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THE REDWOOD MEALY BUG (DACTYLOPIUS SEQUOIÆ, SP. NOV.)

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PLATE XXVII.

PREFATORY NOTE.

THE author's attention was first called to the Coccid described in this paper, in December, 1899, while searching for scales on a small isolated redwood tree *(Sequoia sempervirens)* on the grounds of Cedro Cottage Place, about one mile west of Stanford University. Early in January, 1900, the young were found making their appearance on the lower branches of redwoods, where the tree was thick and the insects well protected.

From this time on, the insects were under daily observation, both on their native trees and on potted branches in the laboratory, until the male and female were fully developed, the female had deposited her eggs, and the young

were hatched and had passed into winter quarters. The descriptions of the various stages in the development of the male and female, and notes on the habits of this species, will occupy the major part of this paper.

I have to acknowledge my indebtedness to Mr. T. H. Pergande of the Division of Entomology, U. S. Department of Agriculture, who, after an examination of my specimens determines the scale to be new (with *D. citri* and *D. poæ* showing most resemblance to it).

This paper was prepared in the Entomological Laboratory of Stanford University, under the direction of Professor V. L. Kellogg.

I. DESCRIPTION OF THE SPECIES.

Dactylopius sequoiæ, sp. nov.

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1. THE EGG.—The egg is ovate in form, averaging about .37 mm. in length, and .2 mm. in breadth at the widest part. In newly laid specimens the color is a transparent, light lemon yellow, but after a few days it gradually changes to a darker yellow, probably on account of the developing embryo showing through the transparent shell. The average number of eggs laid by each female is about seventy-five.

2. THE LARVA. (*First Stage*, fig. 1).—On emerging from the egg the young are very small, averaging about .4 mm. in length, and .2 mm. in breadth. The general shape of the body is elongate oval, widest at the middle, beginning to taper rather abruptly at a point about 5 μ distant from the middle on either side. The extremities of the body are slightly truncate. The color is at first a rather dark yellow, but soon changes to the characteristic grayish color. The integument of the young larva is quite transparent, revealing such of the internal organs as are not of themselves transparent.

The segments composing the body are not easily made out but seem to be at least thirteen, viz.: one to the head, three in the thorax, and nine abdominal, although the ninth

is so closely associated with the eighth that it cannot be clearly distinguished. In specimens which subsequently develop into males, the lateral margins of each segment are furnished with a few slender spines, visible only under the high power of the microscope. These spines are not present in the female at any stage. There are about six short hairs, or spines, between the eyes, three on either side of the middle point. From either margin of the eighth abdominal segment there arises a conical protuberance, bearing a single long hair and two short ones about one-third the length of the long one. The caudo-ventral margin of the ninth segment bears the anal ring, a narrow, flattened, circular ring-plate, bearing the six slender, equidistant hairs, which are about .06 mm. in length. Protruding from this ring may be noticed a conical organ supposed to be the anus. The outer lobes of the ninth segment bend around until they are nearly on a level with the end of this organ.

The two eyes are situated on the cephalo-lateral angles of the head, and rather below the lateral line. They are not very prominent and show no dark pigment as in some other species. The mouth-parts are similar to those of the adult female, except that the buccal setæ are quite long, so that when doubled up in the body they reach to the last abdominal segment. The labium, or beak, is also large in proportion to the other parts.

The antennæ arise from the cephalo-lateral angles of the head, just in front of the eyes. They are about .15 mm. in length, of quite regular outline, and six-jointed. The formula is 6, 2, (3, 4, 5) 1; i. e., the sixth segment longest, the second next in length, segments three, four, and five about the same, and segment one the shortest. The antennæ are well supplied with hairs, the figure (fig. 1) showing their distribution.

The legs are nearly equal in size and shape, so that a description of one will answer practically for all. The coxa is quite large, rather broad at the base. The trochanter is also large, its angle being somewhat more than a right angle. The femur is longer and broader than any other segment.

