THESIS

ON

THE ANTIQUE OR RUSTY TUSSOCK MOTH.

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APPROVED:

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DEAN, SCHOOL OF AGRICULTURE
THE ANTIQUE OR RUSTY TUSSOCK MOTh.

Notolophus antiqua Linn.

Order Lepidoptera. Family Liparidae.

INTRODUCTION.

On account of the abundance of the antique tussock moth, and the ease with which material for study can be secured in the vicinity of Corvallis, an investigation of this insect was thought to be a fitting subject for my graduation thesis. The work was begun in the spring of 1914, and carried on until the spring of 1915. The principal object of the study was to work out the life history and methods of control.

During the course of study, a number of interesting things have been observed. The most interesting fact is the development of a third complete generation, in the laboratory, from two of the egg masses. Another interesting feature is the discovery of the apparent development through parthenogenesis. Egg masses which to the knowledge of the writer had not been fertilized hatched and produced young larvae. Parthenogenesis in the tussock moth has already been mentioned by Barnard in 1880. He, however, bases his statement on the fact that "all winter brood are females, and must reproduce without the co-operation of the male." Observations made at Corvallis show that both males and females are produced in the fall generation. In most cases the larvae passed through five molts from the time of hatching to pu-
pation. In one case, however, a male larva passed through only four molts, and in another case, a female larva passed through six molts. This was observed by Hellins in 1882. He did not take into consideration the molt at the time of pupation.

The hatching of the young is very easily affected by temperature. Egg masses from the laboratory from which young larvae were hatching were placed outside during the month of December. After two days the hatching ceased, and no more larvae hatched until the egg masses had been placed inside for several days. The larvae then hatched out in large numbers. During the winter months larvae from the same egg mass and hatched at the same time were placed on rose foliage both in the laboratory and out of doors. The former developed rapidly while the latter showed but slight traces of feeding, and in the course of several weeks died without having increased much in size.

Life-history studies have been carried on in detail under laboratory conditions, and have been checked by numerous observations out of doors. The first generation developed more rapidly under laboratory conditions than in the field. There was only a slight difference between the second generation in the laboratory and in the field. No development of a third generation in the field has been observed. The common names applied to this insect are the "rusty tussock moth", "antique tus-
sock moth", "vaporer moth", "old tussock moth", and "European tussock moth".

CLASSIFICATION AND SYNONYMY.

When first described by Linnaeus, in 1758, this insect was placed in the genus Bombyx. In 1831, Miss Dix writes about this insect under the genus name Phalaena. Various writers since 1864 have placed it in the genera Orgyia and Notolophus. In 1894, Neumoegen and Dyar, in their "Preliminary Revision of the Bombyces North of Mexico", place it in the genus Notolophus; and Dyar, 1902, in his "List of North American Lepidoptera", retains it in that genus.

Notolophus antiqua has been described in several distinct species. In 1865, Fitch described it as Orgyia nova or the new tussock moth. He states that the wings of the male are more darkly clouded than in antiqua, and that the larvae have two bright red tubercles on the sixth and seventh abdominal segments. The latter character, he claims, cannot be found for the antique tussock moth. In 1904, Miss Patch mentions the presence of these tubercles on antiqua. This fact is also mentioned by Woods in 1906, by Sanderson in 1908, and by Comstock in 1909. In the work carried on here, the presence of the above mentioned tubercles was found on all the larvae.

In 1874, Edwards describes Notolophus antiqua as Orgyia badia. His chief distinction was that in anti-
qua the fore wings were nearly unicolorus, and that in badia they were much paler centrally. In the experiments carried on here, both types of adults have been obtained.

HISTORY.

This insect is a native of Europe, and was probably brought to this country on imported fruit trees. The only definite statement found to this effect was that of Parrott, 1909, who states that the eggs were found on seedlings imported into New York. However, it was reported as early as 1831, by Miss Dix, as being found in Rhode Island and Maine. Perkins, 1877, reports its presence in Vermont. Fletcher, 1907, states that in Nova Scotia the larvae eat the foliage and gnaw holes in the growing apples. Cooley, 1910, reports that the season of 1909 was the first in eleven that the insect had been abundant. Its presence in British Columbia was reported in 1914.

