The Great Lakes Entomologist

Volume 21
Number 3 - Fall 1988 *Number 3 - Fall 1988*

Article 1

October 1988

Biology, Injury, and Control of the European Needle-bending Midge (Diptera: Cecidomyiidae) on Scotch Pine in Michigan

Louis F. Wilson
USDA Forest Service

Frank J. Sapio
Michigan Department of Natural Resources

Gary A. Simmons
Michigan State University

BIOLOGY, INJURY, AND CONTROL OF THE EUROPEAN NEEDLE-BENDING MIDGE (DIPTERA: CECIDOMYIIDAE) ON SCOTCH PINE IN MICHIGAN

Louis F. Wilson[1], Frank J. Sapio[2], and Gary A. Simmons[3]

ABSTRACT

Contarinia baeri is univoltine in Michigan. Adults emerge in spring, and females deposit eggs in small clusters in the sheaths of new-growth pine needles. Larvae hatch shortly thereafter and there are three larval instars. Larval feeding causes the needles to at first droop, discolor, and eventually drop, reducing the quality of Christmas trees and occasionally killing shoots. Larvae overwinter on the ground in cocoons, and pupate in spring. Adults were suppressed (> 75% control) with formulations of Pydrin® (fenvalerate) and Tempo® (cyfluthrin) applied within a week after adult emergence.

The European needle-bending midge, *Contarinia baeri* (Prell), a pest of Scotch pine, *Pinus sylvestris,* was first observed by Butovitsch (1930) in Europe. Soon after, Prell (1931) described it as a new species.

In 1953, Reeks (1954) discovered a new midge on red pine, *P. resinosa,* in New Brunswick, Canada, which came from Europe probably on imported nursery stock. He later identified it as *C. baeri.* Since then the midge has injured Scotch pine and red pine in Nova Scotia, Ontario, and Quebec. It may have been introduced into Canada more than once, considering the disparity in time, geography, and hosts (DeBoo et al. 1973).

In Michigan, the midge was first detected in 1976 in a Scotch pine Christmas tree planting in Emmet County. Other Christmas tree growers found midge injury in their plantings in the late 1970's, but misidentified it as pine chafer, *Anomala oblivia* Horn, injury for years. Accordingly, their attempts to treat it were unsuccessful. Since then this midge has spoiled Christmas trees throughout the state.

In Europe, *C. baeri* is commonly referred to as "the needle-bending pine gall midge" from "die nadelknickende Kieferngallmücke" coined by Prell (1931). Canadian reports refer to *C. baeri* variously as "needle midge" (Lavallée and Benoit 1978, Sippell et al. 1978), "pine needle midge" (DeBoo et al. 1973, DeBoo and LaPlante 1975, Sterner and Davidson 1981), and "European pine needle midge" (Lavallée et al. 1981, Kondo and Taylor 1984). We prefer the name "European needle-bending midge" to distinguish it from other North American and European pine needle midges. In Europe the condition or injury is called "needle droop" (Skuhravý 1973).

[1]USDA Forest Service, North Central Forest Experiment Station, 1407 S. Harrison Road, East Lansing, MI 48823.

[2]Michigan Department of Natural Resources, Regional Headquarters, Box 128, Roscommon, MI 48653.

[3]Department of Entomology, Michigan State University, East Lansing, MI 48824.

METHODS AND MATERIALS

We studied this midge in 1984 and 1985 in three widely separated Scotch pine Christmas tree plantations in the Lower Peninsula of Michigan. From north to south the study areas were located near Cheboygan (Cheboygan Co., 45°40′ N. lat.), Lake City (Missaukee Co., 43°50′ N. Lat.), and Brooklyn (Jackson Co., 42°6′ N. lat.). The trees were 1–3 m tall, sheared at least twice, and lightly to heavily infested by midges. Insect specimens were collected weekly or bi-weekly in spring and early summer and monthly in late summer and fall of both years. Midge eggs and larvae were studied by collecting needles before and after injury. Larvae that dropped to the ground were tallied using aluminum pans placed beneath the trees. Adult emergence was determined with ground traps made from aluminum cake pans, each with an attached plastic cup and vial full of ethylene glycol. The traps were similar to, but smaller than, those used by DeBoo et al. (1973). In 1984, many 25 cm square, yellow, sticky-trap boards with overlays of various colors were tied near the leaders of some trees to capture adults, but these were later abandoned because they captured too many other insects.

