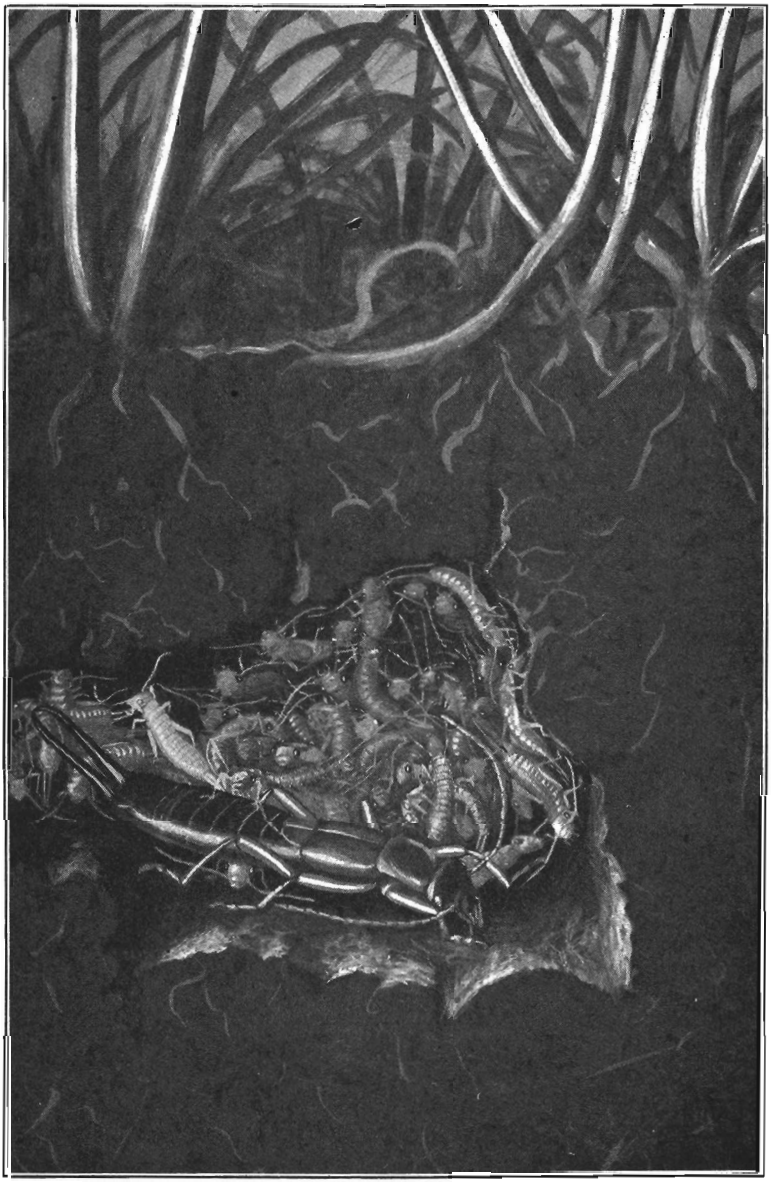

PLATE I. SECTION OF SOD SHOWING AN EARWIG IN UNDEGROUND NEST WITH YOUNG.

which is greatly distended and completely fills the body cavity. The solid contents of the intestine occupy only the extreme posterior end of the body. The air is swallowed by the nymph as was observed in the case of the newly hatched earwigs. After again acquiring the normal gray color the nymph is quite noticeably smaller than during the white period. The purpose of this period of inflation is not clear. It may serve to shape the new integument until it has hardened properly.

The question arose regarding transformations of the wings at the last moult. Although many recently moulted individuals were seen while still white and inflated, yet none were observed in the act of shedding the last nymphal skin. In all of those observed the wings were already fully developed and folded. In a few cases the wings were rather loosely folded, and the part which normally lies next to the body was exposed, each wing assuming a roof-like position. The wings probably expand in this loosely folded condition. The wing pads of earwigs about to moult for the last time show, by the position of the tracheæ, that the incipient wings are already folded along the lines of the adult wing.

The various stages can be distinguished by the changes in the thorax, the number of antennal segments, and the size and shape of the forceps and pygidium. In the thorax of the first instar the segments are transverse and of nearly uniform width throughout (Plate II, 6). In the succeeding instars the pronotum becomes more quadrate; the posterior lateral angles of the metanotum become lobed in the second and third instars, and appear as well developed wing pads in the fourth (Plate II, 7-9). The antennæ in the first instar have 8 segments; in the second instar, 10; in the third instar, 11; in the fourth instar, 12; and in the adult, 14 (Plate II, 10-14). This is the normal number, but it may vary by loss of segments in earlier instars. In the third segment of the antennæ in each stage, the additional segments of the following instar can be detected by a slight constriction in the outline of the segment and by a differentiation in the internal structure.

