Plantation Research: VIII. The pine needle midge, <u>Contarinia baeri</u> (Diptera: Cecidomyiidae), a new insect pest of Scots pine.

by

R.F. DeBoo and L.M. Campbell

Chemical Control Research Institute, Ottawa, Ont.

and

J.P. LaPlante and L.P. Daviault

Laurentian Forest Research Center, Quebec, P.Q.

Chemical Control Research Institute

Canadian Forestry Service

Ottawa, Ontario

Information Report CC-X-41

August, 1973.

TABLE OF CONTENTS

INTRODUCTION

Severe and unique defoliation of current-year shoots occurred on Scots pine (*Pinus sylvestris* L.) Christmas trees in Quebec's Eastern Townships from 1968 (Martineau and Ouellette 1969) to 1972 (Lavallée and Benoit 1973). The loss of this foliage abruptly curtailed the sale of thousands of otherwise marketable trees. Concerned growers there and at other locations in Quebec and eastern Ontario (where the problem was first reported in 1971) requested assistance from the Canadian Forestry Service in the identification of the causal organism and recommendations for appropriate control methods.

Preliminary examination of larvae from branch collections by staff at the Laurentian Forest Research Center indicated that this loss of foliage was caused by an undetermined species of midge (Cecidomyiidae). Subsequent reviews of available forest insect survey records and published literature, however, did not reveal any pertinent information describing the activity of a non-gall forming species of pine midge fitting the recent observations made in Quebec and Ontario. An unpublished report by Reeks and Smith (1956) on midge defoliation of red pine (*P. resinosa* Ait.) in New Brunswick and Nova Scotia was the sole Canadian reference found with descriptions that approximated these observations. Other reports by Davis (1939), Haddow (1941), Patton and Ricker (1954), Toko (1954), and Kearby and Benjamin (1963, 1964), describing types of pine needle blight, droop, and midge attack were primarily on problems specific to red pine.

Since rearing of larvae to adults for identification purposes proved difficult, and since knowledge of applied control methods for defoliating pine midges in general was lacking, a cooperative research program was initiated in 1971 by the Chemical Control Research Institute and the Laurentian Forest Research Center. Major objectives were to:

(1) Assist in the identification of the midge species infesting Scots pine in Quebec and Ontario.

(2) Contribute to the knowledge of the biology of the insect through observations on its life history and habits in Scots pine plantations.

(3) Evaluate feeding impact in Scots pine Christmas tree and (non-sheared) amenity plantings.

(4) Develop methods for chemical control of the midge in high-value plantations.

This report, then, summarizes recent work on an insect pest problem new to the production of quality Scots pine. It is hoped that the report will be of assistance to those growers and forestry extension personnel within the infested areas of the two provinces for the implementation of appropriate control programs as warranted.

SYSTEMATIC POSITION, WITH REFERENCE TO THE CANADIAN SITUATION

Collections of larvae from infested trees in both Quebec and Ontario were reared under controlled laboratory conditions, at the Laurentian Forest Research Center and at the Chemical Control Research Institute for production of adult specimens. Of the several rearing attempts made, none were successful mainly due to heavy parasitism by a small wasp (*Tetrastichus* sp.). Adults were obtained, however, from cages installed under trees in Quebec plantations. These, along with larval specimens collected from foliage of trees at locations in Quebec and Ontario were submitted for identification to the U.S. National Museum via the Biosystematics Research Institute, Canada Agriculture, Ottawa. Also specimens were collected by

W.A. Reeks in 1953 from red pine in New Brunswick (C.N.C. Lot 53-576) were submitted for comparison with these recent collections from Scots pine. It was determined after intensive examinations that all specimens were of the same species:

Order	:	Diptera
Family	:	Cecidomyiidae
Genus	:	Contarinia
Species	:	baeri (Prell 1931)

The insect apparently is well known in Europe (Barnes 1951, Browne 1968). There, it is commonly referred to as the "needle-bending pine gall midge" - an obviously misleading designation since galls do not occur as a result of feeding. A more appropriate and simpler designation would be "pine needle midge" in reference to the feeding location and preferred host trees.

The occurrence of the insect in North America is new, and quite possibly has been introduced through the importation of nursery stock. As very little Scots pine was planted in New Brunswick during the 1950's, it is also possible that two or more separate introductions have occurred, accounting for the disparities in time, host plants, and geography between the two recorded Canadian infestations. Alternatively, there exists the remote possiblity that the New Brunswick infestation has spread westward to Quebec and Ontario via tree shipments, and has recently re-established on the preferred European host, Scots pine, in these provinces. In any case, a new insect pest of European origin may now be included in the growing list of problems facing Canadian growers of Scots pine.

KNOWN DISTRIBUTION ON SCOTS PINE

The known distribution of the pine needle midge on Scots pine extends from the Eastern Townships and the Laurentian Playground area north of Montreal in Quebec westward to Ottawa, Kemptville, and several other tree producing localities in southeastern Ontario (Fig. 1). Previous Canadian Forestry Service survey records do not clearly indicate the occurrence of the species elsewhere. Records citing "needle droop" are common, however, and it is highly probable that the insect occurs as far west as Sault Ste. Marie in Canada, and in most of the border States in the U.S. (Maine, New Hampshire, Vermont, New York).

In the Maritime Provinces, the insect is known to occur near Parker's Ridge and Fredericton, N.B., and near Lorne, Picton Co., N.S. (Reeks 1954, Reeks and Smith 1956). All collections from the Maritimes, however, have been made from red pine.