Midge injury within a tree was assessed on nine 1.5–2.5 m tall trees. Tree injury was subjectively ranked light, medium, or heavy from an estimate of the amount of foliage missing or yellowing in the upper crown. Three trees per category were selected, and the percentage of injured needles was used to assess injury on the top whorl and the four vertical quarters of the tree.

In 1984 we installed eleven 0.10-ha (0.25-acre) test plots on the east edge of the Cheboygan plantation. Each treatment contained 100 to 150 trees. Treatments assigned randomly were: check, and various dosages of trifumuron (Alsyston®), fenvalerate (Pydrin®), cyfluthrin (Tempo®), and acephate (Orthene® Tree and Orchard Spray). Chemicals were applied with a Solo 432 backpack mistblower calibrated to deliver 142 l/ha (15 gal/ac). The treatments were made on 21 June starting at 10 a.m. with slight wind and 22°C temperature. Two weeks later the check and spray plots were surveyed by determining the number of infested needles on the top whorl and leader of 75 randomly selected trees. In October, 50 trees in each plot were reassessed to determine full effect of midge feeding, using the following ranking: 0—no discernible midge damage; 1—light; 2—moderate; and 3—heavy. A light ranking meant noticeable injury but negligible degrade; moderate indicated some degrade for the current year; and heavy meant trees were considerably degraded and unmarketable for 2 to 3 years. Damage values were analyzed using the non-parametric Kruskal-Wallis Analysis of Variance, and individual treatment comparisons were made with a Wilcoxon Rank Sum test.

In 1985, to test chemicals further, we set up 16, 10-tree test plots scattered throughout a portion of the Lake City plantation. Treatment chemicals were applied by a mistblower calibrated for 142 l/ha to plots assigned randomly. Eight plots were treated on 11 June, and the other eight plots were treated in the same manner on 19 June. The treatments were done one week apart to see if timing was critical for control. Treatments consisted of check, and various dosages of fenvalerate, acephate, and cyfluthrin. Chemicals were applied in the morning when temperatures were 25° to 26°C. The trees were rated on 9 September by two individuals who estimated the percentages of foliage missing (5% increments) on the top whorl and leader. The transformed data ($\sqrt{\text{arc sine}}$) were analyzed by ANOVA for dosage and spray date with dates later pooled for treatment comparisons.

LIFE HISTORY AND HABITS

C. baeri is univoltine in Michigan. Detailed drawings of the various life stages and descriptions of morphological features can be found in Reeks and Smith (1956), DeBoo et al. (1973), and Skuhravý (1971).

The time of adult emergence depends upon temperature and latitude. In 1985, adults first appeared on 17 May, 1 June, and 8 June at the Brooklyn, Lake City, and Cheboygan locations, respectively. Within a day or two after adult eclosion, each female lays several smooth, yellow, slightly curved eggs, usually in small clusters (2–8) beneath the outer scales of the fascicles on new-growth needles. She places the eggs as far under the sheath as her flexible telescopic ovipositor permits. Ten eggs averaged 0.30 mm (range 0.25–0.38) long by 0.07 mm (range 0.06–0.09) wide.

