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*Bark Beetle Carriers of Gremmeniella abietina and Other
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(L.) in Ontario*

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INSECT PATHOLOGY

Susceptibility of the Larch Sawfly to *Pleistophora schubergi* (Microsporidia).—The larch sawfly, *Pristiphora erichsonii* (Hartig), is a serious defoliator of tamarack, *Larix laricina* (Du Roi) K. Koch. Only one pathogen has been reported from this insect, and that was a microsporidium, *Thelohania pristiphorae* (Smirnov, J. Invertebr. Pathol. 8:360-364, 1966). *Pleistophora schubergi* has a wide host range (Kaya, J. Invertebr. Pathol. 22:356-358, 1973) and had previously been shown to infect some of the sawflies (Wilson, Can. J. Zool. 53:1799-1802, 1975). Thus it was decided to determine the susceptibility of larch sawflies to *P. schubergi*.

In the summer of 1979, an aqueous suspension of *P. schubergi* containing 5×10^8 spores/mL and 30 gm/L of IMC 90-001 (sunlight protectant) was sprayed on branches of larch trees naturally infested with colonies of larch sawfly. The branches were sprayed to saturation to a distance 0.6 m (2 ft) back from the colonies. Ten colonies in all, each containing 15-25 larvae in second or third instar, were treated. Check colonies were tagged in the same general area. After 5 days each colony was collected and reared separately on untreated larch foliage in lantern globes in the laboratory. Insects were reared at room temperature (21-23°C) and a relative humidity of 40-60%.

Data for this 1979 treatment indicated that 8% of the 112 larvae examined before spraying were infected with an undetermined *Pleistophora* species of microsporidium. Examination of 175 larvae from the 10 colonies 2 or more weeks after treatment showed the level of infection to be 40% compared with 10% for 170 control larvae.

In 1980, first and second instar larvae were collected from the field, placed on foliage (treated as follows) in lantern globes, and reared in the laboratory. Four lantern globes, each containing 12-20 larvae, were sprayed with an aqueous suspension of 4×10^6 *P. schubergi* spores/mL, and 7 lantern globes with 12-20 larvae each were sprayed with 4×10^8 spores/mL. The foliage was sprayed to saturation. Controls were sprayed with distilled water. In this test, cocoons were collected 24 h after spinning and weighed.

Infection levels caused by *P. schubergi* from larch sawfly larvae treated in the laboratory were as follows: controls — 0%; 4×10^6 spores/mL — 45.5%; and 4×10^8 spores/mL — 65.6%. These results were based on examination of 50 or more larvae at each dose. As indicated by the data, increasing the spore dosage increased the level of infection. There was a slight decrease in cocoon weight for insects treated with the higher spore dose: controls — 70.2 mg; 4×10^6 spores/mL — 71.5 mg; and 4×10^8 spores/mL — 65.8 mg.

It was not possible to determine what mortality was attributable to the microsporidium because mortality was high in all laboratory rearings of the larch sawfly. However, these preliminary tests indicate that the larch sawfly is susceptible to *P. schubergi* in both the laboratory and the field. —G.G. Wilson, Forest Pest Management Institute, Sault Ste. Marie, Ont.

SILVICULTURE

Yield of Seed in *Larix laricina* in Newfoundland.—Data on the seed quality of larch are scarce and do not always reflect annual and geographic variability. Knowledge of seed yields is necessary to plan provenance trials, to design seed orchards, and to improve production. This study evaluates the quantity and quality of larch seed in planted and natural stands.

An exceptionally heavy crop of larch seed was produced in Newfoundland in 1976. Collections were made to evaluate seed yields at 19 locations in natural stands and at 4 locations in plantations. The natural stands and the plantations ranged in age from 15 to 25 yr. Few flowers have been produced in the natural stands since 1976, but one of the plantations (Avondale) has produced a cone crop annually. Cone collections were made from 1976 to 1979 in the Avondale plantation to assess annual variation in seed quality.