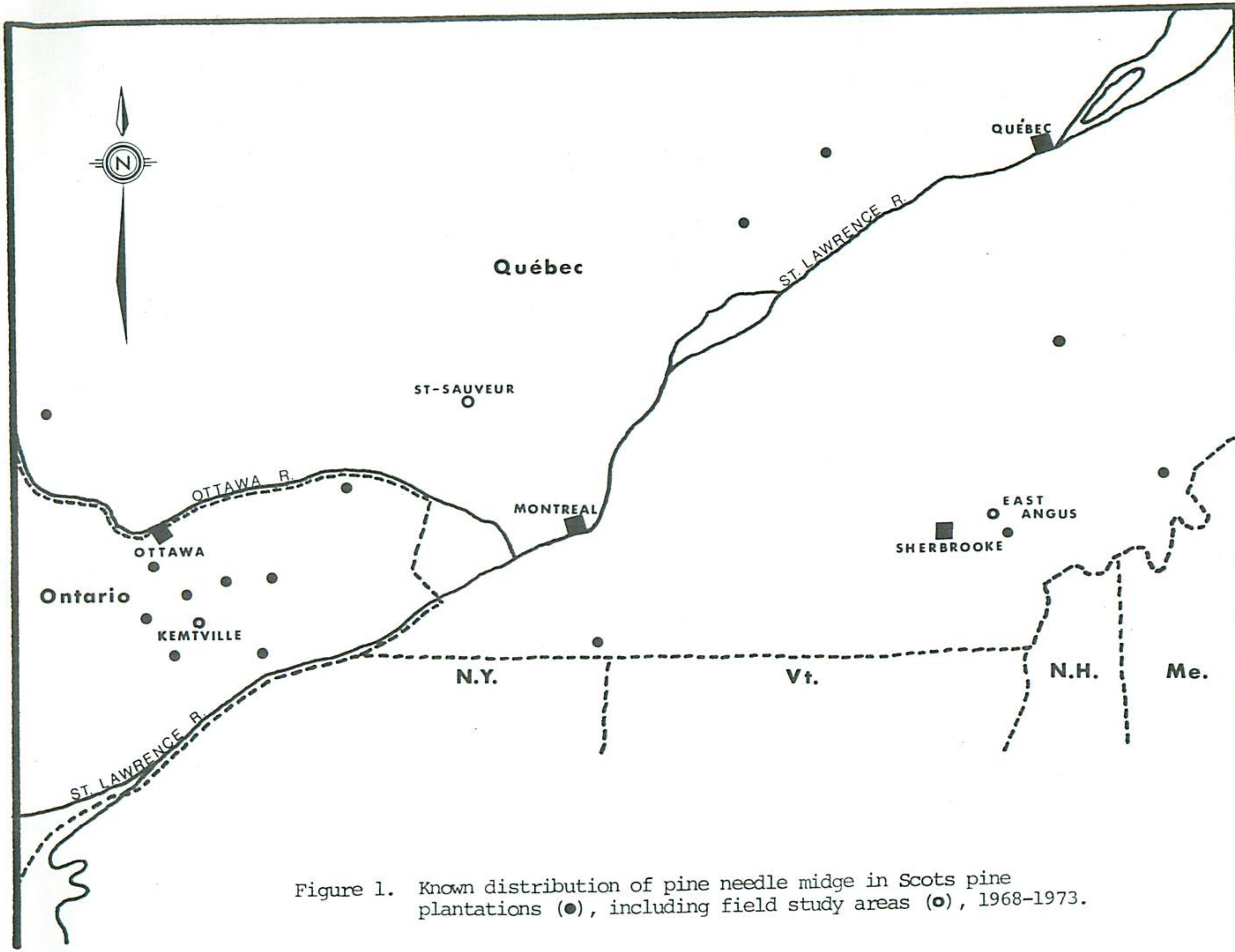


Figure 1. Known distribution of pine needle midge in Scots pine plantations (●), including field study areas (o), 1968-1973.

DESCRIPTION OF LIFE STAGES

Prell (1931) has described the species from European collections while Reeks and Smith (1956) have described the various life stages based on the New Brunswick collections. Microscopic examinations of the various taxonomically important structures of specimens collected in Quebec and Ontario indicated that those descriptions by Reeks and Smith (1956) are appropriate for inclusion here. A plate from their report (Fig. 2) is included also.

Egg. Since no eggs were found in the field, the following applies to those dissected from ovarioles of adults. Length about 0.3 mm., color yellow, chorion smooth.

Ultimate Larval Instar. Length 2.6 mm., ranging from 2.2 to 3.2 mm. Colour mostly orange. Head capsule lightly sclerotized; mostly brown; mouthparts greatly reduced; antennae apparently 3-segmented. Body subcylindrical, tapering toward cephalic end, consisting of 13 segments excluding the head. These represent the supernumery segment, pro-, meso-, and meta-thoracic segments, and nine abdominal segments; dorsomeson almost straight to slightly concave, and ventromeson convex. Cuticle smooth; the last abdominal segment terminating in a pair of forked outgrowths, each supporting two short, thick spines. Sternal spatula or breast bone distinct, located on the ventromeson of the prothorax; length of spatula of 28 specimens 0.16 ± 0.02 mm.; heavily sclerotized, cephalic end bifurcate and notched on each side, caudal end bulbous. Respiratory system peripneustic, with a pair of spiracles on the prothorax and all abdominal segments except the seventh. Spiracles minute, slightly raised, and those on the eighth abdominal segment somewhat larger and projecting caudally; the spiracles of the prothorax and eighth abdominal segment dorsad of the spiracular line. Larva in cocoon somewhat shortened.

Cocoon. Variable in shape but generally irregularly ovoid, about 2 mm. in length and 1 mm. in width; whitish to greyish-white, translucent with larva visible through the cocoon.