Within 6 to 10 days, the larvae eclose, penetrate the inner sheaths of the fascicle, and enter the crevice between the needles. Reeks (1954) found as many as 25 larvae in a single red pine needle cluster, a number that seems unusually high. In Canada, DeBoo et al. (1973) reported that new shoots are two-thirds to three-fourths grown at larval eclosion. At first all larvae feed on the inner flat surface of the basal part of the needle, but usually only one mature larva is found in the sheath. Skuhravý (1971) counted 1–8 larvae/sheath in Czechoslovakia in July, but only 1–3 remained by mid-August. The larval population peaks about 3 weeks after emergence. Larvae vacate the needles 2–3 weeks later, but a few individuals, for reasons unknown, remain in the intact needles until fall. DeBoo et al. (1973) found a small number of larvae feeding in October, and Skuhravý (1971) indicated about 3% of the larvae were still present in needles in late September. He also found much overlap in the developmental stages.

Head-capsule measurements indicated three larval instars. Mean head capsule widths for 42 larvae were 0.030, 0.040, and 0.052 mm for the three larval instars, respectively. Third-instar orange-yellow larvae taken from needles ranged from 1.5 to 3.0 mm long depending upon their age. Each third-instar larva has a bilobed sternal spatula (see Reeks and Smith 1956).

When fully grown, most larvae vacate the needles and drop to the ground. After penetrating the upper layers of duff and soil, they form papery cocoons. Some larvae spin their cocoons while still in the fascicle, and these insects eventually fall to the ground when the needles drop. The overwintering larvae pupate in the spring, and adults emerge a few weeks later.

HOST INJURY

The earliest symptom characterizing *C. baeri* injury is a slight bending or drooping of one or both needles of the pair in a fascicle on new foliage shoots in the spring (Fig. 1). Frequently needles twist. This drooping or twisting is caused by a lesion made by feeding larvae at the base of the needle (Fig. 2). As the injured tissue attenuates and dies, the droop becomes more pronounced. Eventually one or both of the needles turn brown. By early to mid-July, heavily infested trees appear brownish, especially in the upper crown. This is followed by a thinning of the dead needles in late July and August. Leaders and upper whorls may be completely defoliated when heavily infested (Fig. 3). Several investigators have noted that the top of the tree is usually damaged more than other parts; the leader receives the most injury. Our census of injured needles on nine trees indicated that regardless of the injury category, more than 90% of the damage occurred in the upper half of the tree, and 21 to 42% was on the first whorl (Table 1). In the 2 years of this study, we found only a few dead leaders and an occasional dead lateral in the top whorl, and these were only on the most heavily infested trees.

We noted also that whenever trees were heavily infected with stem galls of the jack pine gall rust, *Cronartium sp.*, midge attack was rare or absent. The needles on the galled trees were stunted considerably and may have been unsuitable for oviposition or larval development.

CHEMICAL TREATMENTS

In the 1984 tests, Pydrin® at 0.22 kg AI/ha (0.20 lbs. AI/ac) dosage reduced the insect population by 99.8%. Tempo® at 0.05 kg AI/ha (0.05 lbs. AI/ac) and Pydrin® at 0.11 kg AI/ha (0.10 lbs. AI/ac) provided 90.7 and 89.2% reduction, respectively (Table 2). Lower dosages of Pydrin® and Tempo® gave correspondingly lower insect suppression,

Fig. 1 Needles drooping on Scotch pine due to *Contarinia baeri* feeding.

Table 1. Distribution of injury by *Contarinia baeri* on nine Scotch pine Christmas trees for three injury categories.

	Percentage of injured needles				
Injury[a]	First whorl	First quarter[b]	Second quarter	Third quarter	Fourth quarter
Light	26	68	24	8	0
Moderate	21	81	15	3	1
Heavy	42	74	20	5	1

[a]Each category consists of three trees.
[b]Includes injury from first whorl.

as did Alsystin® at 0.28 and 0.56 kg AI/ha (0.25 and 0.50 lbs. AI/ac) dosages. Orthene® Tree and Orchard Spray applied at 2.19 l/ha (15 fl. oz/ac) gave the poorest control of all treatments, which was only 50.3%. A standard formulation of oxydemeton-methyl (Metasystox-R®), applied twice by the plantation owner to the rest of the stand as an independent test, reduced the insect population by 93.0%.