Cones were collected between 1 and 31 October, placed in paper bags and stored at 2-3°C. The cones and seed were air-dried after storage for 3 wk at $25 \pm 2^\circ\text{C}$ and extracted in a cone shaker. The empty cones were oven-dried at 60°C for 24 h, counted, and weighed. Seeds were cleaned, counted, weighed.

After 3 wk stratification at 3°C approximately 500 seeds per seedlot were germinated on moist filter paper in covered petri dishes at $22 \pm 2^\circ\text{C}$. Seeds were considered to have germinated when the emergent radicle was 3 mm long. Germination counts were made twice a week for 4 wk. Nongerminated seeds were cut in order to determine the proportion of full seeds that did not germinate.

The following statistics were derived:

- a) weight of ovendry cones;
- b) weight of 1000 seeds;
- c) number of seeds per cone;
- d) number of full seeds per cone;
- e) percentage of full seeds that germinate (germinative capacity).

The yield of seed in natural stands was generally greater in eastern Newfoundland than in western or central Newfoundland. In central Newfoundland the yields were lowest (Table 1). The stands sampled in each part of the Island had a wide range of total seeds and full seeds per cone. Germinative capacity was less variable. The low numbers of full seeds per cone in central and, to a lesser extent, in western Newfoundland compared to eastern Newfoundland are attributed to insect damage. The eastern spruce budworm, *Choristoneura fumiferana* (Clem.), severely damaged the developing flowers on larch in June 1976 in most of Newfoundland. The flowers in the plantation in western Newfoundland were damaged by the insect, but the remaining plantations were not affected. Plantations generally produced more seed than did the natural stands but there was no significant difference in seed quality as measured in numbers of full seeds per cone. Quantity and quality of seed produced in excellent seed years vary considerably according to geographical distribution of larch stands. In this study seed yield was seriously affected by the spruce budworm and it is suspected that future losses to cone crops are likely to occur.

The yield of seed in the Avondale plantation was assessed over 4 yr (Table 2). Seed extraction and germination methods were similar to those already described. Weight of seed, total numbers of seeds per cone, and full seeds per cone were variable. However, the weight of cones and germinative capacity varied less from year to year. The total numbers of seeds per cone declined over the 4-yr period; but the numbers of full seeds declined for 3 yr and then increased in 1979.

Information in the literature on quantity and quality of seed produced in larch in the boreal forest is sparse. The Ontario Lands and Forests *Manual of Seed Collecting* describes seed weight as an indirect measure of seed quality and cites seed weights of larch ranging from 1.38 g to 2.04 g, with a mean of 1.80 g. These data are comparable to those reported for the Avondale plantation.

TABLE 1

Quantity and quality of larch seed in natural stands and plantations in Newfoundland in 1976.

	Average cone weight		Weight of 1000 seeds		Total seeds per cone		Full seeds per cone		Germinative capacity	
Natural stands										
Western Nfld. (8 stands)										
Range	0.12	0.20	1.32	2.03	2.1	11.8	0.9	4.9	72.3	99.3
Mean	0.16		1.68		5.5		2.0		92.2	
Central Nfld. (5 stands)										
Range	0.10	0.18	0.74	1.54	1.3	3.5	0.1	1.9	78.6	100.0
Mean	0.15		1.31		2.1		0.7		92.6	
Eastern Nfld. (6 stands)										
Range	0.19	0.27	1.26	2.25	5.6	14.7	1.0	14.1	73.0	97.0
Mean	0.23		1.82		10.7		8.4		86.0	
Plantations										
Western Nfld.										
Mean	0.21		1.42		15.5		1.8		78.3	
Central Nfld.										
Mean	0.30		1.40		8.8		4.4		92.9	
Eastern Nfld.										
Stand 1 Mean	0.22		2.07		9.6		7.6		89.9	
Stand 2 Mean	0.18		1.48		8.4		2.8		95.5	

TABLE 2

Quantity and quality of larch seed produced in the Avondale plantations from 1976 to 1979