The tibia is short and much wider at the lower end than at the upper. The tarsus is slightly longer than the tibia and terminates in a single, rather heavy claw. The coxa has no hairs. The trochanter bears one long hair on the outer side near its articulation with the femur. The femur has several short hairs. The tibia bears several hairs at each end. The tarsus also bears several hairs, and on the upper side a long hair ending in a knob. On the ventral side of the claw near its base are two digitules reaching somewhat beyond the claw and knobbed at their tips.

Second Stage.—The young grow very rapidly, the most marked change occurring about February 1, in the antennæ, which become seven-jointed by an elongation and division of the third segment. The formula now is 7, 3, 6, (1, 2, 4, 5). There is no change in the body or legs except the increase in size. The marginal spines of male specimens show distinctly.

3. DEVELOPMENT OF THE MALE (figs. 2, 3, 4).—Those individuals destined to become male flies continue to grow rapidly until about March 1, when they are considerably larger than the adult female. The segments of the body are now well developed and distinctly marked.

The marginal groups of five or six hairs each are now plainly visible on each abdominal segment. On each lateral margin of the eighth segment there is a group of about ten spines, and the marginal tubercle bears one long hair and three shorter ones. On each margin of the thoracic segment are three groups of from six to eight spines each. On the head there is a small group just above each eye, a large group near the base of each antennæ, and between the antennæ are four smaller groups.

The antennæ are now seven-jointed, formula 3, 7, (1, 2, 4, 5,) 6. They are also well supplied with hairs (fig. 2).

The legs are well developed; coxæ, trochanter, and femur being very stout, tibia and tarsus long and rather slender, the tarsus about two-thirds the length of the tibia. The claw is rather longer and more slender than that of the female, and it bears a short conical tooth on the ventral side near the distal end. The claw bears two knobbed digitules

at its base which extend slightly beyond the end of the claw. All the segments of the legs are more or less covered with hairs which are arranged in rather definite rows.

The mouth-parts are not as large in proportion to the size of the body as in the female of about the same age, and markedly less so than in the adult female. The buccal setæ are especially short.

4. FORMATION OF THE PUPAL CASE (fig. 3).—About February 20, the male larvæ begin to secrete the waxy fibers for the cocoon. With this secretion there is a slight change in the form of the body. The ridge on the back is now quite pronounced, and there is a folding in of the integument near the dorso-lateral margin of each segment, so as to form a second ridge (fig. 3). The secreted fibers first appear at the lateral margins, and there form white plates extending out from the body at right angles. Gradually the whole body becomes enveloped in a white waxy cocoon of semicylindrical shape, slightly conical at the lower end, and bearing two projecting tubes, in which the long waxy caudal filaments are formed. There are also two projections at the cephalic end enclosing the antennæ.

5. THE PUPA (fig. 4).—On examining a somewhat advanced pupa, we notice, first, a general change in form. The head has become much reduced in size and contracted in form, being now very distinctly separated from the prothorax, which is also smaller, and quite distinctly marked off from the mesothorax. The wing-pads are well developed. The lateral margins of the fifth, sixth, and seventh abdominal segments are marked by large tubercles, each bearing a single stout spine. The anal projection of the ninth segment is prominent, and the penis and other reproductive organs have begun to develop. The anal ring and hairs have disappeared, as have also the mouth-parts. The ocelli are not yet visible, although there are indications of them.

The antennæ are noticeably longer and although still enclosed in their pupal sheath show plainly the ten joints

and the numerous hairs which are still compressed in the enveloping sheath. The legs are longer and more slender than in the larval stage.

The pupa at this stage is of a grayish purple color, and the body is covered with short fine hairs.

6. THE ADULT MALE (fig. 5).—The following description was drawn from living specimens:—

Measurements:—Body, from tip of head to tip of abdomen, 3 mm.; caudal lobe, .5 mm.; from tip of head to end of folded wing, along dorso-median line, 5 mm.; antennæ, 3.48 mm.; wings, length, 3.4 mm., width 1.4 mm.; front legs, femur, .6 mm, tibia .9 mm.; tarsus .3 mm., claw .07 mm.; hind legs, femur .8 mm., tibia .1 mm., tarsus .33 mm., claw .08 mm.

Color:—Head, dark olivaceous; eyes, blackish; thorax olivaceous; abdomen, light olivaceous with yellowish tinge; caudal filaments white; legs, olivaceous; wings, semitransparent, smoky, with iridescent rose tint in strong light.