The 1985 spray treatments, because of the way in which they were censused and analyzed, are not directly comparable to the 1984 treatments. In general they reaffirmed that the synthetic pyrethroid Pydrin® and Tempo® suppressed the insects better than Orthene®. Also, there was no significant difference between the 11 June and 19 June treatments, suggesting there is an adequate spray window of at least 1 week after adults emerge in the spring.

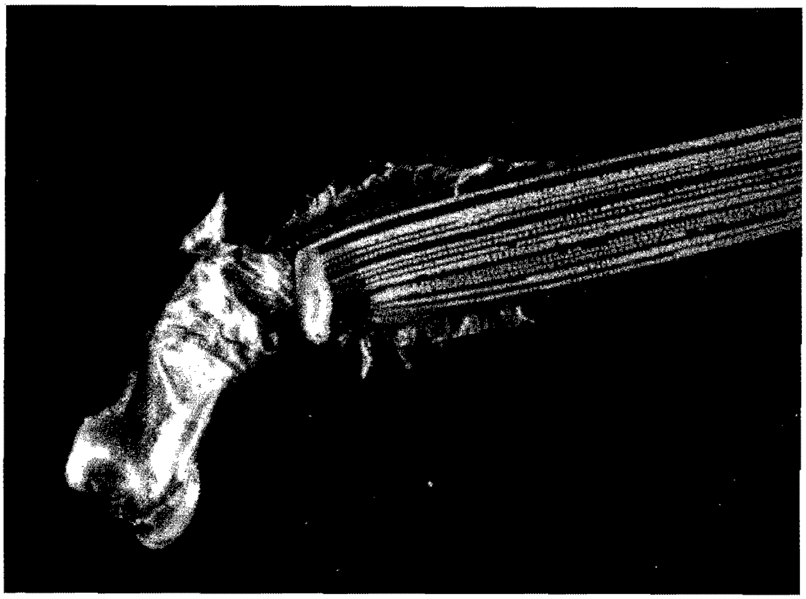

Fig. 2 *Contarinia baeri* larva at its feeding site on Scotch pine needles. The fascicle sheath and opposing needle have been removed.

Other investigators previously tested various insecticides and obtained inconsistent results. Berger (1959) reported that demeton (at 0.5%) reduced needle fall by 94%. His other test chemicals were unsatisfactory. DeBoo et al. (1973) reported that liquid formulations of dimethoate, fenthion, and malathion, applied by knapsack and hydraulic sprayer, were effective in reducing larval feeding. Granular aldicarb, applied on the soil by a seed spreader, significantly suppressed adults emerging from the ground. The chemicals chlorpyrifos-methyl, disulfoton, and lindane gave less consistent and less satisfactory results at all dosages tested.

DISCUSSION

C. baeri does not kill trees, but it causes asymmetrical apical needle drop that disfigures ornamentals and forest trees and lowers the sale price of Christmas trees. Also, pines such as: Chinese pine, *Pinus tabulaeformis;* knobcone pine, *P. attenuata;* ponderosa pine, *P. ponderosa,* Jeffrey pine, *P. jeffrei;* and pitch pine, *P. rigida,* planted in Europe have been injured by this midge (Butovitsch 1930, Skuhravý 1973).