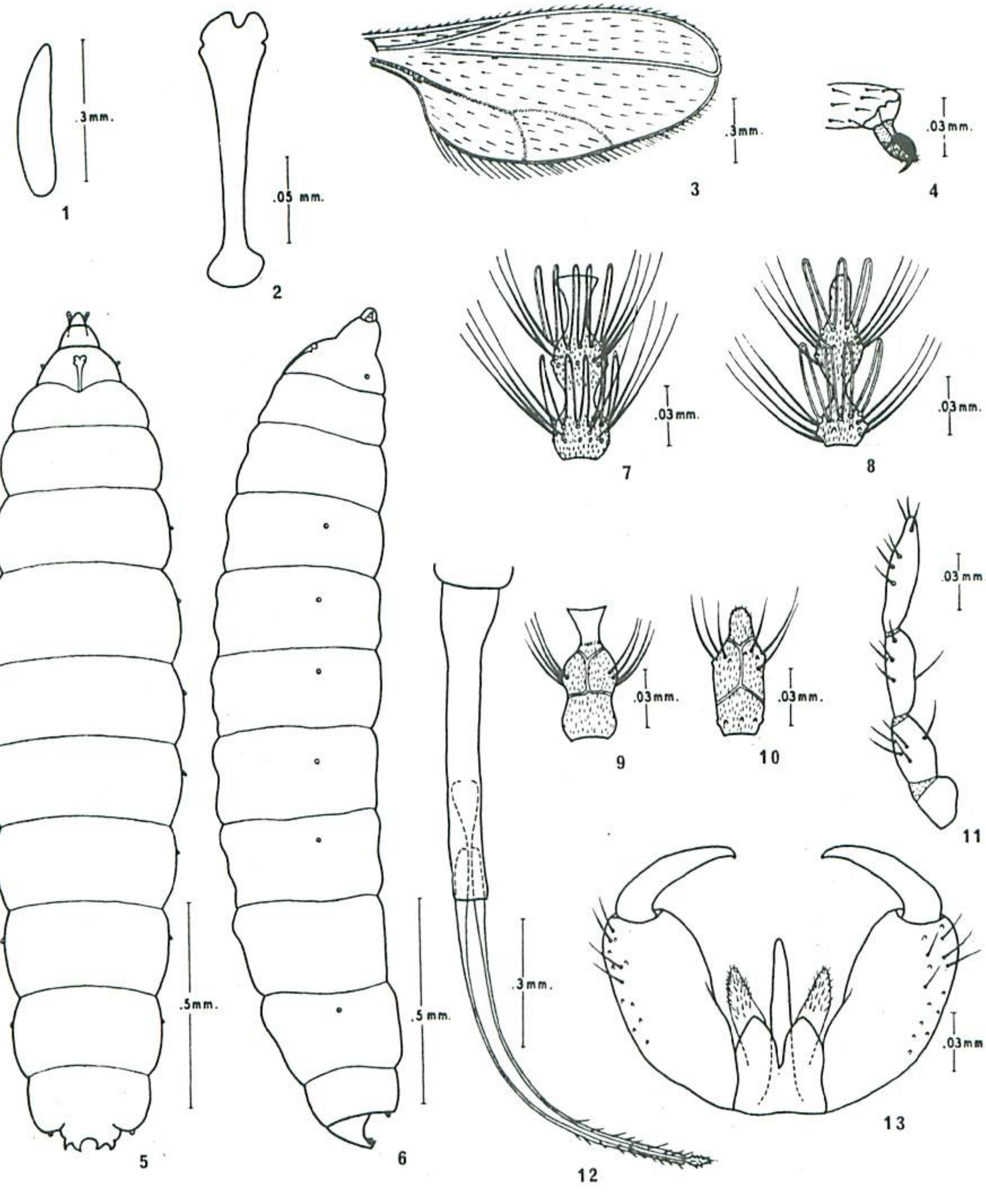
Pupa. Length about 1.6 mm. Exarate, stout, roughly ovate, dorsomeson of abdomen tending to be carinate. Colour yellowish-orange to orange, eyes reddish; wing pads, antennae, legs, and parts of thorax becoming fuscous to yellowish brown and eyes black with advanced development. Cephalic and thoracic horns well developed.

Female Adult. Length about 1.7 mm. excluding extended ovipositor. Head mostly black, with frontal area and mouthparts yellowish. Eyes black, holoptic. Antennae with 14 segments; two proximal segments, small, subglobose; remaining segments flagellate, with the third and fourth fused; flagellate segments subcylindrical, but with a distal constriction forming a stem; proximal portions of flagellate segments bearing long tapered setae, many short setae, sensoria, and faint, opressed circumfilia. Labial palpi 4-segmented as in male, sparsely setose; first segment short and third elongate.

Thorax brownish, with membranous areas yellow. Wings hyaline, slightly fumose; wing membrane lightly haired and hind margin strongly fringed; costa interrupted at its union with the third vein near the apex of the wing, not scaled or thickenedproximally; subcosta uniting with the costa near the proximal half of the front margin of the wing. The third vein strongly developed but not forked; fourth vein and cross veins apparently absent; fifth and sixth veins weakly developed and apparently fused but forking near the hind margin. Halteres yellow proximally, slightly fumose distally. Legs very long and slender, strongly haired; coxa, short, brownish; trochanter and outer surface of femur, tibia, and tarsus brown, inner surface yellowish; tibial spur absent; tarsus 5-segmented, first segment about one-fifth length of second; tarsal claw simple, strongly curved; pulvillus (empodium of some authors) almost as long as tarsal claw.

Abdomen mostly yellowish, with tergites more fuscous-brown, and fringed with long hairs. Ovipositor yellow; when fully extended about equal to body in length; sparsely clothed with fine setae distally, and produced apically with a pair of sub-triangular, sparsely setose lobes.

Male Adult. Length about 1.5 mm. Antennae 14-segmented, with third and fourth segments fused. Flagellate segments with distal contruction as in female and a second constriction near the proximal third; very long, tapered setae and two multi-looped circumfilia on flagellate segments. Wings more heavily fringed caudally than in female, and legs more heavily haired. Genitalia brownish; basal clasp segment stout, not lobed; terminal clasp segment slender, terminating in single tooth; dorsal plate bilobed; lateral angles of ventral plate projecting beyond lobes of dorsal plate; style straight, long, about three quarters of the length of the basal clasp segment. Other characters similar to female.



1. Egg dissected from adult.
2. Sternal spatula of larva.
3. Wing of female.
4. Prothoracic tarsal claw of female adult.
5. Ventral view of larva removed from needles.
6. Lateral view of larva.
7. Fifth antennal segment of male adult.
8. Ultimate antennal segment of male adult.
9. Fifth antennal segment of female adult.
10. Ultimate antennal segment of female adult.
11. Labial palpus of male adult.
12. Ovipositor.
13. Dorsal view of male genitalia (diagramatic)

Figure 2. Some morphological features of the life stages of <u>Contarinia baeri</u> (from Reeks and Smith 1956).

LIFE HISTORY AND HABITS

Adult midge collections obtained from traps placed over ground litter (Fig. 3) indicated that emergence activity commences during late June and peaks during the first week of July within the boundary of the known distribution in Quebec and Ontario. Eggs were not found during the course of the study, but it is suspected that deposition occurs in the area of the needle sheaths on new shoots.

Larvae were first observed during the last week of June when the pine shoots had attained approximately 2/3 to 3/4 of their ultimate length and when the foliage was extended at about a 45° angle from the shoot axis (Fig. 6.). At first, two to five larvae were found commonly between needle pairs within the sheathed area. Later, however, usually only one larvae was found at these feeding sites. Feeding appeared to be restricted to the interior flat surface at the needle base where a resinous lesion is produced. Feeding was normally completed by early- to mid-August, although a small number of larvae may continue feeding into September and October. The ultimate instar larvae spin cocoons (Fig. 4) and overwinter within this protective enclosure between needles. Since the bulk of the foliage on which larvae feed ultimately drops to the ground, most larvae pupate there during June of the following year to complete the univoltine life cycle (Fig. 5). The fate of other larvae, which may remain in needle fascicles suspended in tree crowns, is unknown.