Balancers stout, with three long hooked claws fitting into socket in wing (fig. 5, *a*).

The head is very much reduced, in fact, it seems to serve simply as the seat for the eyes and the antennæ. It is longitudinally bisected by a distinct groove, ending posteriorly on the ventral side in a triangular depression occupying the position of the obsolete mouth-parts. On each lateral half of the head there are seven ocelli arranged in a transverse line just back of the antennæ. Posterior to the middle one of these ocelli there is, on either side, a single large ocellus. The antennæ are ten-jointed, formula, 4, (3, 5, 6,) 7, 8, 9, 10, 2, 1. All segments have numerous hairs.

The legs are very slender, covered with rather long slender hairs for their entire length. The tarsi are armed on either side with a ventro-lateral row of short stiff spines. The tibia have also a few short spines on the ventro-lateral margins of the distal half. The claws are rather slender, with a slight tooth on the ventral side near the tip. The two digitules are present at the base, though not perceptibly knobbed.

7. THE ADULT FEMALE (fig. 6).— The adult female just before impregnation is rather long and slender as compared with the male propupa stage. The length is then about 1.8 mm., width about 1 mm. After impregnation there is a considerable shortening of the body and a consequent broadening as the eggs develop. The shape of the unimpregnated female is almost a perfect oval as to dorsal and lateral outlines, the ventral a nearly flat surface.

In the live insect the color is a characteristic gray. The abdominal segments are distinctly marked dorsally, although the lateral margins show almost no indentation.

The antennæ are rather slender, about .65 mm. in length, and eight-jointed,—formula, 8, (2, 3,) 7, (4, 5, 6,) 1. The number of hairs and their arrangement on the segments are about as described for the first larval stage. The eyes are prominent though not very large. The legs have not developed in proportion to the size of the body. The shape and relative lengths of the different segments are about as in the first larval stage, except that the tibiæ are now longer than the tarsi. The claws terminate in distinct hooks and have the two knobbed hairs, or digitules, at the base on the ventral side. There is a single long hair at the distal end of the tarsus, on the dorsal side (fig. 6, *a*).

The anal ring bears six long hairs as in the young, and the marginal lobes of the eighth segment each bear a single long hair, with two shorter ones at the base.

The head, thorax, and abdomen are covered with short hairs, and on the caudal margin of each abdominal segment is a row of longer hairs. A few scattering long hairs are visible on the thorax and head.

II. LIFE-HISTORY AND HABITS.

1. THE YOUNG LARVA.—The young larvæ within the egg-sac were quite active soon after hatching, crawling about over the unhatched eggs. In a few days they left the egg-sac and ran about over the leaves and twigs. In a week or ten days after the first young appeared all were hatched and had entirely deserted the egg-sac. Those hatching on

potted branches in the laboratory all left the branches and disappeared in a few days.

June 1, 1900, I marked several females on a redwood tree at Cedro Cottage Place, which were just beginning to secrete ovisac. I watched them until the young had disappeared from the egg-sac, and although I searched very carefully for these young on leaves and branches none was found.

In January, 1901, I found the young insects abundant on this same tree and of exactly the same form as the just hatched larva, the antennæ still being six-jointed and of the same formula, legs the same shape. The only change that had taken place was that they had grown to nearly twice the size of the very young stage. They must, therefore, conceal themselves on the branches or in the bracts at the base of the leaves on the lower branches, where they are thick and protected. There they lead a semiquiescent life for a period of about six months. In the first days of January they began to crawl about and were easily found, always, however, partially concealed at the base of the needles.

2. SECOND LARVAL STAGE.—These larvæ grew quite rapidly, and about February 1 the antennæ became seven-jointed. There was, however, no perceptible change in form at this time. Possibly a third change may be noticed in the male just before pupation, but it is very slight. In the course of these three stages I have not actually observed any moulting.

3. THE MALE PUPA.—The male begins to secrete the wax for its cocoon about February 20, and I have found the completed cocoons by March 1. Now begins the radical transformation of the male larva, a complete metamorphosis being undergone before the fly issues. The whole process occupies a period of about twenty days.