The forceps in the first instar are straight, delicate, and seem to show a barely perceptible segmentation, like the filiform cerci of many other insects (Plate II, 1). In the second instar they assume the typical curved form, and in succeeding instars they increase in length and relative thickness (Plate II, 2-5). The small piece between the bases of the forceps, known as the pygidium, is broadly rounded and scarcely visible in the first instar, becomes protruding in the second, develops slight lateral angles posteriorly in the third, which become more prominent in the fourth. In the adult the pygidium is quadrate, with parallel sides and rectangular posterior angles.

COLOR DESCRIPTION OF INSTARS

First. Young. Pale gray with brownish olive tinge; darkest at posterior end of body; surface glossy; area around mouth pale reddish brown; head with a narrow pale transverse line between eyes which joins a similar median dorsal line extending across occiput, thorax, and first abdominal segment; legs and forceps translucent, integument only slightly infuscated; antennæ a little darker than the legs. Older nymphs of the first instar are a medium brownish olive.

Second and Third. Medium dark, brownish olive, the third instar slightly darker; darkest at posterior part of abdomen; ventral side and legs very pale brown; labrum and mandibles tinged with reddish brown; forceps pale brown at base, distal two-thirds very dark.

Fourth. Dark olive brown, darkening toward posterior part of body where it is nearly black; clypeus and mouth parts except palpi, reddish brown; thorax medium dark in median area; tegmina developing along lateral edges of mesonotum pale brown; wing pads which occupy nearly whole visible portion of metanotum, very pale brown; legs very pale olive brown and translucent; forceps pale and translucent at base, distal two-thirds or more dark brown or black; antennæ medium or dark olive except the two basal segments which are pale.

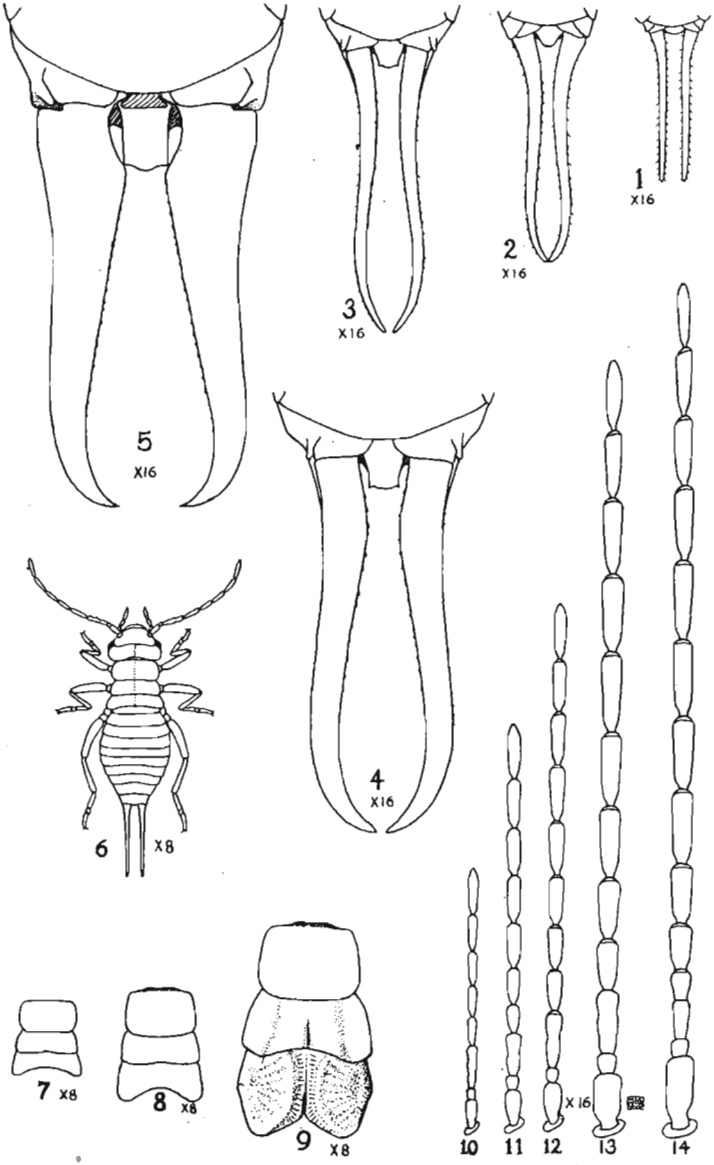

PLATE II. 1-4, FORCEPS OF THE FOUR NYMPHAL INSTARS, RESPECTIVELY. 5, FORCEPS OF ADULT FEMALE. 6, FIRST INSTAR. 7-9, THORAX OF SECOND, THIRD, AND FOURTH INSTARS RESPECTIVELY. 10-14, ANTENNÆ OF THE FOUR NYMPHAL INSTARS AND ADULTS, RESPECTIVELY.

