Some Aspects of the Biology and Dispersal of the Pine Tortoise Scale, *Toumeyella numismaticum* (Pettit and McDaniel) (Homoptera: Coccidae)

by

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Some Aspects of the Biology and Dispersal of the Pine Tortoise Scale, *Toumeyella numismaticum* (Pettit and McDaniel) (Homoptera: Coccidae)¹

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FOREWORD

The senior author conducted this investigation during 1937 and 1938 in the Sandilands Forest Reserve, Manitoba. The results were presented in an unpublished report (Rabkin, 1938). Owing to the current importance of this insect in Manitoba and the Lake States of the United States, it was considered advisable to publish those aspects of the work relating to life history and dispersal. This was undertaken by the junior author.

INTRODUCTION

The insect studied is a soft scale. Specimens submitted to W. R. Richards, Entomology Division, Ottawa, in 1954, were identified as the pine tortoise scale, *Toumeyella numismaticum* (Pettit and McDaniel).

In general, the distribution of the pine soft scales coincides with the northern coniferous regions of the United States and Canada. The economic importance of these scales was first mentioned by L. O. Howard (1907). Studies of *T. numismaticum* have been carried out by Orr (1931), Pettit (1931) and others.

In the Sandilands Forest Reserve *T. numismaticum* attacks jack pine (*Pinus banksiana* Lamb.), Scots pine (*P. sylvestris* L.), and red pine (*P. resinosa* Ait.), in order of preference. The scale is most prevalent on young trees and may kill or severely damage young pines in plantations or natural stands. It has been a sporadic problem in the Reserve since 1935.

LIFE HISTORY OF *T. NUMISMATICUM*

Early Spring Activity

Scales are amongst the first insects to become active in the spring. At the beginning of the season, the female scale is wrinkled, deep brown to black, and appears to be dead. At this time it is about half grown. As development proceeds, the scale fills out, becomes more rounded, and the colour changes to reddish-brown. Beginning of development coincides with the swelling of the buds and the start of terminal growth of jack pine. This period is characterized by a copious secretion of honey-dew by the scales. In 1938, honey-dew was first noted on May 15. Where ants are not present to consume the secretion, it collects on the trees, forming the substrate for a conspicuous sooty fungus.

Maturation and Egg Development

At the beginning of spring activity, the area of the female scales averages about 5.5 sq. mm. Mature scales average 13 sq. mm. The mature insect is decidedly convex and broadly oval (Figure 1). Dorsally, three longitudinal light-coloured bands converge cephalad and caudad. There are two or more rows of small circular depressions in the regions of the bands.

Egg development in the scales was well advanced by June 6 in 1938. At this stage of development most of the eggs are in the uterine envelope, but some are free in the body cavity. Embryonic stages of the developing nymphs can be
seen in the more advanced eggs, while undifferentiated eggs are present in the ovary. A few days after the eggs are liberated into the body cavity, the internal structures of the scale begin to lose their identity, and the body cavity becomes filled with a reddish-brown fluid. The developing eggs float in this fluid.

Nineteen mature or nearly mature scales were dissected to determine the number of ova per female. The number averaged 534, with the standard error of the mean $\pm 50^1$. The size of the scales averaged 13.1 sq. mm., with the standard error of the mean $\pm 0.67$ sq. mm. There was a correlation between scale area and number of eggs present. The correlation was 0.881, which is significant beyond the .01 level.

Oviposition and Emergence

As far as could be determined, the process of oviposition consists of the extrusion of the almost fully developed egg from the genital aperture located in the posterior ventral region of the insect. Usually the eggs are extruded singly, but chains of three or four eggs have been observed. Shortly after extrusion, usually a few hours, the colour of the egg becomes lighter, and eclosion of the nymph takes place. Newly emerged nymphs spend up to a half day under the shell of the female scale before crawling away. As the nymphs emerge, the ventral space underneath the scale is filled with cast chorions.

Nymphal emergence was first noted in the field on June 21 and was general

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1 Orr (1931) obtained 1,524 ova from one mature female. This disparity may be caused by regional, seasonal, or host differences.
by June 23. Observations of six caged females showed that nymphs emerged from June 24 to July 4, with the majority emerging during the first three days.