Pydrin® and Tempo® can alleviate midge injury even at relatively low dosages. Several dosages, which greatly reduced the insect population, were conditionally successful. However, practical success for the Christmas tree grower occurs when the treatment results in many marketable trees with no or light injury but only a few trees with moderate or heavy injury. For example, 32% of the untreated check trees were readily marketable, whereas 68% were degraded to poor quality standard and cull trees. In contrast some Pydrin® and Tempo® treatments resulted in 91–99 percent marketable trees (Table 2). Interestingly, the Tempo® (0.03 kg rate) treatment that had a score of

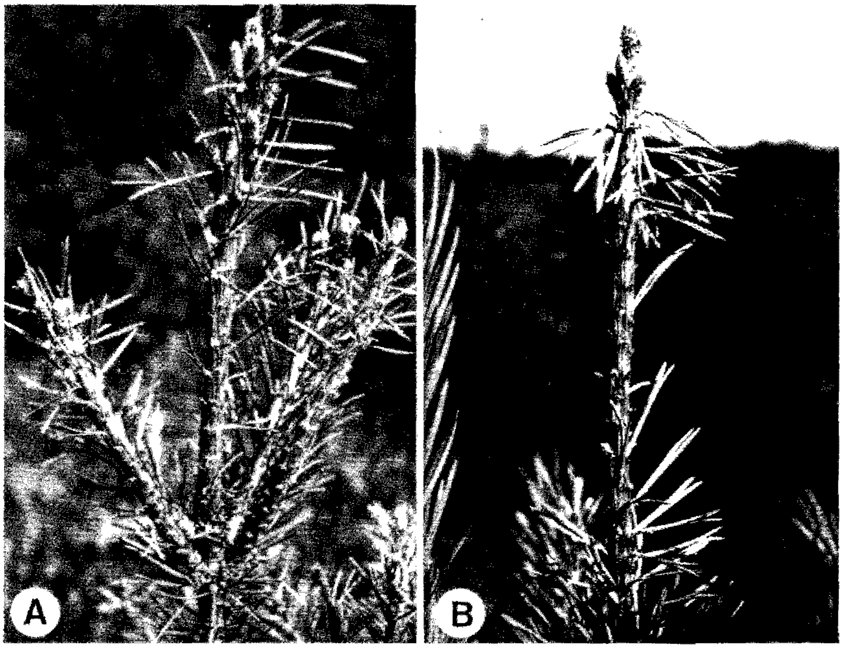

Fig. 3. *Contarinia baeri* damage on Scotch pine showing drooping needles and loci of fallen needles: A. A moderately attacked upper whorl; B. A heavily attacked leader.

Table 2. Effects of mistblower applications of chemicals on *Contarinia baeri* on Scotch pine Christmas trees in 1984.

Treatment[a]	Rate lb AI/acre	Percent reduction	Rank[b]	Percent marketable trees[c]
Pydrin 2.4 EC	0.200[d]	99.8	a	99
Tempo 2 EC	0.050	90.7	abc	99
Pydrin 2.4 EC	0.100	89.2	abc	91
Pydrin 2.4 EC	0.025	77.0	abcd	66
Tempo 2 EC	0.025	76.0	abcd	96
Alsystin 4F	0.250	74.1	bcd	60
Alsystin 4F	0.500	69.1	cd	64
Pydrin 2.4 EC	0.050	60.3	de	64
Orthene T&O	—[e]	50.3	e	60
Check	—	0	f	32

[a]Each treatment consisted of 75 trees.
[b]Percentages with same letter are not significantly different at P > .05.
[c]Trees with none or light midge damage only.
[d]To convert to kg/ha multiply by 1.12.
[e]Tree and Orchard Spray formulation was applied at label-recommended dosage of 15 fl. oz./ac.

96% marketable trees had only 76% population reduction. In this case, success could only be determined by assessing the percentage of marketable trees in the fall, and not by looking solely at the reduction in insect population. The other treatments that provided only 60–66% marketable trees would, for most growers, be considered unsuccessful.

Timing of control is critical, and treatments should be made within a week after the adults emerge in the spring. In Michigan's Lower Peninsula, emergence varied by 3 weeks (17 May to 5 June) from south to north. Most likely the midge would emerge about a week later in the Upper Peninsula, as the Canadians reported emergence in late June at a similar latitude (DeBoo and LaPlante 1975). Emergence may be even later in Europe. Skuhravý (1973) reported seeing midges in late June to early September in Czechoslovakia, the time there depending upon the altitude.