The insect seems first to have been introduced on the Atlantic Coast and then to have spread gradually to the Pacific Coast. It is very probable that it was known to occur in certain parts of the country long before it was reported, but due to the fact that it is not usually a serious pest, it was not mentioned.

DISTRIBUTION.

This insect is found in nearly all parts of Europe, England, northern United States, and Canada. It was no-
ticed in Rhode Island and Maine in 1831 by Miss Dix. Riley, 1880, states that a cocoon sent in to him for identification was that of *Orgyia antiqua*. This cocoon had on it an egg mass enclosed in a frothy covering, and could therefore not have been that of *antiqua*. The eggs of *antiqua* never have a covering. In the same year Barnard mentions the antique tussock moth as feeding on willow. Again, the egg masses were said to be enclosed in a frothy mass, and must have been those of some other species. It was reported from Nova Scotia by Fletcher in 1907; from Canada, east of Toronto, by Saunders in 1909.

**OCCURRENCE IN THE NORTHWEST.** This insect occurs quite abundantly in Oregon, although not in large enough numbers to cause wholesale injury. In 1914, it was reported from British Columbia. No report has been made of its presence in Washington, but it is possible that it occurs there also.

**NATURE AND EXTENT OF INJURY.**

It is during the larval stage of this insect that the injury occurs. This is of two kinds. The larvae feed on the foliage, and also gnaw holes into the sides of growing apples. This latter form of injury, however, is rare. After hatching, the larvae feed for some time on the eggshells, then begin to feed on the upper surface of the leaves. As they become older and increase in size, they feed more heavily, later eating entire
leaves, with the exception of the midrib and larger veins. As a rule they are not abundant enough to do serious damage, but occasionally they may become sufficiently numerous to strip the trees of a large part of their foliage.

**LIFE-HISTORY.**

The winter is spent in the egg stage. The egg masses are found fastened to the old cocoons on the trunk and branches of the trees, and on old leaves on the ground. The eggs hatch in the spring from the first part of April to the first of May. The larvae reach maturity and pupate from about the latter part of May to the middle of June. The insect remains in the pupal stage for several weeks, the first adults emerging about June 24 and the last about the first week of July.

After emerging the female remains on the old cocoon, where copulation with the male takes place. Egg deposition begins almost immediately after fertilization, the eggs being deposited in a mass on the old cocoon. In from 10 to 12 days these eggs hatch, giving rise to a second generation. These larvae feed for some time on the egg shells, then on the foliage, in a manner similar to those of the first generation, but they develop in a somewhat shorter time. By the first part of September practically all of the larvae have pupated. The adults begin to emerge about the middle of September and continue to emerge throughout the month. The
females are fertilized by the males and then deposit eggs, which remain over winter on the cocoons.

**THE EGG.**

The eggs are laid in a mass, one layer deep, upon the cocoon from which the female has emerged. Each mass generally contains from 200 to 300 eggs, but masses have been found to contain as high as 600 eggs. The eggs are usually in regular rows and do not have any covering as is the case in allied species.

**DESCRIPTION.** The egg is about 1 mm. in diameter, spherical, the top slightly flattened and depressed. Around this sunken or depressed area there is a dark ring. When first deposited, the egg is of a cream color, but soon turns to a dirty gray. The shell of the egg is thick and brittle.

**THE LARVA.**

The larva, in emerging from the egg, begins to eat through at the central part of the depressed area of the egg, increasing the size of the hole until it is large enough to permit it to escape. At this time the hole usually extends almost to the dark ring. After leaving the shell, the young larva feeds on it for some time, often completely devouring it. It then begins feeding on the foliage. At first it feeds only on the upper surface of the leaf. About a week after emergence entire areas are eaten out; and finally entire leaves, with the exception of the midrib and larger veins, are destroyed.
It is characteristic of the young larva when disturbed to suspend itself by a silken thread. When the danger is over, it draws itself up by means of this thread and resumes feeding. If touched at any time while at rest or feeding, it will curl up in a ball.