The life cycle, as observed during the course of the present study, is similar to that observed by Reeks and Smith (1956). Barnes (1951) however, has indicated that two generations may occur annually in Europe.

Figure 3. Wooden ground litter cages with vial traps at the St-Sauveur-des-Monts plantation.

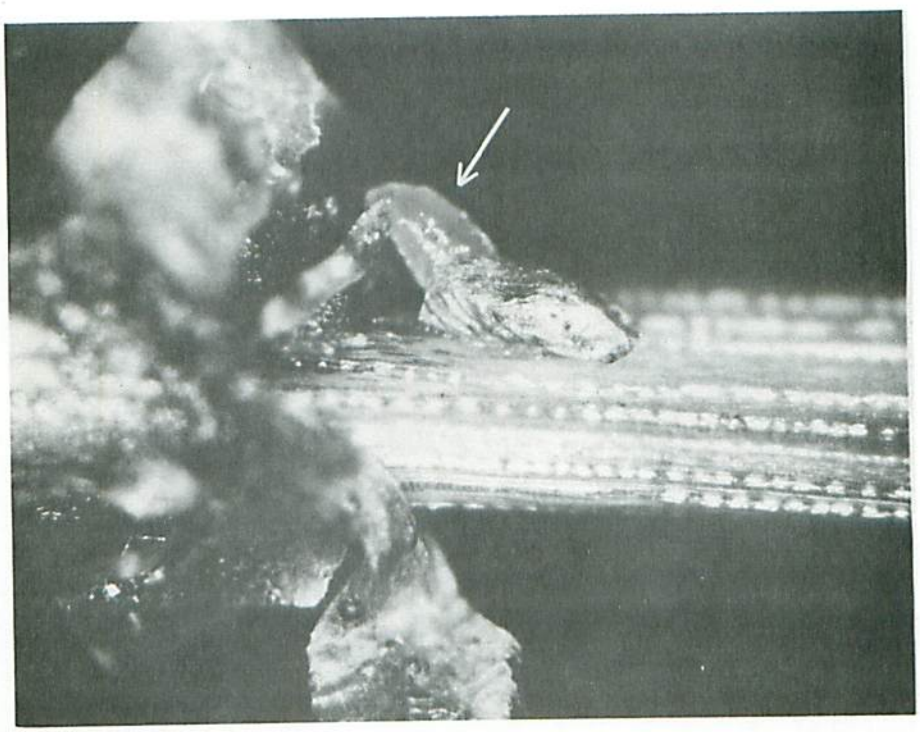


Figure 4. Overwintering larva of Contarinia baeri (cocoon peeled back).

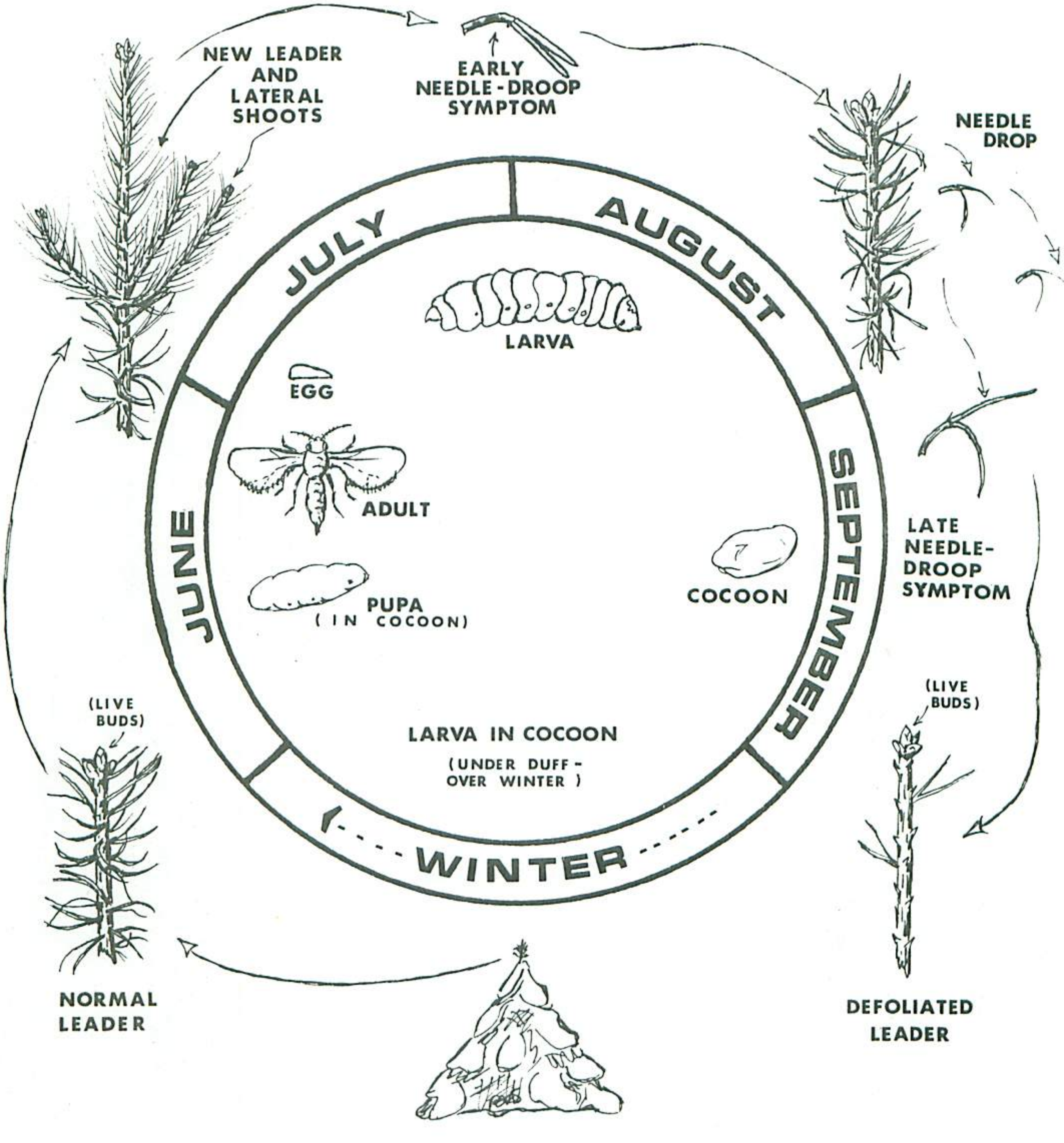


Figure 5. Life cycle of Contarinia baeri with graphic representation of life stages (not to scale) and damage to the leader of a Scots pine Christmas tree.

