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Description and Bionomics of a New Red Pine Scale, Matsucoccus Resinosae

BY

JAMES L. BEAN
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BEFORE 1946 only one species of the coccid genus *Matsucoccus* was known to occur in the Northeast: *Matsucoccus gallicolus* Morr. The chief host plants of this species are pitch pine and scrub pine. It has not been found attacking red pine.

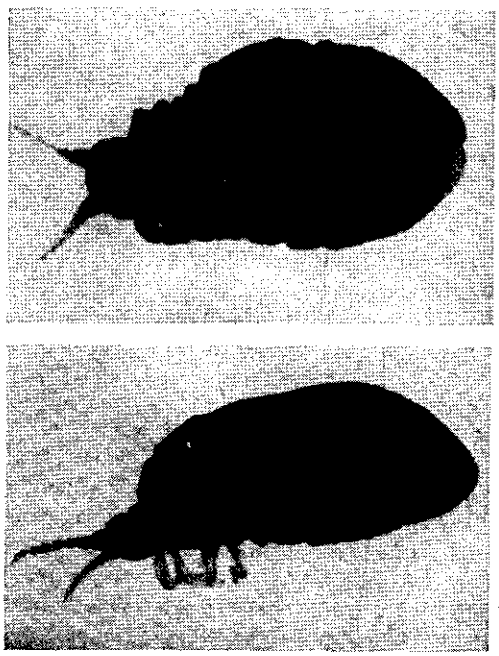

FIGURE 1. Matsucoccus resinosae, *adult female. Dorsal view (upper) and lateral view (lower). Photo from Conn. Agric. Exp. Sta.*

But in November 1946 a number of red pines (*Pinus resinosa* Ait.) in the vicinity of Hemlock Reservoir, Easton, Connecticut, were found to be heavily infested with a species of *Matsucoccus*. Preliminary studies have shown that on the basis of biology and host preference this newly found red pine scale is entirely different from all other known nearctic species of the genus. Taxonomically, the red pine scale is more difficult to define than the pitch pine species.

The genus *Matsucoccus* is not only of taxonomic interest, but it also contains species that are of considerable economic importance. The effects of these scales, which confine their attacks to the pines, is to injure the twigs and branches, weaken the crowns, and deform or kill the younger trees.

All known North American species of the genus *Matsucoccus* are given in a tabulation below with their hosts and their known distribution.

The authors are Entomologists at the Northeastern Forest Experiment Station, Forest Service, U. S. Dept. of Agriculture. They express great indebtedness to Dr. Harold Morrison, Taxonomist, Section of Insect Detection and Identification, Agric. Research Serv., U. S. Dept. of Agriculture, for assistance in preparing the technical description of *M. resinosae*.

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Species of *Matsucoccus*	Hosts	Distribution
acalyptus Herbert	*Pinus edulis* *P. monophylla* *P. balfouriana* *P. aristata*	California, Arizona, New Mexico, Utah, Colorado, and Idaho
alabamae Morr.	*Pinus* sp.	Alabama
bisetosus Morr.	*P. ponderosa* *P. jeffreyi* *P. radiata*	California and Oregon
californicus Morr.	*P. ponderosa* *P. jeffreyi*	California and Arizona
degeneratus Morr.	*P. ponderosa*	Arizona
eduli Morr.	*P. edulis*	Arizona
fasciculensis Herbert	*P. ponderosa* *P. jeffreyi* *P. sabiniana*	California and Oregon
gallicolus Morr.	*P. rigida* *P. echinata* *P. ponderosa* *P. taeda* *P. virginiana* *P. glabra* *P. serotina*	New England west to Ohio and Missouri and south to Florida and Georgia
monophyllae McK.	*P. monophylla* *P. edulis*	California
paucicicatrices Morr.	*P. lambertiana* *P. monticola* *P. flexilis*	California, Oregon, Montana, and Wyoming
resinosae, n. sp.	*P. resinosa*	Connecticut and New York
secretus Morr.	*P. ponderosa*	California, Nevada, Arizona, New Mexico, and Colorado
subdegeneratus Morr.	*P. occidentalis* (*cubensis*)	Dominican Republic
vexillorum Morr.	*P. ponderosa*	California, Nevada, Arizona, New Mexico, and Colorado

Technical Descriptions

The genus *Matsucoccus* was set up by Cockerell (1909, p. 56) to accommodate a scale described by Kuwana (1905, p. 91; and 1907, p. 209) as *Xylococcus Matsumurae*. The chief characters of the original description, given in key form, are as follows:

Female without marsupium; broad posteriorly; not elongated, antennae 10-jointed, and very peculiar crab-like legs, the femur large; male without whorls of long hairs on the antennal joints; caudal brush long, arising from apical segment; rudimentary hind wing with very large hooks. (Japan).