Year collected	Cone weight (g)	Weight of 1000 seeds (g)	Total seeds per cone	Full seeds per cone	Germinative capacity
1976	0.22	2.07	9.6	7.6	89.9
1977	0.27	1.31	6.3	1.7	100.0
1978	0.17	1.06	4.4	0.1	100.0
1979	0.28	1.46	3.1	2.0	99.8

Reasonable estimates of full seeds per cone are necessary when cone collections are planned for provenance tests. For example, collection from one of the eastern Newfoundland stands in 1976 resulted in 1.4 L of cones with an average of 10.7 full seeds per cone. On a per litre basis this means that 4 500 full seeds per litre of cones was produced. Results from other collections in Newfoundland show that young (15-yr-old) trees produce up to 0.5 L of cones and mature trees from 2 to 5 L. On this basis and in a good seed year, a young tree could be expected to produce approximately 2 000 full seeds, whereas mature trees would yield 9 000 to 22 500 full seeds. The numbers of full seeds per cone were less than 10.7 in most collections, therefore, the previous figures are near the maximum yields obtainable.—J. Peter Hall, Newfoundland Forest Research Centre, St. John's Newfoundland.

ENTOMOLOGY

Bark Beetle Carriers of *Gremmeniella abietina* and Other Pathogenic Microfungi.—The North American race of *Gremmeniella abietina* (Lagerb.) Morelet, infecting small trees and lower branches of larger trees (Dorworth et al., Plant Dis. Rep. 61:887-890, 1977), is an important causal agent of mortality of young pines (*Pinus* spp.) (Martineau and Lavallée, Annual Report, Forest Insect and Disease Survey, Can. For. Serv. 32-48, 1970) in Quebec. A race of *G. abietina* on spruces (*Picea* spp.) causes mortality of young trees (Smerlis, Plant Dis. Rep. 51:584-585, 1967; Smerlis, Laur. Forest Res. Cent. Inf. Rep. LAU-X-23, 1976) in the central region of the province. Bark beetle galleries are frequently associated with diseased red pine (*Pinus resinosa* Ait.). They are less common in eastern white pine (*P. strobus* L.), jack pine (*P. banksiana* Lamb.), Scots pine (*P. sylvestris* L.), black spruce (*Picea mariana* (Mill.) B.S.P.), red spruce (*P. rubens* Sarg.), and white spruce (*P. glauca* [Moench] Voss). The presence of insect galleries on branches and stems of conifers infected by *G. abietina*, particularly where the entrance holes are adjacent to fruiting bodies of the fungus, is indicative of a possible vector-pathogen relationship. To determine whether or not adults of the bark beetles are contaminated with *G. abietina*, isolations from some insects were made during the summer of 1979.

Dead red pine branches showing entrance holes of insect galleries were collected on 13 June and 12 September near Matane, and on 4 and 30 July and 9 and 24 August near Les Méchins (both in Matane County and 50 km apart). The branches collected on 13 June had died approximately a year before and bore mature pycnidia of *G. abietina*, and the remaining branches had died during the spring of 1979. On 13 June it was cloudy with showers, but the other collection days were sunny. Branches were brought to the laboratory and stored in a dark cold-room at 2°C. Within 24 h they were examined in a lighted room at 20°C and isolations were attempted from the bark beetle adults present. The bark near gallery entrances was lifted, either with a sterile scalpel or a

needle, and the exposed adult was deposited with a needle on a sterilized 5 x 5 cm² piece of paper. When the adult had advanced to the edge of the paper, it was held above an open petri dish containing 30 mL of 3% malt agar, and the insect dropped to the medium. The dish was immediately closed. After 30 min the dish was inverted and opened, and the insect was removed with a sterile needle. The plates were incubated in a dark cold-room at 10°C. The 81 insects involved were placed individually in vials and numbered for identification purposes. Sixty-three were identified as *Orthotomicus caelatus* Eichh. and 18 as *Pityophthorus* sp. Because of the complexity of the genus *Pityophthorus* Eichh. and the small number of specimens available, no attempt was made to identify them to species. Table 1 gives the percentage of adults plated from each of the six collections.