SYMPTOMS OF ATTACK AND INJURY TO SCOTS PINE HOST TREES

Although larvae are very small and not readily visible, early symptoms of attack are quite characteristic and indicative of the species. At first, only a slight droop of one needle is apparent (Fig. 6). Separation of the needles and examination of the needle base indicated a characteristic longitudinal lesion (Fig. 7) caused by the feeding of one or more larvae. Soon thereafter browning of the needle occurs and tissue in the vicinity of the lesion attenuates and dies (Fig. 8), thereby enhancing characteristic drooping.

By late July, infested foliage becomes detached from shoots by wind and drops to the ground or snags into lower living foliage and branches.[1] The result is a thinning of foliage of new shoots under light and moderate attack (Fig.10) or complete defoliation of shoots under conditions of severe infestation (Fig. 9). Because population distribution appeared to be concentrated within the upper third of tree crowns, most of the observed defoliation was restricted to this zone. Defoliation throughout the crown was found only on a few unsheared amenity plantings. The problem for Christmas tree growers, then, is primarily the loss of foliage on the leaders and upper branches of trees which have been carefully trimmed and shaped for market.

Examinations of shoots one year after severe attack showed only slight mortality due to defoliation by the midge. Only a few non-vigorous shoots died on non-sheared trees. Leaders of Christmas tree stock mostly survived also, to produce the desired annual complement of shoots and

---

[1] Fruiting bodies of the fungus _Pullularia pullulans_ deBary are found commonly on cast foliage.

foliage. Since two successive years of complete defoliation was observed on only a few trees, chances of top-killing and complete-tree mortality appeared to be slight. High population levels of the midge were found to persist for 3 or 4 years, but locations of attack centers varied from year-to-year within plantation boundaries. The total impact of midge defoliation observed during the course of the study, therefore, was basically non-detrimental to tree survival; the loss of foliage on Christmas trees and amenity plantings rendered many trees temporarily unsightly and unsaleable, however.

Reeks and Smith (1956) have shown that Contarinia infestations are of short duration (Table I), but that two years of severe defoliation may occur at certain locations within plantations. These observations were confirmed at several locations in Quebec and Ontario.

TABLE I

Defoliation of red pine by Contarinia and associated factors at Parker's Ridge, N.B. (from Reeks and Smith 1956).

Location	No. Trees	Defoliation of current foliage in percentage						
		1948	1949	1950	1951	1952	1953	1954
Epicenter	40	3	35	78	98	10	trace	0
Periphery	10	0	0	50	55	47	trace	trace

Exotic and native pines established near Scots pine plantations selected for examination were usually found to be free of symptoms and signs associated with attack by this midge. Only at one location were red pines found to have foliage droop similar to that associated with midge attack. Observations at this location (near an infested Scots pine Christmas tree plantation adjacent to Uplands Airport at Ottawa) were made in late autumn, 1972, but neither collections of insect specimens nor subsequent investigations in this area have been made.

In addition to Scots pine, Barnes (1951) lists pitch pine (*Pinus rigida* Mill) as a probable European host in addition to species of spruce (*Picea*) and fir (*Abies*).

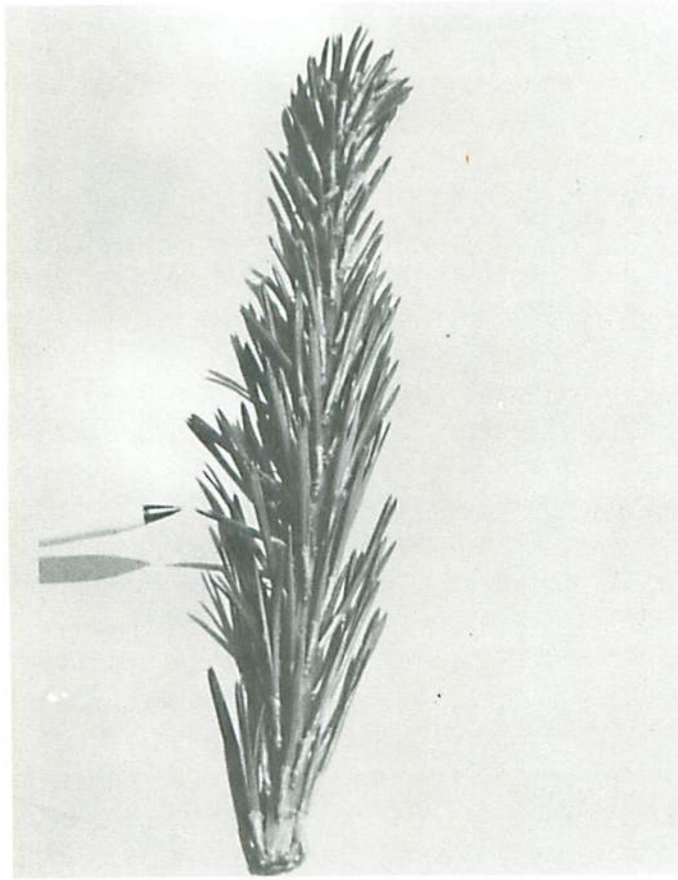


Figure 6. Early symptom of attack: needle droop.

Figure 7. Feeding lesion caused by larva of <u>Contarinia</u> <u>baeri</u>.

