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43. *NEODIPRION SWAINEI* MIDD., SWAINE JACK-PINE SAWFLY (HYMENOPTERA: DIPRIONIDAE)

J. M. McLeod and W. A. Smirnoff

PEST STATUS

The Swaine jack-pine sawfly, *Neodiprion swainei* Midd., has been a threat to jack-pine stands in Quebec and is now the major forest insect problem in the Province (3). Although infestations have

Commonwealth Agricultural Bureaux. CIBC Technical communication no 4: 162-167.

also occurred in Ontario, they were less severe and widespread than in Quebec (1). Extensive tree mortality and general stand deterioration have resulted from outbreaks of this sawfly in Quebec (3, 7), but the principal danger is expected to occur in the 1970's as extensive pure stands of jack-pine, most of which originated from fires in the early 1920's, reach maturity and become more susceptible to sawfly defoliation (8).

Recent severe and moderate infestations have been generally restricted to the areas outlined in Fig. 18 where outbreaks are expected to recur. Cold weather apparently determines the northern limit of outbreaks (1, 3, 23).

Sawfly populations erupt periodically at intervals of as little as 6 years, and complete defoliation and tree mortality may start 3–4 years after the beginning of particularly severe outbreaks. Feeding is more prevalent in the upper crowns of dominant trees and thus they are the first to show the effects of defoliation (7).

Some outbreaks have been controlled by natural factors mainly low-temperatures during the developmental period (9, 23); predation by small mammals may also be a control factor.

RELEASES AND RECOVERIES

PARASITES

Before 1958, only small numbers of *Pleolophus basizonus* (Grav.) and *Drino bohemica* Mesn. were released against *Neodiprion swainei* in a few localities in Ontario. However, massive releases of these two parasites, as well as *Exenterus amictorius* Panzer and *Dahlbominus fuscipennis* (Zett.) were also made in the early 1940's against *Diprion hercyniae* Htg. in both Ontario and Quebec. All four species have been recovered from *N. swainei* in a number of localities in Quebec since 1958 (Table XXX), but none in Ontario. *E. amictorius* and *P. basizonus* were most abundant, *D. fuscipennis* was less common, and only one specimen of *D. bohemica* was found.

TABLE XXX

Recoveries of parasites from *Neodiprion swainei* Midd. in Quebec 1958–68

Species	Lat.	Long.	Year	Host
Exenterus amictorius Panzer	(See below)		1961–8	*Neodiprion swainei* Midd.
Pleolophus basizonus (Gravenhorst)	(See below)		1964–8	*Neodiprion swainei* Midd.
Dahlbominus fuscipennis (Zett)	(See below)		1960–8	*Neodiprion swainei* Midd.
Drino bohemica (Mesn.)	48°10′	71°01′	1968	*Neodiprion swainei* Midd.

Localities	Lat.	Long.
Lac des Iroquois, Lac St-Jean W.Co.	48°22′	72°28′
R.-à-Mars, Chicoutimi Co.	48°10′	71°01′
L. Potherie, St. Maurice Co.	47°13′	73°49′
L. Baude, Champlain Co.	47°05′	73°18′
L. Chevalier, St. Maurice Co.	47°03′	73°43′
L. McLaren, Champlain Co.	47°11′	73°30′
L. Oriskany, Champlain Co.	47°31′	73°43′
L. Caousacouta, Champlain Co.	47°16′	73°37′

Exenterus amictorius Panzer (Hymenoptra: Exenterini)

This species has appeared regularly in collections from 1961 and since then has dominated the complex of native *Exenterus* spp. attacking this sawfly (2). It lays its eggs on pre-spinning eonymphs. Adult *E. amictorius* emerge from *N. swainei* cocoons in early June and the secood generation develops on alternate hosts, notably the egg-overwintering *Neodiprion pratti banksianae* Roh. and *Neodiprion nanulus* Schedl. which are fairly widely distributed through the recovery areas on jack-pine (6). It also attacks *Diprion hercyniae* which is usually present in low numbers on black spruce scattered through jack-pine stands. Thus second generation *E. amictorius* adults emerge from host cocoons in mid-August, just in time to lay on pre-spinning eonymphs of *N. swainei* which are present in late August and September. Parasitism by this species on *N. swainei* in the localities sampled (Fig. 18) averages 1 per cent. over a 6-year period.