Since the publication of the original description of the genotype, 14 new species, including the species described in this paper, have been described from North America, and the genus has been redescribed by Herbert (1921, p. 15). His definition of the genus follows.

Coccidae referable to the subfamily Margarodinae; i.e., adult female and first larva

with legs and antennae, and at least one intermediate stage without these appendages.

Adult female elongate, broader posteriorly, with 9-segmented antennae, the latter transversely striated, except 1st and 2d segments. Legs well developed, also transversely striated. Tarsus attached at apex of tibia and strongly curved outward; with spines on inner margin of tibia, two hair-like digitules on tarsus and two knobbed digitules on tarsal claws. Without marsupium or anal tube. Mouthparts sometimes present.

Intermediate larval stage without legs, antennae or anal tube, the only conspicuous characters being mouthparts and spiracles. First stage larva with legs and 6-segmented antennae. All three stages possessing two thoracic and seven abdominal pairs of spiracles.

The Division of Forest Insect Research,[1] Northeastern Forest Experiment Station, has for the past 3 years been conducting biological and seasonal-history studies of a new species of *Matsucoccus* occurring on *Pinus resinosa* Ait. These studies have been sufficient to call for a technical description of the scale and its complex developmental stages. The species is described below.

Matsucoccus resinosae, new species

This new species of *Matsucoccus* belongs to the superfamily COCCOIDAE, family Margarodinae, tribe Matsucoccini. A technical description of the various stages follows.

Adult female. Body strongly elongate-ovoid (Figs. 1 and 2), anterior apex almost angulate, characteristically widest behind the middle of the abdomen. Size is variable, one well-developed and probably average example measured 4.25 mm. long by 2.5 mm. wide. Derm is membranous, though densely stippled throughout with somewhat darker dots as in other species of the genus.

Antennae (Fig. 3) characteristic for the genus, with a pair of curved sensory setae on each of the four terminal segments and with a loose cluster (usually 5 to 6) of sensory pores on the second segment, all segments beyond the second having an imbricate-reticulate pattern distinctly developed on the distal portion of each segment, with this visible over most of the surface of the four terminal segments. Segmental lengths of an average antenna: I, 58μ; II, 87μ; III, 63μ; IV, 71μ; V, 71μ; VI, 63μ; VII, 59μ; VIII, 63μ; IX, 67μ.

Eye small, about 16μ in diameter in specimens examined, subhemispherical, in center of a flattened sclerotized cone with an irregularly circular diameter of 40 to 48μ.

Legs (Fig. 3) characteristic for genus, the parts showing the usual imbricate-reticulate pattern, length of these for an average posterior