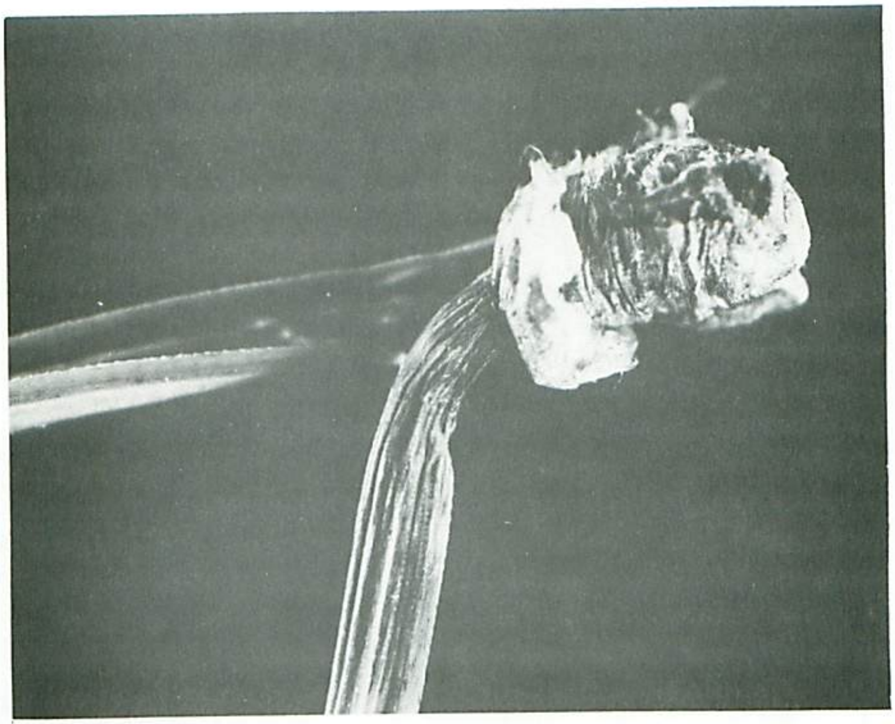


Figure 8. Tissue dessication and mortality of a Scots pine needle caused by Contarinia baeri.

Figure 9. Severe defoliation of unsheared ornamental Scots pine shoots.

Figure 10. Defoliation on leader of a Scots pine Christmas tree.

NATURAL CONTROL

A larval parasite, Tetrastichus sp. (Hymenoptera: Eulophidae), is probably the most important natural agent of population suppression in Quebec and Ontario. Heavy parasitism was observed in several collections of midge larvae from trees that were infested for 2-3 years (Table II). It is suspected that this parasite may be the key factor in terminating pine needle midge outbreaks.

The effects of other parasites, predators and weather on populations of the pine needle midge infesting Scots pine in Quebec and Ontario are unknown.

TABLE II

Parasitism of *Contarinia baeri* by *Tetrastichus* sp., based on laboratory-reared collections.

Location, Date	No. *Contarinia* larvae reared	No. *Contarinia* adults recovered	No. *Tetrastichus* parasites recovered	Mortality other causes
Cookshire, Que. 1969	17	0	9	8
East Angus, Que. 1970	65	0	59	6
East Angus, Que. 1970	35	0	30	5
East Angus, Que. 1970	Unknown (200-300 needle pairs)	0	676	-
St. Sauveur-des-Monts., Que. 1971	60	0	39	-
Kemptville, Ont., 1971	131	0	117	-

SILVICULTURAL CONTROL

When localized infestations have occurred on a few 4- to 8-ft. Christmas trees selected for harvest, some growers have successfully eliminated the defoliated shoots by hand clipping just prior to cutting and baling for market. This method is not practical, however, where infestations are widespread, when trees are larger than 8 ft. in height, or for untrimmed ornamental plantings.

CHEMICAL CONTROL EXPERIMENTS

Areas selected for field studies included Christmas tree plantations near East Angus, P.Q., Kemptville and Oxford Mills, Ont. and an estate plantation at St-Saveur-des-Monts, P.Q. Christmas trees ranged from 4 to 8 ft. in height, while the unsheared trees at St-Sauveur measured approximately 20 ft. All plantations had been infested by the midge for one or more years.

Two approaches were taken in the application of insecticides: (1) Insecticides were applied as granulars or water-emulsion drenches to the ground for control of adults emerging from the duff and for subsequent translocation to the foliage for control of larvae commencing feeding, and (2) selected other chemicals were applied by knapsack sprayers to the top 1/3 of Christmas trees for the protection of the new foliage (i.e. against larval feeding) in this most susceptible portion of the crown. Applications to the soil litter were made in advance of suspected adult activity; foliar sprays were applied to coincide with the commencement of feeding by larvae.

A seed spreader and a two-piece hydraulic sprayer were used for treatments to ground litter while a variety of knapsack mistblowers and compressed-air sprayers were employed for the application of foliar sprays (Figures 11-14). All insecticides selected for application (Table III) were applied at one or two concentrations of active ingredient (a.i.), and volumes for water-based sprayers were calculated in Imperial liquid measure.

The randomized complete block design was utilized for the establishment of treatment blocks. Two replicates of 100 trees were used for each foliar treatment and two 1/10-acre blocks for each ground treatment during 1971. During 1972, treatments were made to larger numbers of trees: Two replicates of approximately 1500 trees (1 acre) comprised each treatment.

Sampling for results involved (1) the periodic collection of specimens from trap vials on four cages (each covering approximately 2 square feet) placed randomly over duff in each ground treatment plot and (2) detailed examination and counting of needles present or missing on 6-inch lengths of leaders of 20-100 trees selected at random within foliage treatment and untreated check plots. Data were later collated and summarized for efficacy ranking of spray treatments (Tables IV, V).

Evaluation of treatments indicated that 4 of the insecticides provided protection of foliage. Most foliar application of dimethoate, fenthion and malathion were effective in curtailing larval feeding (Table V) while granular applications of aldicarb caused high mortality of emerging adults (Table IV). Timing of foliar sprays was extremely important as best results of all were obtained in 1972 at the Spruce Haven farm where all treatments were made immediately after the detection of the first larvae infesting the foliage. It was suspected that foliar sprays at East Angus, and at Kemptville during 1971 may have been applied slightly early and late, respectively (Table V).

TABLE III

Insecticides selected for experimental application
(toxicological information from Kenaga and Allison 1971.)

Common Name	Trade Name®	Type of Insecticide	Formulation Used	Acute Dermal Toxicity (LD_{50}) (R=rats; Rb=rabbits)	Source
aldicarb	Temik	carbamate	10 G	Rb: 5	Union Carbide
arprocarb	Baygon	carbamate	13.9 EC	R: >1000	Chemagro
demeton	Systox	phosphate	25 EC	R: 8-200 Rb: 24	Chemagro
dimethoate	Cygon	phosphate	4 E	R: 150-1150	American Cyanamid
disulfoton	Di-Syston	phosphate	65 EC	R: 20-50	Chemagro
-	Dursban	phosphate	2.4 E	Rb: 2000	Dow
fenthion	Baytex	phosphate	45 EC	R: 275-1300	Chemagro
lindane	-	chlorinated hydrocarbon	25 WP	R: 500-1200 Rb: 300-4000	Green Cross
malathion	Cythion	phosphate	50 EC	R: >4000 Rb: 4100	American Cyanamid
trichlorfon	Dylox	phosphate	80 SPA	R: >2800 Rb: 5000	Chemagro

[1] Mention of trade names in this report implies neither endorsement nor recommendation by the Canadian Forestry Service.