Pleolophus basizonus (Grav.) (Hymenoptera: Ichneumonidae)

This species parasitizes *N. swainei* cocoons. It was first recovered in samples in 1964 (5), and since then has been recovered consistently from all areas sampled (Fig. 18). It is bivoltine, on *N. swainei*, lays on eonymphs in cocoons in the fall, on eonymphs in extended diapause, and pronymphs, pupae, and adults in cocoons in June and July. Alternate hosts available during the summer include egg-overwintering *Neodiprion* spp. on jack-pine, and *Diprion hercyniae*. First generation parasitism on *N. swainei* averaged 2 per cent. over a 6-year period but its greatest impact probably occurs during the second generation which presently cannot be estimated precisely.

Dahlbominus fuscipennis (Zett.) (Hymenoptera: Eulophidae)

This species has been recovered sporadically in all sampled areas (Fig. 18) since 1962. Its populations are generally quite low, and its attacks occur mainly on pupae and adults in cocoons during June and July.

Drino bohemica (Mesn.) (Diptera: Tachinidae)

One specimen was identified in dissections of *N. swainei* cocoons collected from Rivière-à-Mars, Chicoutimi County, Quebec, in 1968. However, it is a common parasite of *N. pratti banksianae* and *N. nanulus* in Quebec.

PATHOGENS

The *Borrelina* virus was first discovered in a larva of *N. swainei* in a forest insect survey sample from Bear Island in Lake Timagami, northeastern Ontario, in August 1953. It was next reported in September 1956 near Lake Gagnon, in the St. Maurice Region of Quebec where it caused a moderately heavy infestation. Studies on the nuclear-polyhedrosis of this insect have been in progress since 1957 (12). The disease develops in the nuclei of the cells of the mid-gut epithelium. Polyhedral bodies ranging from 0·5–1·7 microns in diameter fill the nuclei of infected cells. Infected larvae begin to lose their appetite within a few days, their greenish colour changes to yellow, and the intestinal track becomes cream-coloured and fragile (12). Although the virulence of the original strain of the virus was low, a more virulent strain was obtained by selection. The latter caused 40–80 per cent. mortality of first-instar larvae with polyhedra concentration $2{\cdot}00^4$ per ml. Mortality is proportional to the virus concentration and inversely proportional to the age of the larvae. Effective virus concentrations ranged from $5{\cdot}10^5$–$3{\cdot}10^6$ polyhedra per ml. The higher concentrations neither hastened the development of the disease nor increased mortality of larvae. Best results were obtained when spray was applied at the end of the first or beginning of the second instar. Spraying was done in a severely defoliated jack-pine stand where tree mortality was insignificant and where, 3 years after spraying, the foliage density had returned to normal. The virus has persisted in the stand, and *N. swainei* populations continue at low levels.

An experimental aerial dispersion of the virus was made in 1960 over heavily infested jack-pine stands (15, 16). The virus at polyhedra concentration $2{\cdot}10^6$ per ml was mixed with two formulae; a water-latex dry ox-blood solution, and an oil-magma bentonite-spane water emulsion. The virus was applied at the rate of 0·5 and 4·0 gallons per acre. The results obtained were excellent. The year following the spray application, the plots and surrounding 0·25 mile zone were completely protected from defoliation and the disease had spread 2 miles from the plots.

In 1964, 7,000 acres of infested jack-pine forest were sprayed operationally with virus in a water-latex, dry ox-blood solution (22). The results obtained were not as good as those in 1960 mainly because unseasonable cold and rainy weather accompanied and followed the treatment (20, 21).