MEASUREMENTS OF INSTARS (IN MILLIMETERS)

(Alcoholic specimens)

FIRST	Body	2.7	2.8	3.9	4.0	.....	.....
	Antennæ	1.96	2.25	2.30	2.45	.....	.....
	Forceps	1.22	1.27	1.32	1.42	.....	.....
SECOND	Body	.....	4.6	5.0	6.0	.....	.....
	Antennæ	2.89	3.38	3.43	3.52	3.72	3.80
	Forceps	1.70	1.80	1.90	1.96	2.01	2.10
THIRD	Body	7.0	8.0	.....	.....	.....	.....
	Antennæ	4.28	4.46	4.65	4.90	5.00	.....
	Forceps	2.40	2.45	2.49	2.54	.....	.....
FOURTH	Body	8 to 11	.....	.....	.....	.....	.....
	Antennæ	4.40	6.27	6.30	6.37	.....	.....
	Forceps	2.84	2.94	3.08	3.18	.....	.....

ADULTS *Female*

Body 10, 11, 11, 11, 12, 12, 12.5, 13, 13, 14, 14, 14, 14, 15, 15, 15.
Antennæ 14 segments, 7.4; 13 seg., 6.4. 6.5, 7.0; 12 seg. 5.7, 6.0, 6.6, 7.0.
Forceps 3.0, 3.0, 3.4, 3.4, 3.5, 3.6, 3.6, 3.6, 3.7, 3.8, 4.0, 4.0, 4.2.

Male

Body 10, 10.5, 11, 11, 11, 11.5, 11.5, 12, 12, 15, 15.
Forceps 3.6, 3.8, 4.0, 4.0, 4.0, 4.3, 4.8, 4.8, 5.8, 5.8, 6.2, 6.8.

Life of the earwig nymph. During the first instar the young earwig remains close to its home. If it ventures out at all it is for a very short distance and time. In the second instar the nymph is stronger, can run quite rapidly, and is well equipped to take care of itself. The nymphs begin to make nightly trips away from the nest. Especially on warm nights they may be seen swarming out in large numbers. Young earwigs that were disturbed while feeding have often been observed carrying particles of food away with them as they scurried for cover. Whether they always return to the same nest after a foraging trip is not known, but another nest would do as well, for it has been observed that the young earwigs are quite welcome in a strange nest.

By the third instar at least, all family connections are broken, the earwigs intermingle promiscuously, old and young, in any convenient hiding place. At night they come out again and wander far in search of food. They no longer remain on the ground but seem to prefer to climb any object within reach. They will be found swarming up the side of houses, on fences, bushes, trees, even to the terminal branches. When daylight approaches they will descend far enough to find a suitable hiding place, under loose bark, or among rubbish in the crotch of a tree, in cracks about buildings or in fences, posts, or walls. Earwigs of all ages show a gregarious instinct and love to hide where there are more of their kind. Hiding places become more attractive after they have been used, probably because they become thoroughly imbued with the peculiar odor of earwigs.

Broods. The majority of earwigs hatching from the over-wintering and early spring eggs mature in the latter part of June. The over-wintering adults become scarce when the young are half-grown in late May or June. It has been thought that they die off before their offspring mature. This may be the case with many of them, for dead adults can be found at that time.

Recent observations of the author on caged earwigs show another explanation for the disappearance of adults in early summer. Of the eleven females brought into the laboratory with their eggs in early

spring, five of them closed up the nest again and deposited a second batch of eggs after the first brood had reached the third instar or had died. The number of eggs appeared to be only about half of the usual number found during the winter. Two of the sets contained 25 and 27 eggs respectively, but the others could not be counted without breaking up the nest. One of the females, taken from the ground with her first eggs on January 19, had raised the first brood in the laboratory during February and deposited the second set of eggs as late as April 16. Another nest, which contained a large family still in the second instar, was found one morning to be deserted except by the adult, which had blocked out the young ones and deposited a second set of eggs. In the other cases the second brood eggs were deposited while the young were in the third instar. One lot of the second-brood eggs all hatched after about 20 days, another lot partly hatched after 13 days, and one lot failed to hatch. The other two sets disappeared after a few days and the nests had been invaded by the large nymphs of the first brood, which probably devoured the eggs.