The larva passes through a series of five molts covering a period of five to eight weeks. The fifth molt takes place at the time of pupation, and after the cocoon is spun. After the third molt, the female larva grows much more rapidly than does the male larva. It is after the fourth molt that the larva attains its full growth. The male pupates several days before the female. The larval stage of the second generation is of shorter duration than that of the first. The time between molts, given in the following description, is from records obtained under laboratory conditions.

**DESCRIPTION OF INSTARS.**

**FIRST INSTAR.** The larva, when first hatched, is about 2 mm. in length. It is yellowish with a black head and with long, yellowish hairs. Within a day the color changes to brownish black.

**SECOND INSTAR.** The first molt occurs about eight days after hatching. The larva is then about 4 mm. in length; general color black. On either side of the first thoracic segment is a distinct knob or tubercle, bearing long, black hairs. The second and third thoracic segments are white, dorsally. The first, second,
third, and fourth abdominal segments are black; the fifth segment white, dorsally; the sixth and seventh black with a distinct orange tubercle located centrally on the dorsum of each. The eighth segment has a knob or tubercle on the dorsum, bearing long, black hairs; ninth segment black. The entire body covered with black and whitish hairs.

THIRD INSTAR. The second molt occurs about seven days after the first, and 15 days after hatching. At this time the larva is about 7 mm. in length. On either side of the first thoracic segment is a tubercle, black at the top and orange at the base. Each tubercle bears a compact pencil of long, black hairs about 1 mm. in length. This pencil is surrounded by scattered black hairs, measuring about 4 mm. in length. The second thoracic segment has two distinct, whitish square areas dorsally placed and each bearing a short tuft of whitish hairs. The third thoracic segment has a white patch which merges into faint orange near the lateral edges. The first, second, third, and fourth abdominal segments each have an oval-shaped black area surrounded by a border of orange, tinted with white.

From the center of each of the patches on the first and second segments arises a compact, grayish tuft about \( \frac{3}{4} \) mm. in length; and from the center of the patch on the third and fourth segments a white tuft about \( \frac{1}{2} \) mm. in length. The fifth segment is dorsally covered with a
patch of white having an orange tinted border. The sixth and seventh segments are black, bearing, centrally, a distinct, small, circular, orange-colored tubercle. The eighth segment is black with a tubercle bearing a compact pencil of black hairs slightly less than 1 mm. in length. The ninth segment is whitish gray. Each segment bears on its sides tubercles, from which arise tufts of whitish hairs intermingled with blackish hairs. These tufts measure about 2 mm. in length.

FOURTH INSTAR. The third molt occurs about six days after the second, and 21 days after hatching. The male larva is about 9 mm. and the female larva about 11 mm. in length. The pencils on the first thoracic segment are 3 mm. in length, and each hair is now feathered near the tip. Between the two pencils are two flat tufts of whitish hairs, 1\(\frac{1}{2}\) mm. in length, and extending forward over the head. A broad, black, velvety stripe runs longitudinally along the center of the dorsum, except on those segments having white patches. On either side of the black stripe there is another stripe, nearly as broad, dark purplish-gray in color. In each there is also a row of pale orange tubercles, one to each segment, bearing tufts of whitish hairs intermingled with a few black hairs slightly longer. Adjacent to this stripe, on either side, is a narrower, whitish stripe, including a second row of tubercles similar to those of the first row, but more brownish in color. Then comes
another grayish stripe, on either side, reaching to
where the legs and prolegs join the body. This includes
tubercles similar to those of the second row, but small-
er.

All tubercles bear tufts of hairs. The pencil on
the eighth abdominal segment is more compact than those
on the first thoracic segment, and is about 2 mm. in
length. The hairs are feathered near the tip. The or-
ange tubercles on the sixth and seventh segments are
present, but have not increased in size. The brushes
on the third and fourth segments are yellowish in color.
The legs and prolegs are light gray.