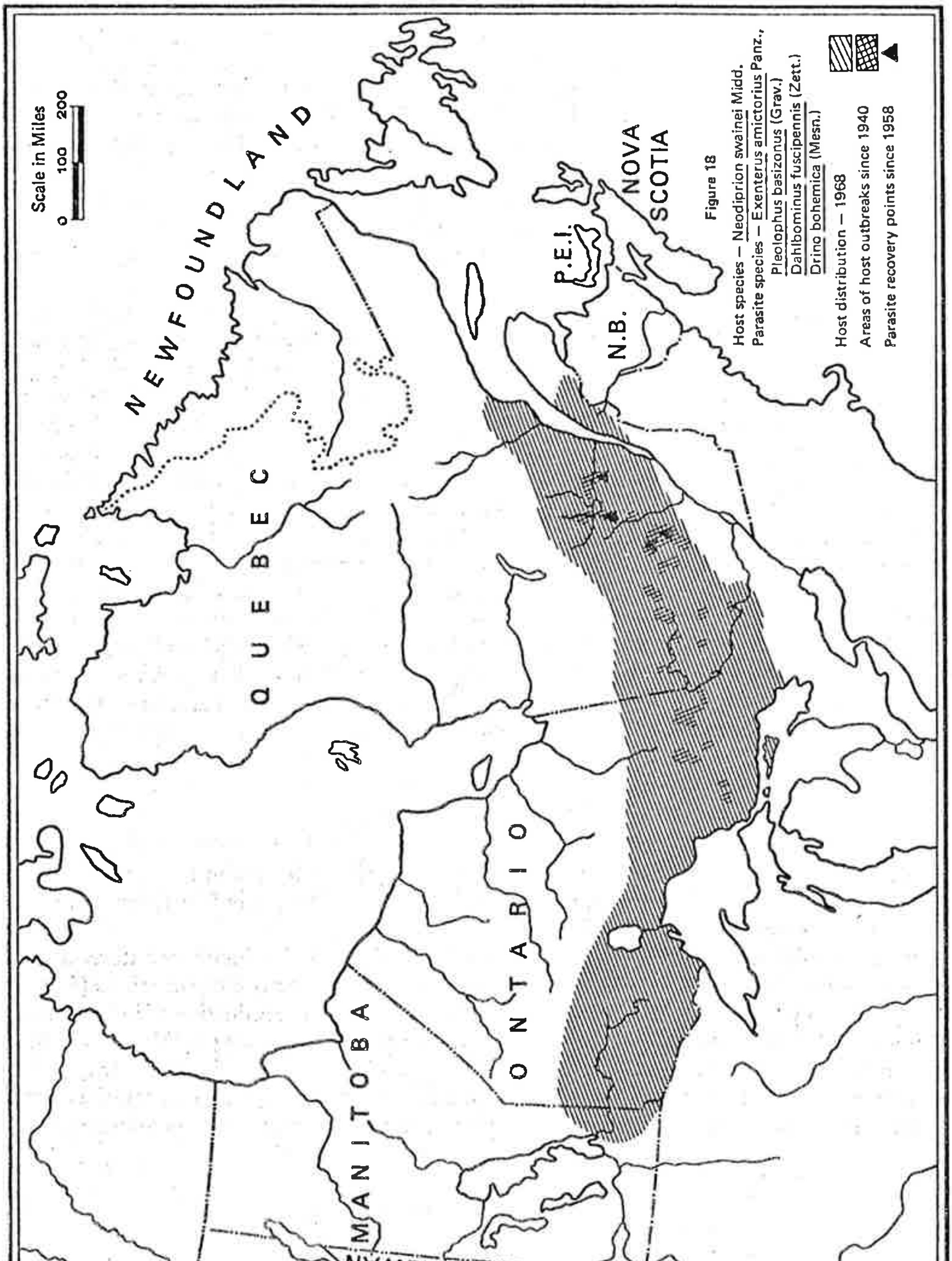

Figure 18

Host species – Neodiprion swainei Midd.
Parasite species – Exenterus amictorius Panz., Pleolophus basizonus (Grav.) Dahlbominus fuscipennis (Zett.) Drino bohemica (Mesn.)