The females which did not deposit a second lot of eggs died before their first brood matured. Two of them were examined after they died and their ovaries were found to contain undeveloped eggs about a third as long as fully developed eggs. Many adult females were found in the spring of 1923 which had the bodies full of well developed eggs. On May 9, 1924, adult earwigs were examined in Portland, and most of the females were found to contain eggs, some very small but others apparently fully developed. Some of the adults had apparently holed up for the purpose of oviposition, but no eggs were found. Most of the young earwigs of the first brood were in the second instar at that time.

These observations indicate that at least a large number of adult females go into the ground again some time in June and rear a second brood of young. They also explain why newly hatched earwigs appear occasionally during early summer when the rank and file of earwigs are nearly mature. In 1923 first instar nymphs were found on July 14 and earlier, when the main brood had already reached maturity.

By the first of September all earwigs are found to be in the adult stage. The author made no observations on the earwig out of doors between the middle of July and the first of September, but feels sure that there is but one generation a year and that the females of the new generation do not make nests until fall. The second brood of young is probably much smaller than the first. Poisoning operations carried on during the time the first brood is in the second instar should poison the adults before any of them retire to raise the second brood.

The following observations on the life-history of the earwig, made by Mr. Howard Stearns in Portland in the spring of 1924, confirm the foregoing conclusions regarding the two broods. The last day eggs were found out of doors was April 21. Eggs collected on this day and earlier had all hatched by April 23. On April 24 all but a few of the young earwigs were in the first instar. On May 2 a number of females were opened and about 90 percent were found to contain eggs, an average of 30 each. From then on few females were found which did not contain eggs. By May 10 many of them had well-developed eggs, indicating that oviposition would soon take place. On May 13 two females in the laboratory deposited 40 eggs each. By May 22 no eggs had been

found in the field, but most of the females had holed up in the ground. No accurate data were obtained on the proportion of females which lived to produce a second brood, but observations in the field indicate that at least 40 percent did so. By May 22 most of the males had died; this was true at least of those in captivity, and few could be found in the field. At that time most of the young of the first brood were in the third instar; a few were in the second or fourth instars but probably none had matured.

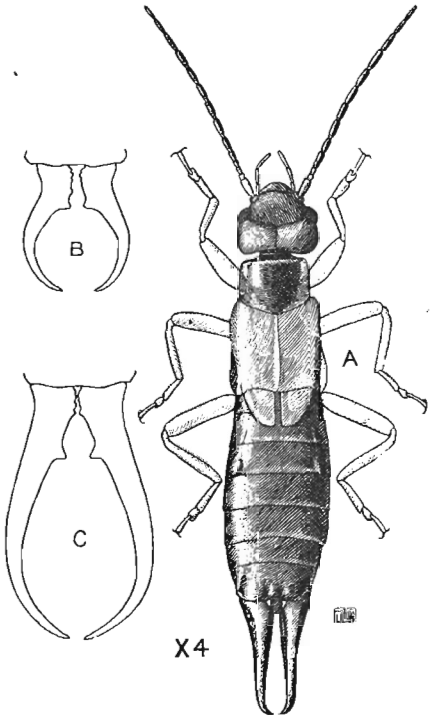

Fig. 5. *A*, Adult female earwig. *B*, *C*, Forceps of small and large males.

Description of adults. The adult female earwig (Fig. 5) is about 16 mm. or $\frac{5}{8}$ inch in length including forceps when alive. In dead specimens 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, wings, and edge of pronotum medium yellowish brown; center of pronotum practically black; legs pale yellowish-brown, forceps pale at base, black on distal part and along both lateral edges.

The forceps differ greatly in the two sexes. Those of the female are about $3\frac{1}{2}$ mm. long, nearly straight on the inner edges and curved inward at the tips so that they cross over when closed (Fig. 5, A). The male forceps have wide flat bases, beyond which they are strongly arcuate and caliper-like. The males are dimorphic in regard to the size

of the forceps (Fig. 5, B, C). The great majority of them have forceps ranging either about 3.5 mm. in length or about 7 mm. Brindley records a male with forceps 12.25 mm. long. The males with the long forceps are usually much larger in body. They have been referred to in taxonomic literature as variety *forcipata*. The proportion of males with large or small forceps varies with different localities.