TABLE IV

Results of experimental applications of insecticides to plantation ground litter for control of pine needle midge adults; treatments May 26, 27, 1971.

Treatment[1]	Rate of Application (amt. a.i./acre)	Trap collections: No. of midge adults trapped														Total No. Trapped
		May				June					July					
		8	20	25	31	7	9	17	24	30	9	13	16	23	29	
A. Eastern Quebec Christmas Tree Farms, East Angus, P.Q.																
Aldicarb	32 oz.	-	-	-	-	-	-	0	-	0	0	-	0	0	0	0
Lindane	16 oz.	-	-	-	-	-	-	0	-	0	20	-	3	1	1	25
Lindane® + Target E®	16 oz. + 1 gal.	-	-	-	-	-	-	0	-	0	39	-	7	6	-	52
Dursban® + Target E®	8 oz. + 1 gal.	-	-	-	-	-	-	0	-	0	-	-	68	6	12	86
Dursban®	8 oz.	-	-	-	-	-	-	0	-	0	83	-	30	30	-	143
Disulfoton	20 oz.	-	-	-	-	-	-	0	-	0	68	-	57	33	20	178
Untreated Check	-	-	-	-	-	-	-	0	-	0	83	-	102	20	47	252
B. W.F. Mainguy Estate Plantation, St-Sauveur-des-Monts, P.Q.																
Aldicarb	32 oz.	0	0	0	0	0	0	-	0	0	-	0	0	0	0	0
Disulfoton	20 oz.	0	0	0	0	0	0	-	0	0	1	-	3	0	0	4
Lindane® + Target E®	16 oz. + 1 gal.	0	0	0	0	0	0	-	0	16	0	-	1	0	0	17
Dursban® + Target E®	8 oz. + 1 gal.	0	0	0	0	0	0	-	0	12	61	-	29	2	2	106
Dursban®	8 oz.	0	0	0	0	0	0	-	1	2	59	-	20	32	6	119
Lindane	16 oz.	0	0	0	0	0	0	-	0	10	77	-	17	20	0	124
Untreated Check	-	0	0	0	0	0	0	-	7	9	75	-	43	11	10	155

1- Mention of trade names in this report implies neither endorsement nor recommendation by the Canadian Forestry Service. Target E® is a molasses-base adjuvant of Agway Inc., Syracuse, N.Y. See Table III for formulations of insecticides used. Treatments ranked according to efficacy.

TABLE V

Results of foliar applications of insecticides for control of the pine needle midge

Insecticide Treatment	Dosage (% a.i.)	Spray Mix (gal/acre)	No. Needle Sites Examined	No. Needles Missing	Percent Defoliation
A. Eastern Quebec Christmas Tree Farms, East Angus, P.Q.[1]					
Fenthion	0.9	15	1389	62	4.3
Malathion	2.5	17	1912	96	4.8
Dimethoate	1.0	20	1699	384	18.4
Trichlorfon	1.8	20	1534	473	23.6
Trichlorfon + Target E*	1.8	18	1611	720	30.9
Untreated Check	-	-	1283	332	20.6
B. E. Johnson Christmas Tree Plantation, Kemptville, Ont.[2]					
Malathion	2.5	16	1143	74	6.5
Dimethoate	1.0	23	1173	80	6.8
Disulfoton	1.0	17	1208	112	9.3
Demeton	1.0	20	1162	124	10.7
Arprocarb	1.0	21	1352	189	14.0
Untreated Check	-	-	1346	229	17.0
C. Spruce Haven Christmas Tree Farm, Oxford Mills, Ont.[3]					
Fenthion	0.4	72	1828	64	3.5
Fenthion	0.2	80	1909	48	2.5
Malathion	0.6	104	1745	52	3.0
Malathion	0.3	102	1629	72	4.4
Dimethoate	0.2	74	1792	70	3.9
Dimethoate	0.1	76	1622	70	4.3
Untreated Check	-	-	1667	492	29.5

* Target E @ 8 oz/gal.

1 - Knapsack mistblowers, June 23, 1971.
2 - Knapsack mistblowers, June 16, 1971.
3 - Knapsack compressed air sprayers, July 4, 1972.

Figure 11. Cyclone seed spreader used for application of granular insecticide.

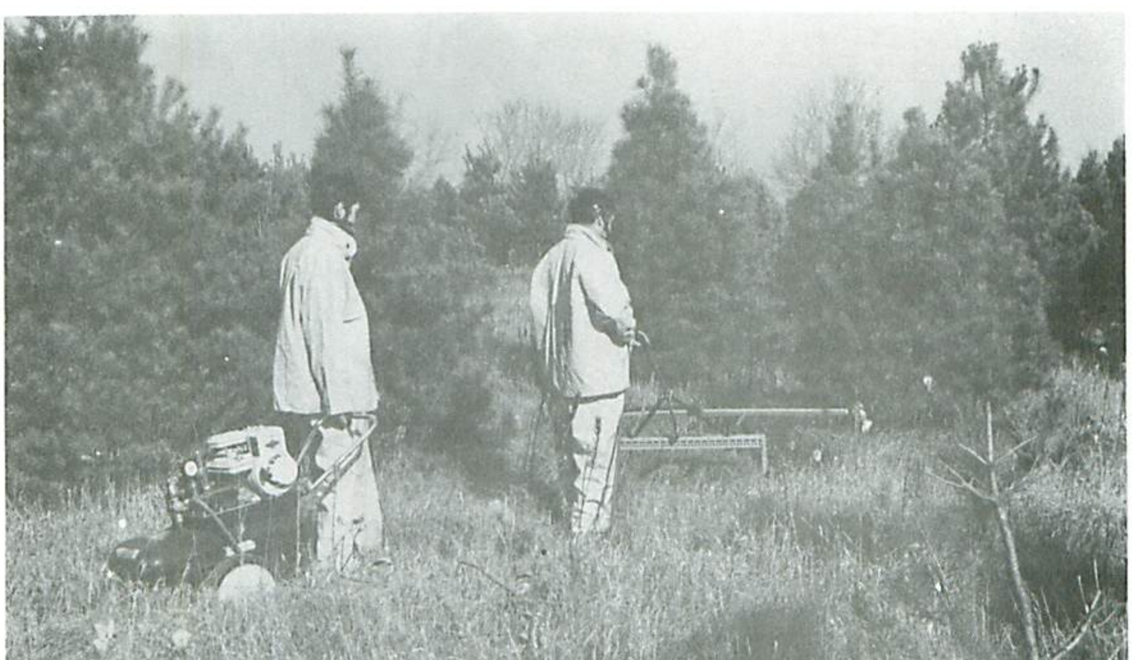


Figure 12. Application of soil drenches using a John Bean Spartan sprayer attached to a 4-ft. long boom mounted on wheels for uniform spray distribution between tree rows.