**Nymphal Feeding**

Following the selection of a suitable site, the nymphs begin to feed. In 1938, feeding was general by July 7. Though some preference is shown for new growth, nymphs settle down anywhere on the branches and twigs.

On the first day of feeding, no external changes are evident. In the second day, a white powdery material appears at the outer ventral margins of the nymphs. Except for an increase in size, no further external changes occur up to the fourth or fifth day.

At this time, segmentation and nymphal markings are lost, and the insects assume the typical scale appearance. Growth progresses uniformly for about two weeks without visible sexual differentiation.

Following this two-week feeding period, various external changes can be observed. Males cease to grow laterally and begin to elongate, while females continue to grow uniformly. About three weeks after the beginning of feeding, the males are full grown and can be readily recognized by their clear, waxy covering (Figure 2). Females are still immature, and are convex, broadly oval in shape, resembling the mature scale.

**Sex Ratios**

The sexes may be readily distinguished by the last week of July. Random samples from infested trees were collected to determine general sex ratios and related data. A total of 9,168 scales were counted; of these 6,456 were alive. Data pertaining to the distribution of scales on the host tree and sex ratios are given in Table 1.

<table>
<thead>
<tr>
<th>Location on tree</th>
<th>Average scales/linear inch</th>
<th>Percentage dead</th>
<th>Ratio ♂ to ♀</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main stem ...</td>
<td>33.9</td>
<td>9.5</td>
<td>44:56</td>
</tr>
<tr>
<td>Branch</td>
<td>39.5</td>
<td>26.5</td>
<td>55:45</td>
</tr>
<tr>
<td>Twig</td>
<td>37</td>
<td>54</td>
<td>57:43</td>
</tr>
</tbody>
</table>

The table shows that the proportion of males to females tends to increase as the mortality rises, indicating a selective mortality of females. No consistent relation was found between population density and sex ratio, but it was observed that there are a lower proportion of females to males on severely infested trees suffering from the effects of scale attack.

**Fertilization and Development**

The first adult males emerged on August 3, and began to fly immediately. The adult is small, fragile, and has no mouth parts or alimentary system. The gonads occupy the entire abdominal cavity. Males rarely live more than two days in captivity.

Females are fertilized in the immature stage, which resembles the adult female except for size. Ventral segmentation is apparent and the mouth parts are well developed. The antennae and legs are greatly reduced and locomotor function is lost. Within a few hours after fertilization, the female begins to secrete honey-
dew. The female continues to develop well into the fall; secretion of honey-dew has been observed in late September.

DISPERSAL

Following emergence of nymphs from the eggs in late June and early July, experiments were carried out on factors contributing to dispersal. A knowledge of these factors is essential for following the course of scale infestations, and for planning control procedures. Various authors have suggested that birds, squirrels, ants, and other insects might be responsible for spreading nymphs. The senior author felt that animal agencies are only incidental and that wind and air currents might easily carry nymphs for appreciable distances, thereby starting new infestations. Such migratory activities could account for the patchy condition of the infestation in the Sandilands Forest Reserve in 1938.

Methods

Tanglefoot traps were placed in various parts of the Reserve to capture nymphs. A commercial preparation of tanglefoot was spread evenly on sheets of white bond paper, 8 by 10 inches. A 1-inch margin was left free for handling. The papers were tacked to boards of slightly larger dimension that had first been nailed to stakes 3, 6, and 9 feet high. In addition, similar traps were placed on top of an 80-foot fire-lookout tower.

After various periods of exposure, the papers were removed and the nymphs trapped in the tanglefoot were counted.
Under "Results" the term "trap-day" refers to one tanglefoot trap exposed for one day. The first traps were exposed on June 21 and the last trap was removed from the field on August 28, though the dates of exposure of individual traps varied considerably within this period.

Results

Table 2 summarizes the number of nymphs captured in traps in various locations in the Reserve.