On each side of the dorsal aspect of the fourth abdominal segment (third visible segment) is a small fold in the integument, and the border of the tergite is notched at that point. A similar but smaller structure is located on the third segment. These folds mark the orifices of certain glands which are probably responsible for the peculiar odor char-

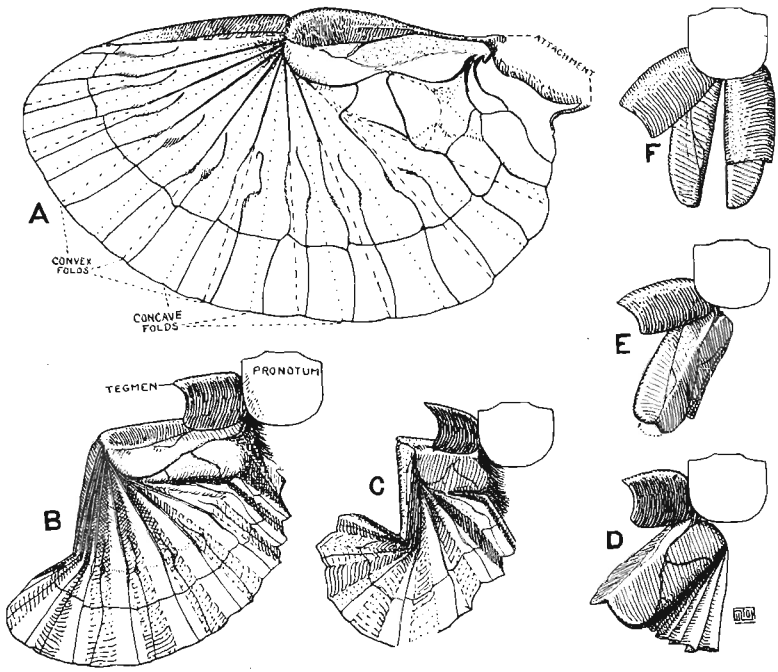

Fig. 6. *A*, Spread earwig wing. *B*, *E*, Stages showing process of folding the left wing. *F*, Both wings completely folded, left tegmen raised.

acteristic of earwigs. If an earwig is picked up small drops of liquid are sometimes discharged from these glands. It spreads over the body of the earwig and dries rapidly. If wiped off with the corner of a piece of paper it imparts a brown color. In cleaning the body the earwig often passes the hind tarsi over these glands and back along the abdomen. It is possible that the liquid from the glands may serve to clean the body and lubricate the segments.

The wing of the earwig is one striking feature which is seldom observed. The hind wings are tightly folded and only a small part shows, protruding from under the tegmina, or modified fore wings. To unfold

one of the wings is a rather difficult feat to accomplish without tearing or crumpling the delicate membrane. The system of folding is complex.

A point on the costal margin of the wing, a little over a third of the way from the base, is the focus of a series of radial folds which spread fanlike over the major part of the area (Fig. 6). The basal area is divided by a main longitudinal fold which also meets the focus of the radial folds. When folded the distal or radial part of the wing resembles a closed fan which has been folded again transversely or doubled upon itself, and the whole is enclosed within the main fold of the basal area, which is of heavier texture and serves to protect the more delicate parts. It can best be described by likening the wing to a fan which opens out in the form of a semi-circle but which has the ends of the rays trimmed off shorter on one side. Imagine that it is attached to the body by the ends of some of the shorter rays, that the handle lies in the anterior or costal margin, and the longer rays extend posteriorly and outwardly. As it closes, the ends of the longer folds would strike the body, but this is avoided by a cross fold so that the tip of the fan when closed is doubled upon itself and lies near the handle. Then imagine that the last fold of the fan on the short, attached side is much broader and of heavier texture and that the rest of the fan when closed is tucked away inside of this fold, and you have a fair idea of the mechanism of the earwig wing.

Flight. There has been much discussion in literature about whether *Forficula auricularia* can fly. The Little earwig, *Labia minor*, which is also found in Oregon, has frequently been seen flying. Collinge[12] records the flight of *Forficula auricularia* in England. On three warm, sultry evenings about the first of July a number of male earwigs flew into his house between 9:30 and 10.30. In Oregon the flight of the European earwig must certainly be a rare phenomenon, for so far as the writer knows it has never been observed here, in spite of the enormous number of the insects.

Reaction to light. Earwigs are not normally attracted by light of any intensity. They do not become active until it is thoroughly dark. They are disturbed by an artificial light as weak as the ordinary pocket flashlight, which can be thrown on most nocturnal insects without causing them to depart from their normal activities.

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