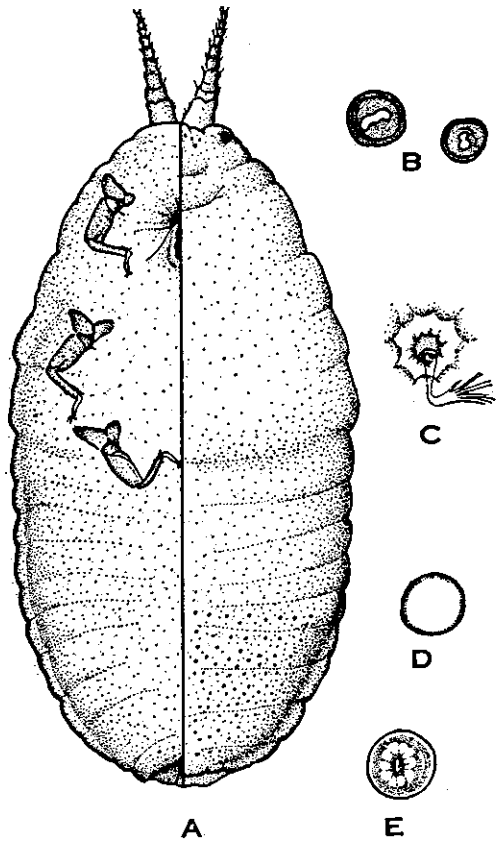

FIGURE 2. Matsucoccus resinosae, *Adult female.* A, *outline of body, ventral (left) and dorsal (right);* B, *bilocular derm pores;* C, *abdominal spiracle;* D, *dorsal cicatrice;* E. *multilocular derm pore, surface view. (Drawing from mounted specimen.)*

[1]Formerly the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine.

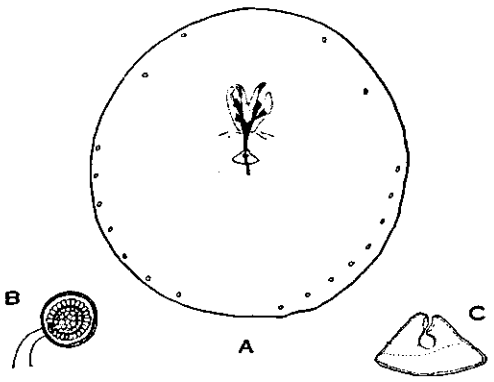

FIGURE 4. Intermediate female of Matsucoccus resinosae. A, *outline of body, ventral;* B, *right thoracic spiracle, with disk pore plate;* C, *beak.*

50 to 52 irregular pores, in each spiracular pore plate the largest around the margin, with about 33 in the anterior abdominal and 14 to 17 in the apical, in specimens examined; trachea entering the thoracic spiracle opposite the posterior median (inner) curve of the pore plate in contrast to the condition reported for some other species described from this country, but in the usual position along the posterior curve, in the abdominal spiracles; pore plate diameter of anterior spiracles in one individual 32 to 35μ, anterior abdominal spiracle 24 to 26μ, apical spiracle 12 to14μ; mature individuals and cast skins showing a dark ring or band around each spiracle opening.

Derm at molting breaks irregularly at the posterior end of the body for the emergence of the adult. Male form of this stage is similar to that of female except smaller.

First-stage larva. Characteristic for the genus (Fig. 5). One individual, after enlargement but before feeding, 410μ long by 197μ wide, long ovoid, tapering more strongly anteriorly. Derm membranous. Antennae quite close together at base, interspace about one -third width of a basal segment: I, very stout, 24μ wide by 14μ greatest length; II, 15μ long by 12μ wide; III, 4μ long; IV, 16μ long; V, 8μ long; VI, 28μ long, apical sensory spines 12 and 13μ long; legs and beak characteristic. Eyes fairly prominent, approximately hemispherically protruding, basal diameter about 12μ; thoracic spiracles minute, inconspicuous, the 7 abdominal pairs much more evident, each with the trachea entering the center of an apparently poriferous disk set at the bottom of a faintly sclerotized, invaginated dermal cup, this cup barely evident with the anterior spiracle but gradually deeper with each succeeding posterior spiracle, with the apical invaginated almost the diameter of the plate; anal lobe seta about 160μ long.

During the growing period a gradual change in shape and size takes place. With the increase in body length a waxy secretion forms along the posterior margin, eventually covering the abdomen. This is followed by a gradual swelling of the cephalo-thoracic area, giving the scale a pear shape. The actual shape depends on the space into which the larva crawls.

The egg. The egg is elongate-ovoid with both ends broadly rounded; color amber-yellow, with a smooth and shining surface, approximately 0.20 mm. long by 0.16 mm. wide; enclosed in a white, waxy secretion. Several hundred eggs are enclosed in one egg mass. During oviposition the female covers each egg,