**Table II**

Summary of Scale Nymphs Caught in Tanglefoot Traps

<table>
<thead>
<tr>
<th>Location No.</th>
<th>Location of traps</th>
<th>No. of traps</th>
<th>No. of trap-days</th>
<th>Nymphs trapped</th>
<th>Nymphs per trap-day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Centre of heavily infested area</td>
<td>7</td>
<td>131</td>
<td>2,481</td>
<td>18.9</td>
</tr>
<tr>
<td>2</td>
<td>1925 seed plots in heavily infested area</td>
<td>7</td>
<td>124</td>
<td>2,231</td>
<td>18.0</td>
</tr>
<tr>
<td>3</td>
<td>Another point in heavily infested area</td>
<td>9</td>
<td>126</td>
<td>21,903</td>
<td>173.8</td>
</tr>
<tr>
<td>4</td>
<td>Opening in heavily infested area about 3/4 mile from nearest trees</td>
<td>4</td>
<td>84</td>
<td>107</td>
<td>1.3</td>
</tr>
<tr>
<td>5</td>
<td>Lightly infested, 2-3 miles removed from edge of severe infestation</td>
<td>13</td>
<td>553</td>
<td>1,503</td>
<td>2.7</td>
</tr>
</tbody>
</table>

In location 1, over half the nymphs were trapped during the first nine days of exposure. In location 2 the greatest number were also caught during the early part of the period.

Special interest attaches to results from traps exposed on an 80 foot firelookout tower, near the edge of a severe infestation. The tower is situated on a knoll, and the traps at the top of the tower would be about 100 feet above the surrounding country.

A number of traps were exposed at the top of the tower, and at the base about 3 feet above ground level. In 163 trap-days, 219 nymphs were caught at the top of the tower. At the base, 2,038 were captured in 130 trap-days.

About 99 per cent of the nymphs trapped in the experiments described were caught during the period June 21 to August 2.

An effort was made to determine if windborne migration is an accidental or deliberate process. Nymphs were difficult to dislodge from severely infested branches that were shaken vigorously. In another instance, traps were placed beneath infested trees and also 15 to 25 feet removed. There were no other scale-infested trees in the immediate vicinity. Traps 25 feet removed from the nearest tree caught about three times as many nymphs as those underneath trees.

However, these two observations should not be accepted as conclusive evidence that nymphs do not drop from the trees. In some instances many nymphs were seen on the ground beneath infested trees. Firm conclusions can only be based on more extensive studies and observations under a variety of conditions.

During these investigations it was observed that nymphs move about on trees on which they emerge, and from one tree to another where the branches intertwine. However, it is believed that few new trees are infested by this means of dispersal.
Discussion

In the experiments described in this section, it was demonstrated conclusively that large numbers of nymphs are distributed by air currents. The number distributed varies with the density of the stand, but the precise influence of stand density cannot be determined from the data available.

It was shown that nymphs can be carried for distances up to three miles but it is doubtful if many new infestations can be established by windborne dispersal much beyond a 3-mile radius from the edge of an infestation. In reviewing results of his own and other work, Wellington (1945) concluded that long-distance distribution of insects by wind usually may be neglected since it is an unsteady phenomenon, but that short-range, high- or low-altitude processes, produced by local topography, are of utmost significance economically.

No data are available on animal agents of migration. There is a strong possibility that birds, squirrels, and insects may transport nymphs from tree to tree and, in some cases, over a considerable distance. Locomotor migration by nymphs is probably limited to the tree on which they emerge or to adjacent trees where the branches intertwine.

SUMMARY

The scale studied was identified as the pine tortoise scale, *Toumeyella numismaticum* (Pettit and McD.). In Manitoba the insect attacks jack pine, Scots pine, and red pine in this order of preference. It is primarily a pest of seedlings and saplings.

The half-grown, fertilized females start development in the spring when the jack-pine buds begin to swell and terminal growth commences. The scales mature rapidly and egg development begins in early June. The number of ova per female averaged 534. Oviposition begins shortly after mid-June. Oviposition consists of the extrusion of almost fully developed eggs, singly or in short chains, from the genital aperture in the posterior ventral region of the insect. Newly emerged nymphs spend up to one-half day under the female scale before crawling away. Nymphal emergence takes place during late June and early July.

Following emergence, the nymphs undergo a period of dispersal, principally by means of wind and air currents. Some locomotor migration was also observed.

After finding a suitable host, the nymphs begin to feed. Following a two week feeding period, males and females begin to show external evidence of differentiation. Normally males and females occur in about equal numbers. Male scales are mature after three weeks of feeding. Adult males emerge in early August and fertilize the immature females, which continue development well into September.

REFERENCES


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