FIFTH INSTAR. The fourth molt occurs from six to
seven days after the third, and 27 to 28 days after
hatching. The male larva is about 14 to 15 mm. in
length, while the female larva is about 18 to 20 mm. in
length and much stouter. The general body color is a
purplish gray. There is a black, dorsal stripe running
longitudinally. The first row of tubercles on either
side is bright orange, while the second and third rows
are paler in color. Between the first and second rows
of tubercles on either side, running longitudinally, is
a narrow, broken, black line, with light blotches below
it where the segments join. The white brushes on the
first, second, third, and fourth abdominal segments ter-
minate in a neat point.

On either side of the second segment is a black
pencil, similar to, though shorter than, those on the first thoracic segment, and extending straight out from the side of the body. These two pencils distinguish the larva of the species *antiqua* from the larva of other species of *otolophus*. Dorsally on the fifth segment there are two bright orange markings. There is a small, bright orange tubercle, centrally, on the dorsal side of the sixth and seventh segments. The color of the female larva is not as bright as that of the male. In the first generation the male larva attains a length of about 20 to 24 mm. and the female larva about 25 to 32 mm. In the second generation the male larva attains a length of about 25 to 32 mm. and the female larva about 32 to 37 mm.

PUPA. The fifth molt occurs after the larva has spun its cocoon, and just at the time of pupation. This is about six days after the fourth molt and about 33 to 34 days after hatching.

**THE COCOON.**

When the larva is mature and ready to pupate, it seeks a hiding place on the trunk of a tree, on a branch, or among leaves. It then spins a large, loose, outer covering, within which it constructs a smaller, closely woven sack. Within this sack the last molt occurs and the insect transforms to the pupa.

**DESCRIPTION.** The size of the cocoon varies according to the larva and the conditions under which it is
spun. The average length is about 20 mm.; average width about 10 mm. The male cocoon is smaller than that of the female. The outer portion consists of a loose whitish covering made of silken threads, intermingled with the long, black hairs from the body. Within this is a much smaller, somewhat more closely woven covering or sack, in which the shorter hairs of the body are interwoven.

THE PUPA.

The pupa of the male is much smaller than that of the female and the pupal stage is longer. The pupal stage of the first generation is about 14 to 17 days for the female, and about 20 to 24 days for the male. The pupal stage of the second generation is seven to nine days for the female, and 11 to 12 days for the male.

DESCRIPTION. Both male and female pupae are at first pale yellowish green in color, later becoming black with brown and yellow tints. The ventral surface is smooth; the dorsal surface is covered with short, fine whitish hairs, and also shows the places where the four white brushes occurred on the first, second, third, and fourth abdominal segments of the larva.

MALE PUPA. 11 to 13 mm. in length, by about 4 mm. in width. On the ventral side one can plainly see where the eyes, wings, and feathered antennae of the future adult lie by the outline of the raised portions of the pupal case. The general color of the pupa is brownish
black. (The shade varies, being much lighter in some specimens.) The edges of the raised portions and the greater portion of the posterior third of the pupa are brownish yellow in color.

FEMALE PUPA. 17 to 20 mm. in length by 6 to 7 mm. in width at the widest part; slightly flattened on the ventral side. Looking down upon it, dorsally or ventrally, it appears oval in shape, tapering toward both ends. The position of the eyes, antennae, and rudimentary wings are plainly visible on the ventral surface of the pupal case. The general color of the female pupa is lighter than that of the male.

THE ADULT.

The adult moths do not feed. The males usually emerge a day or two earlier than the females. The wingless females crawl out of their cocoons, and remain hanging to them until the eggs are deposited. The males and females copulate (?) and the females very soon afterward begin depositing their eggs. The greater part of them is deposited the first day; some the second; and a very few the third day. During this process the females shrivel up to about one-third their original size.

When the eggs have been deposited, the spent females drop from the cocoons. They usually die in from 10 to 12 days after emerging. In some cases the unfertilized females remain suspended from their cocoons for about three to five days, then deposit eggs scatteringly
and in bunches, and finally drop to the ground without having deposited all of their eggs. In other instances they deposit the eggs in the same manner as the fertilized females.