The process of emerging from the pupal case and skin is very interesting. On March 21, at nine a. m., I found the young male in the cocoon which was completed March 1 to be in the act of emerging. The pupal skin first split along the dorso-median line of the head. The head suddenly burst through, next the wings, then the legs. In the process,

the skin became exactly reversed, leaving the abdomen attached until the very last thing. The male had entirely freed himself from the skin by twelve o'clock, and soon began to move the legs and antennæ, at first very feebly, gradually increasing the movements as he gained strength.

The process of the unfolding of the wings is also very interesting. In a few minutes after the male emerged, the wing-pads began to swell up at the base, and proceeded to expand in much the same way that a balloon does in being inflated with gas. The swelling passed rapidly from base to apex of wing, the wing expanding at the same time. This process occupied about fifteen minutes, although the full expansion of the wing was not complete until the following morning.

The long waxy caudal filaments were at first folded up and it took some time for them to straighten out.

Soon after emergence the male began to move about quite actively, walking with wings extended at an angle of about forty-five degrees above a horizontal plane. The long white filaments were also extended at an angle of about thirty degrees and directed slightly upward, giving him a very graceful appearance.

When approaching a female, the antennæ were used to discover her definite location, and there was a rapid vibration of the wings when he first found her. I reared a number of males in glass breeding jars, and in no case did I observe even a short flight, or attempt to fly, although I shook the jar and even touched the insects with a needle.

From my observations, I should say that the males live on an average for three days after maturity; the longest record I have is four days, and the shortest, two days.

4. THE FEMALE AND OVISAC (fig. 7). — The females began to secrete ovisac about April 1. The first appearance of it was a little white fringe of waxy filaments protruding from the ventral margins of the three caudal segments of the abdomen. As the process of secretion continued and the ovisac grew in length and thickness, the abdomen of the female was gradually raised up so that it finally stood nearly at right angles to the natural position. In about two days

the proximal third of the ovisac was completed, and the egg-laying process began. No eggs, however, were deposited in the proximal third, the eggs being deposited in the remainder of the sac as it was completed. The whole process occupied about five or six days.

The first young appeared in about twenty days and in two or three days more all had hatched. The mother insect usually lives for several days after the young are hatched. In one case she survived for ten days after all young were hatched. The larger number of females come to maturity in April and the first part of May; but there are stragglers until late in June and even a few in July. However, the great bulk of the young appear about the middle of May.

5. DISTRIBUTION.—I found the first specimens of this species in December, 1899, on a small, isolated, cultivated redwood tree *(Sequoia sempervirens)* on the grounds at Cedro Cottage Place, one mile west of Stanford University. Later, I found them on a well protected redwood tree in the Stanford Arboretum. A few scattering specimens were found on other redwood trees in the arboretum, but they were most abundant on the single tree mentioned.

March 1, 1900, I found the young quite abundant on a clump of young redwoods at Woodside, about six miles west of the University, near the foot-hills. A curious fact with reference to these last mentioned individuals is that they nearly all developed into males, the proportion being about ten males to one female. On the tree in the arboretum exactly the reverse of this is true.