The isolations demonstrated that adults of both *O. caelatus* and *Pityophthorus* sp. are carriers of *G. abietina*. Sixty-two percent of the *Pityophthorus* adults collected on 13 June were contaminated with the fungus (Table 1), whereas 7 to 46% of *O. caelatus* adults collected from 4 July to 12 September carried it. It is interesting to note that *O. caelatus* is contaminated with *G. abietina* for a longer period than reported for spore discharge. In central Quebec, spores of *G. abietina* occurring on jack pine are discharged from the first week of May to the first week of August, the maximum occurring in the third week of June (Smerlis, Bi-mon. Res. Notes 24:10, 1968). The time difference might be phenological. It is also possible that toward the end of summer, adults of *O. caelatus* are contaminated with mycelial fragments or that conidia are formed on the mycelium in insect galleries.

In addition to *G. abietina*, several other fungi were isolated from the adults of *O. caelatus* and *Pityophthorus* sp. (Table 1). Six of these are known to be causal agents of cankers or diebacks of various species of conifers. Pathogenicity has been demonstrated for *Leucostoma kunzei* (Fr.) Munk (Waterman, Phytopathology 45:686-691, 1955; Lavallée, Can. J. Bot. 42:1495-1502, 1964), *Potebniamyces coniferarum* (Hahn) Smerlis (Hahn, Plant Dis. Rep. 41:623-633, 1957; Smerlis, Can. J. Forest Res. 3:7-16, 1973), *Scolecnectria cucurbitula* (Tode ex Fr.) Booth (Smerlis, Plant Dis. Rep. 53:979-981, 1969), *Sydowia polyspora* (Brev. & v. Tav.) E. Müll. (Smerlis, Can. J. Bot. 48:1613-1615, 1970), and *Tympanis hypopodia* Nyl. and *T. laricina* (Fckl.) Sacc. (Smerlis, Phytoprotection 51:47-51, 1970).

Of the two species of bark beetles plated, *Pityophthorus* sp. is the more common. It was present in 93% of the 27 samples collected in 1979 from eastern white pine, jack pine, Scots pine, red pine, black spruce, red spruce, and white spruce. *Orthotomicus caelatus* was present in 22% of the samples, and it was found only on jack pine and red pine.

The genus *Pityophthorus* is large, containing about 50 species in Canada alone, nearly all of which attack dead or dying twigs and small branches of coniferous trees. Many of the species are so similar taxonomically that they are difficult to separate, and as a result their seasonal history and habits are not well known.

Orthotomicus caelatus is a common bark beetle found in spruces and pines throughout Canada (Bright, Can. Dep. Agric., Publ. 1576, 1976). It is not considered of economic importance, since it normally invades only dead or dying trees. Its occurrence in twigs as reported

TABLE 1
Fungi isolated from *Orthotomicus caelatus* and *Pityophthorus* sp., and the percentages of adults contaminated

Fungi isolated	Percentages of adults contaminated									
	13 June*		4 July		30 July		9 August		24 August	
	A(2)**	B(13)	A(13)	B(0)	A(11)	B(1)	A(14)	B(0)	A(12)	B(4)
<i>Alternaria</i> sp.			15		18				8	
<i>Epicoccum purpurascens</i> Ehrenb. ex Schlecht.			8						8	
<i>Leucostoma kunzei</i> (Fr.) Munk	100		92		82		79		83	50
<i>Lophium mytilinum</i> (Pers.) Fr.		8			9		7		8	25
<i>Gremmeniella abietina</i> (Lagerb.) Morelet		62	23		46		7		8	
<i>Penicillium</i> spp.		15	23		9					9
<i>Potebniamyces coniferarum</i> (Hahn) Smerlis			8		18				8	
<i>Scolecnectria cucurbitula</i> (Tode ex Fr.) Booth	50	15	54		36	100	7		50	27
<i>Strasseria geniculata</i> (Berk. & Br.) Höhn.			8						8	
<i>Sydowia polyspora</i> (Brev. & v. Tav.) E. Müll.	100	69	46		36		21		25	25
<i>Tympanis hypopodia</i> Nyl.										46
<i>T. laricina</i> (Fckl.) Sacc.			8							37
Unidentified		15	23		27		57		42	9

*Date of collection.