**DESCRIPTION.**

**THE MALE** has a wing expanse of about 26 to 33 mm. The wings are of a rusty brown color. The forewings are crossed by two broad, dark, wavy bands, one near the body and the other near the distal edge. Near the costal margin, in the light area between the two dark bands, are two V-shaped, dark brown markings, one behind the other. The points are toward the body when the wings are spread. Near the anal angle there is a distinct, white crescent. The antennae are 3 to 4 mm. in length and broadly feathered. They are brownish in color. The thorax and abdomen are brown in color and covered with rusty brown hairs. Those on the thorax are much longer than those on the abdomen.

**THE FEMALE** is without wings and measures 11 to 14 mm. in length by about 5 to 6 mm. in width. Through long disuse the wings have degenerated to mere rudimentary wing pads. The thorax and abdomen are not separate, but are fused into one mass, causing the female to resemble closely an animated sack of eggs. The body is grayish black in color, covered with short, gray to grayish-yellow hairs. Dorsally the female appears to have a dark stripe running longitudinally with the body. This
is due to the fact that the hairs here are less numerous and the body color shows through. The antennae are about 4 mm. in length, thread-like and only slightly feathered.

**FOOD PLANTS.**

This insect feeds upon the foliage of almost every kind of tree, shrub or herbaceous plant. In Europe it has been reported as feeding on plum, apple, mountain ash, rose, apricot, raspberry, bilberry, heath, hornbeam, hazelnut, alder, willow, beech, birch, oak, pine, and other plants. In this country it has been reported as feeding on apple, plum quince, thorn, rose, aspen, birch, larch, thorn-hedges, and poplar-leaved birch. In Oregon it feeds principally on apple, pear, cherry, and other fruit trees.

**NATURAL ENEMIES.**

Two parasites, a Tachinid fly and an Ichneumon fly (Pimpla inquisitor) were reported by Woods in 1906, the latter being reported as destroying whole colonies while in the pupal stage. These parasites are in turn attacked by other parasites and so cannot be depended upon as a means of complete control.

Fitch, 1865, describes a Hymenopterous insect (Telenomus orgyiae) as being parasitic on the eggs. He states that the insect punctures the eggs of the host and inserts one of its own eggs. The larva on hatching feeds on the egg substance.
At Corvallis, during the past season, a number of the female pupae were found infested with numerous small larvae. These pupae seemed to be entirely filled with the larvae, which could be seen through the pupal case. These pupated within the pupal case of the host and on emerging proved to be Hymenopterous parasites (Dibrachys boucheanus Ratze.)

METHODS OF CONTROL.

Many writers recommend gathering the egg masses during the dormant season and destroying them. At this time they may easily be found attached to the trees or on dead leaves. When very numerous, the larvae may be jarred from the trees and prevented from returning, by placing sticky bands around the trunks.

It has been observed in Oregon that, where the orchards are regularly sprayed with arsenicals, this insect does not become serious. The best time to spray is a short time after the hatching of the eggs, when the larvae are still very small. For Oregon, this would be from the middle to late April, and if necessary, again in midsummer. The larger the larvae get, the more resistant they become to the poison. Often they are not destroyed by the ordinary strengths of the spray. In such cases heavier doses should be applied; arsenate of lead, four pounds to fifty gallons of water, being recommended.
I am indebted to Professor H. F. Wilson, Assistant Professor A. L. Lovett, and other members of the department for suggestions in carrying on the work and in the preparation of the manuscript.

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*Those references marked with an asterisk (*) have not been seen by the writer.
PLATE I.

THE ANTIQUE TUSSOCK MOTH (Notolophus antiqua).

1. Female laying eggs.
2. Spent female and young larvae just hatching.
4. Pupae of, left, male; center and right, female.
5. Female just emerged.
7. Adult hymenopterous parasite (Dibrachys boucheanus Ratz).
PLATE I. THE ANTIQUE TUSSOCK MOTH (Notolophua antiqua).