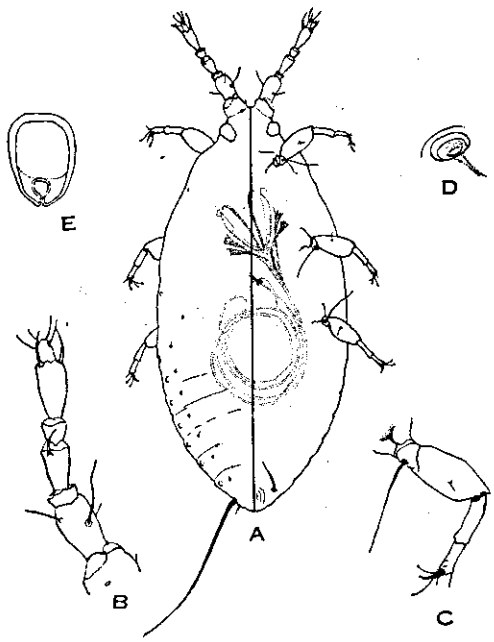

FIGURE 5. First-stage larva of Matsucoccus resinosae. A, *outline of body, dorsal (left) and ventral (right.)* B, *antenna;* C, *leg;* D, *thoracic spiracle;* E, *beak.*

Geographical Distribution

Matsucoccus resinosae was first reported in 1946 by George H. Plumb. The insect was seriously damaging 30-year-old red pines at the southeastern end of Hemlock Reservoir at Easton, Conn. By 1950 the scale had spread to the Easton Lake Reservoir, approximately 4 miles to the northeast. Spread is apparently effected by the wind, for studies made in 1952 showed that first-stage larvae were definitely airborne for at least ¼ mile. In 1953 a survey conducted by the State of Connecticut[2] showed that the infestation had spread over an area of at least 60 square miles (Fig. 7).

The scale was reported from New York in 1950. An intensive survey conducted by the State of New York in 1953[2] showed that an area of approximately 40 square miles was infested on Long Island, and scattered spot infestations occurred along the Hutchinson River Parkway and in Yonkers, Scarsdale, and Tuckahoe in Westchester County (Fig. 7).

The area in which *M. resinosae* now occurs is south of the natural range of red pine. The infested red pines are found only in plantations, in nurseries, or as ornamentals. A cooperative survey of red pine stands in northern New York and New England was undertaken in 1953 by State and Federal personnel to determine if the scale occurred in natural stands of red pine. Both natural and planted red pines were sampled, with special emphasis given to natural stands. No evidence of *M. resinosae* was found.

To date no evidence has been obtained to indicate the origin of this scale. However, the rapid spread of *M. resinosae* in Connecticut since 1946, and the heavy mortality of red pine as a result of its attack, would suggest the scale may be an introduction.

[2]Special report on a cooperative survey for the Matsucoccus scale of red pine in the northeast—1953. U. S. Dept. Agric. Div. For. Insect Invest. 7 pp., illus. 1954. New Haven, Conn.

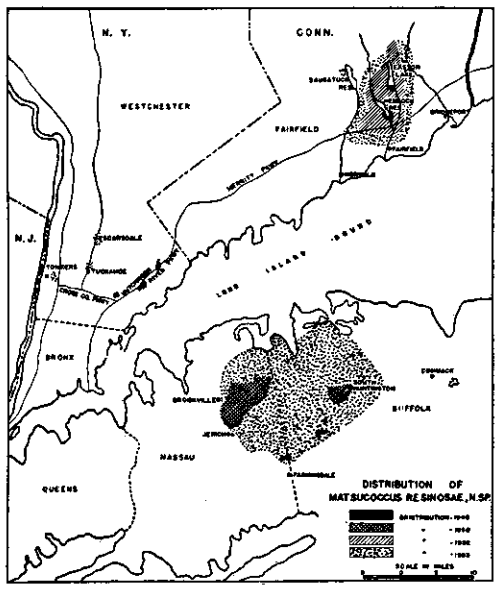

FIGURE 7. The known distribution of Matsucoccus resinosae.

Cooperative studies are now being conducted with the Boyce Thompson Institute in Yonkers, N. Y., to determine scale survival at different low temperatures. It is hoped that this study will determine if a thermal barrier exists that may prevent northward spread of this insect into natural red pine stands.

Host Relationship

Matsucoccus resinosae is apparently host specific. Laboratory experiments carried out in 1952 and 1953 to establish the scale on other species of pines (jack, pitch, scotch, white, Austrian, and mugho) were unsuccessful. In the field, scale-infested red pines were found growing intermixed with these same species of pines, but only the red pine was infested. In nearly all cases the red pine eventually died as a result of feeding by the scale.