Host distribution – 1968
Areas of host outbreaks since 1940
Parasite recovery points since 1958

The phenomenon of virus transmission from parent sawflies to their progeny, accompanied by the spread of infection to healthy individuals (trans-ovum transmission) (14) might be used effectively for control instead of treating large areas with concentrated spray. The method would consist of an application of weak dosage of virus at specific spots in an infected stand, or the dissemination of infected cocoons.

The ecology of the virus on its host and the effects of several external factors, namely temperature, darkness and sunlight, were studied (1, 11, 17, 18, 19, 20, 22). Experiments have also revealed that predators, mainly wasps and pentatomids, act as vectors of virus diseases (10, 13). The disease is also disseminated through migration of *N. swainei* larvae.

EVALUATION OF CONTROL ATTEMPTS

Both of the introduced parasites, *E. amictorius* and *P. basizonus*, appear to dominate their respective parasite communities at high host densities, and *N. swainei* is one of a number of alternate hosts which are exploited by these two parasites when numbers of *D. hercyniae*, against which they were released, are low. Thus, their introduction appears beneficial. A more precise evaluation of their impact should be available in 1 or 2 years following completion of studies in progress in Quebec.

The value of the virus disease for direct control of *N. swainei* is promising. Although the first experimental aerial spraying programme with virus in 1960 was phenomenally successful (15), the operational programme in 1964 showed rather conclusively that an uncontrollable variable, weather, contributed materially to a reduction in effective control (20, 21). Experiments have suggested, however, that effective control might be achieved in incipient outbreaks through trans-ovum transmission following spot spraying of areas with weak virus concentrations or through dissemination of infected cocoons.

Two highly successful aerial spray operations with the chemical insecticides Phosphamidon and Sumithion were carried out in Quebec (7, 8). Sawfly mortality attributable to spray averaged 99 per cent. in both operations, and a minimum of disturbance to birds, small mammals, parasites, and predators occurred as a result of spray application (4, 7).

RECOMMENDATIONS

It seems that aerial application of the insecticide Phosphamidon at the recommended dosages offers the only sure means of controlling *N. swainei* outbreaks. The method is cheap, efficient, and apparently causes a minimum of side effects.

Research should be initiated to determine the efficacy of controlling incipient outbreaks by virus through trans-ovum transmission by spot spraying areas with low virus concentrations (5×10^5 — 1×10^6 polyhedra per ml applied at 2 gallons per acre) or through dissemination of infected cocoons.

Population dynamics studies in Quebec, now nearing completion, may provide clues to the successful manipulation of the parasite complex. Studies in progress will determine whether *E. amictorius* and *P. basizonus* complement or hinder each other and their respective indigenous parasite communities. (Studies in progress by P. W. Price in Quebec are expected to provide answers to these problems).

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44. *OPEROPHTERA BRUMATA* (L.), WINTER MOTH (LEPIDOPTERA: GEOMETRIDAE)

D. G. EMBREE

PEST STATUS

The status of the winter moth, *Operophtera brumata* (L.), has changed dramatically since 1958 (15) owing to the success of two introduced parasites, *Cyzenis albicans* (Fallén) and *Agrypon flaveolatum* (Gravely) (3). The severity of damage on red oak, the principal forest host, is minimal, and the insect is now one of the less common defoliators of hardwoods. In a few towns, populations still occur on shade trees but below a level that would require the application of insecticides. The winter moth has persisted in commercial apple orchards where it is controlled through normal spray programmes. Occasional outbreaks occur in abandoned orchards. The range of distribution has not expanded appreciably since 1958[1] and the insect occurs throughout Nova Scotia and in isolated pockets of New Brunswick and Prince Edward Island (Fig. 19). A key factor in the regulation of winter moth populations in the absence of parasitism was the mortality that resulted when the degree of synchronism

[1] Forbes, R.S. Department of Fisheries and Forestry, Fredericton, New Brunswick. Personal communication.