**A(2) = *Orthotomicus caelatus*, two adults plated; B(13) = *Pityophthorus* sp., 13 adults plated.

here is unusual, for it is found mainly in the thick bark of trees and stumps.

In view of the potential importance of these bark beetles as vectors of disease-causing fungi, further work should be done to determine their seasonal history, habits, and ability to transmit *G. abietina* and other pathogens to healthy trees.—E. Smerlis and R.J. Finnegan, Laurentian Forest Research Centre, Ste.-Foy, Que.

Occurrence of the Introduced Sawfly *Acantholyda erythrocephala* (L.) in Ontario.—This European web-spinning sawfly was first reported in Canada by Eidt and McPhee (Bi-mon. Prog. Rep. 19(4):2, 1963). McPhee collected seven larvae from mugho pine (*Pinus mugho* Turra var. *mugho* Zenari) in Scarborough Township in 1961. These were reared and identified by D.C. Eidt as *A. erythrocephala*. The insect had been reported earlier feeding on red pine (*Pinus resinosa* Ait.), white pine (*P. strobus* L.), mugho pine, Scots pine (*P. sylvestris* L.), Japanese red pine (*P. densiflora* Sieb. & Zucc.), and Austrian pine (*P. nigra* Arnold) in New Jersey and Pennsylvania (Griswold, Rev. Appl. Entomol. (A) 27:651, 1939), having been first found in North America

at Chestnut Hill, Pa., in 1925 (Wells, Rev. Appl. Entomol. (A) 14:641, 1926). In Ontario it is significant because it causes serious defoliation of pines, which are planted extensively in the province.

TABLE I
Number of collections of *A. erythrocephala* recorded by the Forest Insect and Disease Survey in Ontario

Stage	May	June	July	August	Total
Egg	6	1			7
Larva	4	19	5	1*	29
Pupa					
Adult	4	1			5

*This collection was from Kenora District.

A brief description of the life history follows. Adults emerge in the second half of April or early in May. Three to ten eggs are embedded in slits cut in a row on the flattened surface of pine needles of the previous year's growth. The egg stage lasts about 22 days. Newly hatched larvae spin a loose web at the base of the needles, within which they feed gregariously. Larvae in later instars spin silken tubes, in which they feed for 2 to 3 wk between early May and late June. After feeding, the fully grown larvae drop to the ground and form earthen cells 5 to 8 cm