Studies of host relationship will be undertaken this year, in cooperation with the Boyce Thompson Institute, using exotic pines as possible hosts of the scale.

as it is laid, with a loose coating of white, waxy filament. Then the eggs are enclosed in a much larger, loosely woven ovisac. Counts made of field-collected ovisacs gave an average of 300.5 eggs per ovisac with a maximum of 413 and a minimum of 118.

Preadult male. The preadult male is similar to the adult female but somewhat smaller (1.0 to 2.5 mm. long). Antennae and legs are alike in all respects. Derm varies in color from a light to reddish brown with the light yellow wing pads plainly visible beneath the body integument. Pupates in a loose, fluffy, spindle-shaped, waxy cocoon.

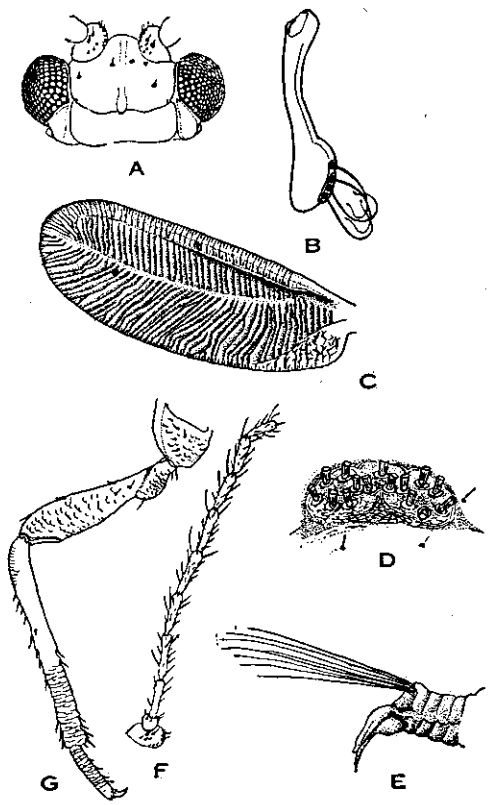

FIGURE 6. Adult male of Matsucoccus resinosae. A, *head, venter*; B, *halter*; C, *wing, showing shape and venation*; D, *caudal brush at end of abdomen*; E, *abdomen, lateral view showing waxy filaments projecting from caudal brush*; F, *antenna*; G, *methathoracic leg.*

Adult male. The adult male (Fig. 6) is practically identical in appearance with this stage of the genotype *M. matsumurae* (Kw.). No critical studies are yet available to establish bases for segregation of species in this stage. The adult male is 2-winged, midge-like in appearance, about 1.0 mm. long, legs and antennae long and slender, transversely striated, the latter 9-segmented. It is easily identified by the peculiar wing venation and the prominent caudal brush at the end of the abdomen. Brush is composed of several long, white, waxy filaments projecting posteriorly.

This insect has been described from a number of individuals of the different stages collected in Connecticut and New York. The female holotype has been selected from specimens collected on *Pinus resinosa* at Easton, Conn., June 2, 1948, by George H. Plumb. Paratypes of the different stages, all from the same host, and including additional adult females, come from Easton, collected by Plumb, Nov. 29, 1946; from Syoset, Long Island, N. Y., collected by Mrs. B. Moore, Dec. 9, 1948; from Fairfield, Conn., collected by S. W. Bromley, Nov. 16, 1950; from New Rochelle, N. Y., collected Sept. 1952, and from Bridgeport, Conn., collected by J. L. Bean, Oct. 15, 1952.

As with most of the species of this genus, there are few, if any, positive morphological characters that can be cited as firm guides to recognition; and as of now, the host and environmental associations that have been established for the species in the area in which it is known to occur have greater recognition significance than do its morphological characteristics.

The adult female seems similar to the true *Matsucoccus matsumurae* (Kw.) from Japan in many structural details, including the tendency of the dorsal cicatrices to spread out over the surface of the abdomen so that it becomes difficult to recognize sharply limited bands and clusters. But the trachea in the thoracic spiracle of the intermediate stage enters the spiracle opposite the posterio-median curve of the pore plate, resembling the condition in *Matsucoccus pini* Green, as recently described by Boratynski (1952, pp. 285-326), while the point of entry in this stage of *M. matsumurae* is on the anterior curve of the plate, as with various North American species.