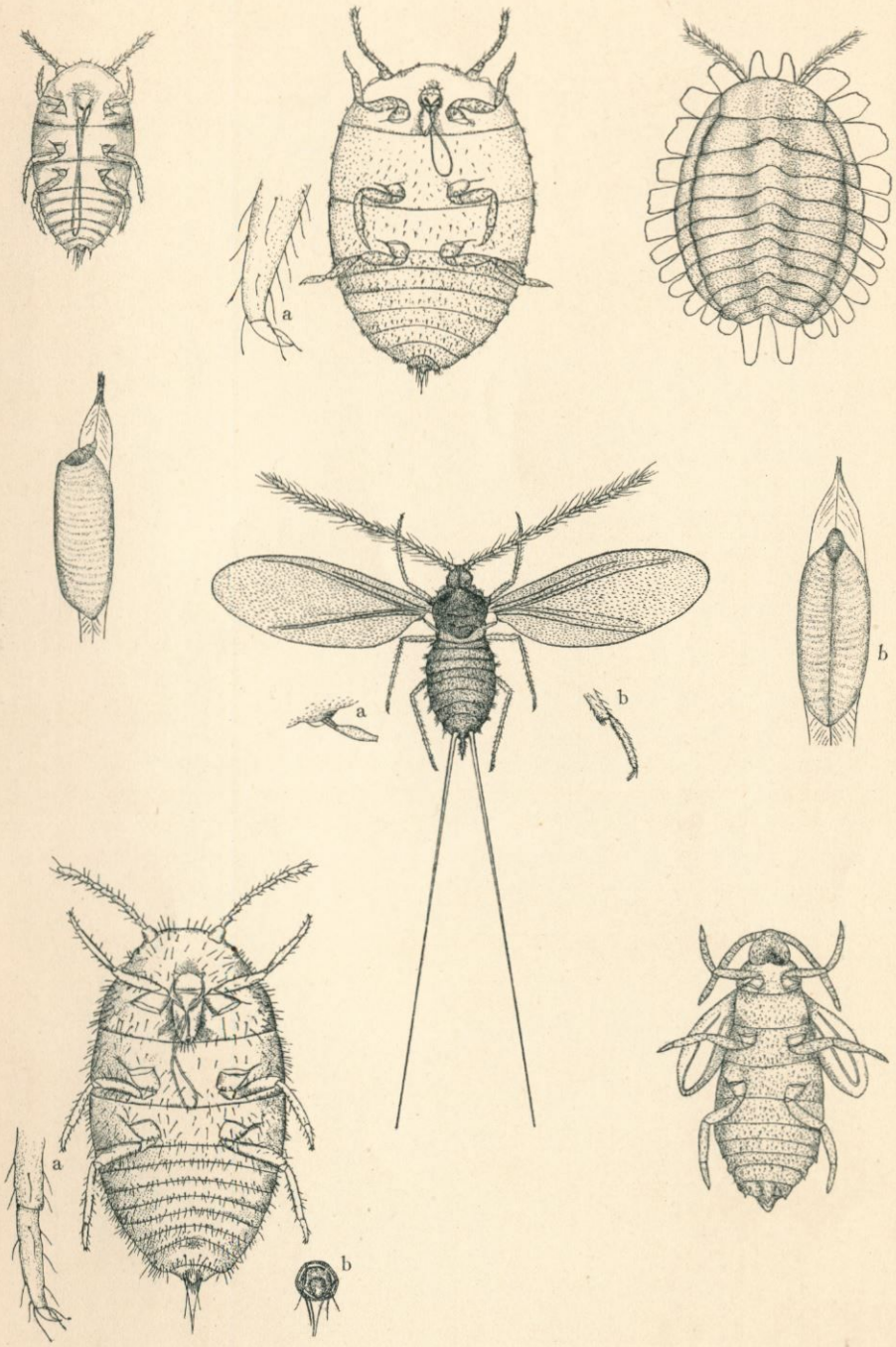
I have since found this scale all through the Sierra Morena Mountains, extending to the coast, and for a distance of from ten to sixty miles from Stanford University, wherever there are redwood trees. They do not seem to be abundant in any locality.

6. PARASITES.—I have found the larva of a ladybird, species as yet undetermined, eating the young and using the waxy filaments of the egg-sac for its own cocoon. I have also bred from the body of the female scale a Chalcid fly, of which the species has not yet been determined.

EXPLANATION OF PLATE XXVII.

Dactylopius sequoiæ, sp. nov.

Fig. 1. Larva, first stage.
Fig. 2. Male larva, propupa stage: *a*, enlarged tarsus and claw.
Fig. 3. Male larva beginning to secrete wax for cocoon.
Fig. 4. Male pupa, advanced stage.
Fig. 5. Adult male: *a*, balancer and pocket; *b*, enlarged tarsus and claw.
Fig. 6. Adult female: *a*, enlarged tarsus and claw; *b*, anal ring and hairs.
Fig. 7. Adult female and ovisac: *a*, lateral view; *b*, dorsal view.



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DACTYLOPIUS SEQUOIÆ, SP. NOV.