Figure 13. A knapsack mistblower for treating tree-tops. Two rows of trees are treated with each pass.

Figure 14. A variety of knapsack compressed-air sprayers used for treating tree tops; one row of trees is treated by each operator during a single pass.

DISCUSSION AND CONCLUSIONS

The identification of the species of midge infesting Scots pine in Quebec and Ontario during recent years has indicated that a new insect problem exists for growers. Periodic examinations of trees for symptoms of insect and disease attack should now include detailed observations of foliage for the needle-droop characteristic of early infestation during late June and early July.

Although extremely high parasitism by Tetrastichus sp. was associated with all midge populations collected for rearing purposes, severe defoliation of new shoots may persist for two or more years, and chemical treatment may be required particularly for the protection of Christmas trees ready for market. It is suspected, however, that the parasite may be the most important cause of ultimate decline and collapse of midge infestations.

Experimental foliar treatments with dimethoate, fenthion and malathion at conventional rates of application indicate that good protection can be attained during the attack years. Timing of sprays is extremely important, however. Application of aldicarb granules to plantation duff also apparently will provide high mortality of emerging adults. It is expected, therefore, that concerned tree farmers should have little difficulty with the midge problem, providing appropriate application methods and precautions are used for any of the three chemicals applied as foliar sprays. Aldicarb granular treatments, because of the high dermal toxicity, should be restricted to use by licensed applicators or for the protection of trees in commercial nurseries.

Future studies of this important new pest of Scots pine should include detailed investigations of (1) the life history and habits, (2) the importance of natural enemies such as the parasite Tetrastichus sp. as factors in population suppression, (3) laboratory methods for rearing larvae to adults,

(4) the North American distribution and host species, (5) and the refinement of applied control methods.

ACKNOWLEDGEMENTS

We wish to thank Mrs. T. Arcand and Mr. C. Monnier, L.F.R.C., for their valuable assistance in laboratory rearings; Dr. J.F. McAlpine, Biosystematics Research Institute, Ottawa, and Dr. R. Gagné, U.S. National Museum, Washington, for assistance in identification of the midge, and Messrs. D. Dyer, R. Ostiguy and C. Nordin, summer assistants at C.C.R.I., for their hard work during spray treatments. Mr. M.J. Hildebrand, C.C.R.I., Dr. A.D. Tomlin (presently with Canada Agriculture, London, Ont.), and Mr. B.G. Sutherland (presently with Environment Canada, Winnipeg, Man.), also assisted during field studies.

Mr. W.A. Reeks provided valuable background information on pine midges. His assistance during the course of the study and permission to use portions of his unpublished report on the New Brunswick investigations are greatly appreciated. Thanks are also extended to staff of the Forest Insect and Disease Survey, C.F.S., at Fredericton, Quebec and Sault Ste. Marie for their collaboration in the study.

Mr. M. Biddell, Graphic Services, Environment Canada, Ottawa, was responsible for the excellent close-up photographs of the midge and its associated damage.

Finally, our sincere thanks are extended to the tree growers for their excellent cooperation during the field investigations, to the manufacturers of the pesticides evaluated for their collaboration in the control phase of the study, and to the reviewers of the manuscript (W.W. Hopewell and P.C. Nigam, C.C.R.I., R. Martineau, L.F.R.C., and W.A. Reeks) for their criticism and comment.

LITERATURE CITED

Barnes, H.F. 1951. Gall midges of economic importance. Vol. V. Gall midges of trees. Crosby, Lockwood, London, pp. 60-64.

Browne, F.G. 1968. Pests and diseases of forest plantation trees. Clarendon Press, Oxford, p. 139.

Davis, W.C. 1939. Needle droop of pine. J. For. 37: 884-887.

Haddow, W.R. 1941. Needle blight and late fall browning of red pine, Trans. Royal Can. Inst. 23(2): 161-189.

Kearby, W.H. and D.M. Benjamin. 1963. A new species of Thecodiplosis (Diptera: Cecidomyiidae) on red pine in Wisconsin. Can. Ent. 95: 414-417.

Kearby, W.H. and D.M. Benjamin. 1964. The biology and ecology of the red pine needle midge and its role in fall browning of red pine foliage. Can. Ent. 96: 1313-1322.

Kenaga, E.E., and W.E. Allison. 1971. Commercial and experimental organic insecticides. Bul. Ent. Soc. Amer. 15: 85-148 (Revision).

Lavallée, A., and P. Benoit. 1973. Insectes et maladies des arbes, region de Québec - 1972. Laurentian Forest Research Centre, Canadian Forestry Service, Environment Canada, p. 10 (published in collaboration with la revue Forêt-Conservation 39, No. 4).

Martineau, R. and G.B. Ouellette. 1969. Cecidomyid on Scots pine. In Annual Rept. of the Forest Ins. and Dis. Survey. Quebec Region. Can. Dept. Fish. and For., pp. 44.

Patton, R.F. and A.J. Ricker. 1954. Needle droop and needle blight of red pine. J. For. 52: 412-418.

Prell, H. 1931. "Die nadelknickende Kieferngallmücke (Cecidomyia baeri n. sp.), ein verbreiteter neuer Kiefernschadling", Tharandt. forstl. Fb., 82, 36-52.

Reeks, W.A. 1954. Damage to red pine by a midge. Can. Dept. Agr. Div. For. Biol., Bi-Mthly. Prog. Rept. 10(3):1.

Reeks, W.A. and C.C. Smith. 1956. Observations on a midge, Contarinia sp., attacking red pine in a New Brunswick plantation, 1951-1955. Can. Dept. Agric., For. Biol-Div., Int. Rept. 1956-1, 22 pp. (unpublished).

Toko, H.V. 1954. A preliminary investigation of a gall midge (Itonidae) attacking red pine (Pinus resinosa Ait.) in New Hampshire. Unpubl. M.S. Thesis., Univ. of New Hampshire.