The types are in the U. S. National Collection of Coccidae.

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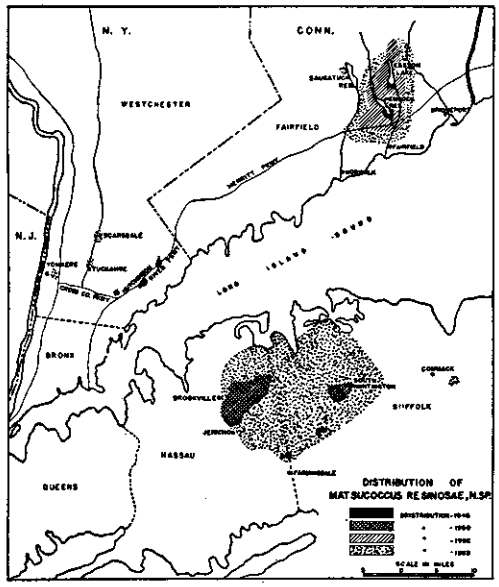

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Effect on Host

The first visible foliar indication of feeding by *M. resinosae* is a slight yellowing and shortening of the new growth. However, this does not occur until the tree has become rather heavily infested. The discolored and shortened growth may not appear immediately over the entire crown, but only on an occasional branch.

As the scale population increases and feeding becomes more severe, the color of the foliage changes from a normal green color to light green, then to light yellow, and finally to a brick-red. This occurs first on individual branches, then over the entire crown. This color change may occur rapidly; some pines with only a single off-color branch in the spring were entirely brick-red by late fall.

The bark on branches and boles that are heavily infested with the scale has a swollen and cracked appearance, and areas of necrotic tissue can be found beneath each feeding scale.

Economic Importance

The infestation of *M. resinosae* has now reached serious outbreak proportions, and the insect has become one of the most serious pests of red pine. The present infestation, although restricted to definite localities, constitutes a very serious threat to thousands of acres of planted as well as natural red pine in the Eastern States. The State of New York alone has planted more than 98 million red pines on approximately 135,000 acres in addition to another 25,000 acres planted on private lands.

The State of Connecticut has approximately 20,000 acres of red pine planted, mainly on watershed property. In New Jersey there are approximately 6,000 acres of planted red pine. The plantation figures for red pine in the other Eastern States are not available; however, they involve several thousand acres.

The volume of natural red pine throughout the region is very large and is of considerable economic importance. For example, there are about 250,000 cords of red pine in the State of New Hampshire alone.

Habits and Seasonal History[3]

Habits

The newly hatched larva of *M. resinosae* is very active and may crawl a considerable distance before it settles down to feed. However, as soon as the young crawler locates a suitable hiding place, either under a loose bark scale or in a crack or crevice, it inserts its long stylet into the bark, commences to feed, and remains quiescent until full-grown. Once the stylet has been inserted, the scale cannot be disturbed or it will die.

Generally the young crawlers are gregarious and may be found in large numbers just under the edge of a loose bark scale (Fig. 8). As many as 53 individual first-stage larvae have been found under one bark scale.

The duration of this stage varies considerably, ranging from 45 to 50 days for the summer generation, and 235 to 260 days for the fall or overwintering generation.

At ecdysis the skin of the first-stage larva splits anteriorly and longitudinally along a mid-dorsal and -ventral line. The antennae and three legs appear on one side of the split and the remaining three legs on the other. The cast skin gradually slips sideways and backwards, eventually encircling the posterior half of the body.

The body of the intermediate stage, following ecdysis, is stoutly ovoid, more or less distorted from its cramped hiding place. The derm at first is soft and membraneous, later becoming very hard, thin, and homogeneous, more or less strongly sclerotized, especially along the margins. The rapid growth of the scale during this stage indicates a considerable amount of feeding.

[3]The authors thank the Bridgeport Hydraulic Company of Bridgeport, Conn., for their splendid cooperation in the study of the habits and seasonal history of the red pine scale, and the active part they played in the insecticide studies carried out in 1954.