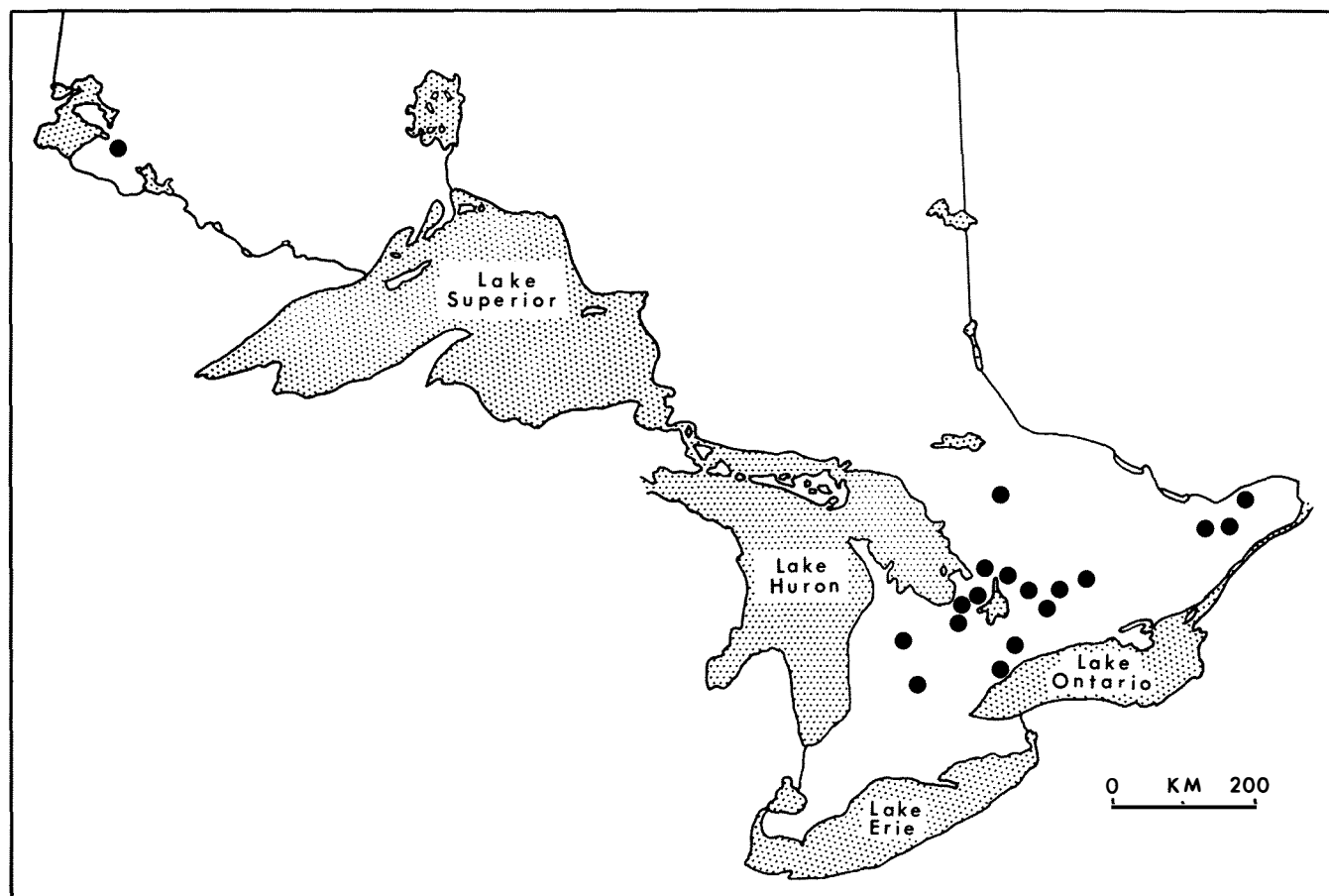


Figure 1. The distribution of *Acantholyda erythrocephala* (L.) in Ontario.

beneath the surface. The prepupal stage lasts until March or early April.

In recent years, records of the Great Lakes Forest Research Centre's Forest Insect and Disease Survey Unit have shown that *A. erythrocephala* is becoming more common and that it now occurs in Ontario south of a line joining Parry Sound and Ottawa and in the Lake of the Woods area in northwestern Ontario (Fig. 1). On the basis of this distributional information and in view of the occurrence of this sawfly in the Lake States (Wilson, page 30 in A guide to insect injury of conifers in the Lake States, USDA Agric. Handb. 501, 1978), it is concluded that spread to northwestern Ontario has been by way of Michigan and Minnesota rather than through Ontario north of Lake Superior. The seasonal distribution of various stages collected is shown in Table 1.

This insect is proving to be troublesome on pines grown as ornamentals or as Christmas trees in various parts of southern Ontario. Heavy infestation destroys the market value of affected Christmas trees in the proposed year of sale. No chemical is yet registered for use in controlling this introduced pest.—Paul D. Syme, Great Lakes Forest Research Centre, Sault Ste. Marie, Ont.

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- 5 **Whitney, R.D. 1978.** *Polyporus tomentosus* root and butt rot of trees in Canada. Pages 283-297 in *Proc. 5th Int. Conf. on problems of root and butt rot in conifers.* Kassel, Germany. 7-12 Aug., 1978.
- 9 **Wilson, G.G. 1979.** Effects of *Nosema disstriae* (Microsporidia) on the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae). *Proc. Ent. Soc. Ont.* 110:97-99.
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