Because Christmas trees grow out of the injury in 2–3 years, a light and perhaps even a moderate attack on trees 2 or more years from market may not necessarily be a serious problem for growers. Most trees can stand a small amount of defoliation, and most moderately injured trees recover in 1 or 2 years. Trees nearer to harvest age can be pruned and sheared to partially alleviate injury. We did not attempt to correctively prune midge-injured shoots, but DeBoo and LaPlante (1975) reported that some Christmas tree growers in Canada successfully restored damaged trees by clipping and shearing.

ACKNOWLEDGMENTS

We thank Ben Burr, Jack Miller, and John Arend for permitting us to research this insect in their Christmas tree plantations; George Heaton, technician, for taking the excellent photographs and helping with the collections and treatments; and Raymond J. Gagné, USDA Agricultural Research Service, Systematic Entomology Laboratory, Beltsville, MD, for identifying the insect.

LITERATURE CITED

Berger, H. G. 1959. Über die chemischen Bekämpfungsmoglichkeiten der Kiefernnadelscheidengallmücken. Allg. Forstz. 34:70–71.

Butovitsch, B. 1930. Beitrag zur Kenntnis einer Nadeln der Kiefer lebenden Cecidomyide. Forstl. Wschr. Silva 18:373–374.

DeBoo, R. F. and J. P. LaPlante. 1975. *Contarinia baeri,* a pest of Scots pine. Can. For. Serv., Bi-monthly Res. Notes 31:(1)1.

DeBoo, R. F., L. M. Campbell, J. P. LaPlante, and L. P. Daviault. 1973. Plantation Research: VIII. The pine needle midge, *Contarinia baeri* (Diptera: Cecidomyiidae), a new pest of Scots pine. Chemical Control Research Institute, Can. For. Serv., Ottawa, Ontario. Information Report CC-X-41, 31 p.

Kondo, E.S. and R. G. Taylor. 1984. Forest insect and disease conditions in Canada 1983. Ontario Region. Forest Insect and Disease Survey, Can. For. Serv. Ottawa, Canada. p. 45.

Lavallée, A. and P. Benoit. 1978. Annual report of the forest insect and disease survey, 1976. Quebec Region. Department of the Environment, Can. For. Serv. Ottawa, Canada. p. 42.

Lavallée, A., P. Benoit and D. Lachance. 1981. Annual report of the forest insect and disease survey, 1977. Quebec Region. Department of the Environment, Can. For. Serv. Ottawa, Canada p. 40.

Prell, H. 1931. Die nadelknickende Kieferngallmücke (*Cecidomyia Baeri* n. sp.), ein verbreiteter neuer Kiefernschädling. Tharandten Forstlichs Jahrbuch, 82:36–52.

Reeks, W. A. 1954. Damage to red pine by a midge. Can. Dept. Agric. Div. For. Biol., Bi-monthly Prog. Rept. 10(3):1–2.

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., Div. For. Biol., Int. Rept. 1956–1, 22 p.

Sippell, W. L., A. H. Rose and H. L. Gross. 1978. Annual Report of the Forest Insect and Disease Survey, 1976. Ontario Region. Department of the Environment, Can. For. Serv. Ottawa, Canada. p. 62.

Skuhravý, V. 1971. Die gallmücke *Contarinia baeri* (Prell)—ein Schädling der Weisskiefer (*Pinus sylvestris* L.) Anzeiger für Schälingskunde und Pflanzenschutz 44:49–56.

Skuhravý, V. 1973. "Needle blight" and "Needle droop" on *Pinus sylvestris* in Europe and *P. resinosae* Ait. in North America (Diptera, Cecidomyiidae). Z. Ang. Entomol. 72:421–428.

Sterner, T. E. and A. G. Davidson. 1981. Forest insect and disease conditions in Canada 1980. Forest Insect and Disease Survey, Can. For. Serv., Ottawa, Canada. p. 31.