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FIGURE 8. Matsucoccus resinosae *first-stage larvae on twig of infested red pine. The bark scale has been removed to expose the insects. Photo from Conn. Agric. Exp. Sta.*

FIGURE 9. Masses of male cocoons on lower side of branch axil. Photo from Conn. Agric. Exp. Sta.

When fully developed, this stage of *M resinosae* is nearly globular in shape, with hard leathery skin, blackish in color. The expanded size of the scale has forced it partly out of the crevice in which it was hiding, and gives it the appearance of a glob of black pitch. The mouth parts, the only means of attachment to the host plant, become very brittle and break at the least pressure.

It is not known for certain just when feeding ceases during this stage. A number of fully developed individuals were removed from twigs and kept in small vials; these invariably failed to molt into adults. Similar individuals not removed from the same twigs molted 2 to 4 days later. This would indicate that growth continues almost up to the time the scale molts.

With this second and final molt the adult female, or preadult male, emerges from the cast skin by backing out through the opening, helping itself with haphazard movements of its legs.

The male form emerging at this time is not the true adult, although it is almost identical to the true adult female. The male form at this stage is called the preadult; it must go through another transitional period before becoming the true adult.

Almost immediately after emergence, the preadult male spins a loose, fluffy, spindle-shaped cocoon of coarse, waxy threads Within this cocoon the transformation to the winged adult occurs. The preadult males are gregarious and gather in large numbers on the undersides of branches, especially at branch axils, to spin their cocoons (Fig. 9). On heavily infested trees these masses of cocoons are very conspicuous and resemble small fluffs of cotton.

The reddish-brown adult female is very active, although awkward of movement. She may crawl a considerable distance over the bark, continually investigating cracks and crevices until she finds a suitable place for laying eggs. This may be any crack or crevice in the bark or under a loose bark scale. The axils of branches provide the best shelters and many ovipositing females may be found there. The duration of the active life is not known. However, in small vials females have wandered around for 3 days before laying their first egg.

Once the female finds a suitable place for laying her eggs, she wedges her head and thorax into the deepest part of the crevice and firmly fixes herself with her claws. In a short time waxy threads are exuded from the abdominal wax pores, forming a loosely wooven ovisac, and oviposition begins. In this position the female will lay her quota of eggs and then die.

Seasonal History

This is the second recorded species of the genus *Matsucoccus* that has two generations a year. *Matsucoccus pini*, a European species found only on *Pinus sylvestris* and limited in its distribution to southern England, is the only other known bivoltine *Matsucoccus* species. Morphologically, *M. pini* resembles *M. resinosae* very closely; but it differs, in addition to distribution, in its host preference and in being parthenogenetic.

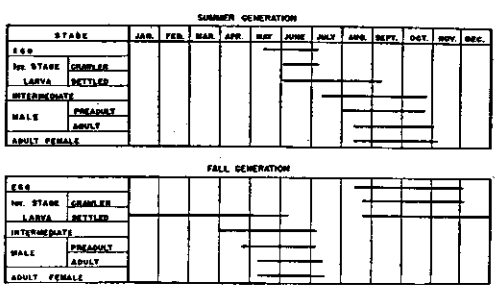

FIGURE 10. The seasonal life cycle for summer and fall generations of Matsucoccus resinosae.

In southern Connecticut and New Y[illegible] where *M. resinosae* now occurs, there are two generations a year: a summer generation, with the first eggs laid in May and adults emerging in early August; and a fall generation, with eggs laid in late August or early September and adults emerging the following spring (Fig. 10). All evidence collected to date indicates that the fall generation overwinters as a partly grown first-stage larva. In the spring, feeding is resumed and the first molt occurs. The resulting legless intermediate stage develops rapidly and by the third week of April preadult males appear. They immediately enclose themselves in silken cocoons and in 10 to 14 days transform into the true adult.

The emergence of the true adult males coincides with the emergence of the adult females. After copulation the females seek suitable shelters and lay the eggs that will produce the summer generation. Under laboratory conditions egg-laying varied from 2 to 4 days. Adults from the overwintering generation may continue to emerge until the first week of July.

Newly hatched larvae have been found in the field 15 days after the eggs were observed. This corresponds very closely to the 15 to 20 days required to hatch eggs under laboratory conditions. The active life of the young crawlers is very short. Settled individuals may be found almost simultaneously with the appearance of the first crawler. Feeding first-stage larvae may be found throughout the year, and in August and September and in early June there is an overlapping of both summer and fall generations.

In approximately 45 days the first-stage larvae reach their full growth and the first molt occurs. The resulting intermediate stage makes its first appearance about the middle of July. During this stage the scale continues to feed, and it increases rapidly in size. When full-grown, the intermediate form may be twice the size of the first-stage larva just prior to molting. It is not known if feeding continues right up to the emer-

1. The May 19 and June 8 application averaged a significantly higher degree of control than either the April 22 or June 27 application.
2. There was a small but significant difference between the three insecticides; Systox averaged highest and ethylene dibromide next in effectiveness.
3. The mist blower, on the average, proved more effective than the hydraulic sprayer.
4. Systox applied by the mist blower averaged the highest effectiveness, with the 2-percent oil emulsion applied by the mist blower and Systox applied by hydraulic sprayer next.
5. The single most effective treatment was the 2-percent oil emulsion applied by the mist blower on June 8, ethylene dibromide and the 2-percent oil emulsion applied by hydraulic sprayer on May 19 were nearly as effective.

The control effected by these single applications was considered unsatisfactory for the purposes of practical control. Further tests are needed, using double applications against the feeding stages (May 19 and June 8) with these same insecticides or with others of equal effectiveness.

Natural Control

Some observations have been made on the natural enemies of *M. resinosae*. A number of predators were collected and reared, but so far no conclusive evidence of parasitism has been found.

One of the most abundant predators reared—and apparently the most beneficial—was a small hemipteron (*Xanotrachelliella inimica* D. & H.).[4] This anthocorid bug was reared on all stages of the scale, but it seemed to prefer the eggs and first-stage larvae. It was very abundant on all scale-infested trees. Adults were collected as late as the last of October.

Another predator, a small coccinellid (*Cleis picta* (Rand.)) appeared to be the next most abundant. Larvae of this beetle were also successfully reared on all stages of the scale. Larvae of a small hemerobiid (*Hemerobius stigmatus* Fitch) and a chrysopid (*Chrysopa* sp. near carnea group) were observed feeding on the eggs and first-stage larvae of *M. resinosae*.

A number of small orange-colored dipterous larvae (*Itonodidini* group *Trifila*, genus and species unknown) were found feeding on eggs within the ovisac of this scale. These larvae were able to consume all of the eggs in one or more ovisacs before they pupated. A small black ant (*Crematogaster cerasi* (Fitch)) was common on scale-infested trees, probably associated with an aphid (*Pineus* sp. (?)) found in abundance on these pines. On several occasions they were observed attacking the crawlers and adult females of the scale.

Plumb[5] reports certain species of spiders as being predacious on the scale. These were collected from red pine on October 13, 1950, and were identified by Dr. B. J. Kaston. They are: *Pityohyphantes phrygianus* Koch, *Theridion unimaculatum* Emerton, *Uloborus americanus* Walckenaer, *Metaphidippus proteruns* Walckenaer.

Spiders of the genus *Theridion* were especially common, and many adult *Matsucoccus* females were observed in their webs.

Mites of the genus *Anystis* were observed by Plumb (1950, p. 4) feeding on the different stages of *M. resinosae*. They occurred in large numbers on scale-infested material.

Literature Cited

BORATYNSKI, K. L. 1952. *Matsucoccus pini* (Green 1925) (Homoptera, Coccoidea, Margarodidae). Bionomics and external anatomy with reference to the

[4]Species was determined by taxonomists in the Section of Insect Detection and Identification, Entomology Research Branch, Agric. Res. Serv., U. S. Dept. of Agriculture.

[5]Correspondence, January 13, 1955.

1. The May 19 and June 8 application averaged a significantly higher degree of control than either the April 22 or June 27 application.
2. There was a small but significant difference between the three insecticides; Systox averaged highest and ethylene dibromide next in effectiveness.
3. The mist blower, on the average, proved more effective than the hydraulic sprayer.
4. Systox applied by the mist blower averaged the highest effectiveness, with the 2-percent oil emulsion applied by the mist blower and Systox applied by hydraulic sprayer next.
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