NON-TARGET LEPIDOPTERA CAPTURED IN TRAPS BAITED WITH SPRUCE BUDWORM PHEROMONE IN ONTARIO

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Abstract

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Traps baited with a 95:5 blend of *E*:*Z*-11-tetradecenal, the sex pheromone of the spruce budworm, *Choristoneura fumiferana* (Clem.), were deployed throughout several summers in Ontario to determine what other Lepidoptera were captured that might be confused with the male *C. fumiferana*. Eight other species of Tortricidae were captured with sufficient frequency to suggest that they were attracted to the traps: *Choristoneura conflictana* Wlk. (the large aspen tortrix), six species of *Acleris*, and one *Gretchena* species. Of these, *C. conflictana* can easily be confused with *C. fumiferana*. The evidence suggests that male *C. conflictana* were not attracted by the pheromone, but blundered into the traps. They are very similar morphologically to male *C. fumiferana*, but can be differentiated with care.

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Résumé

Des pièges garnis d'un mélange 95:5 de *E*:Z-11-tétradécénal, la phéromone sexuelle de la Tordeuse des bourgeons de l'épinette, *Choristoneura fumiferana* (Clem.), ont été installés durant plusieurs étés en Ontario dans le but de déterminer si ces pièges capturent d'autres lépidoptères susceptibles d'être confondus avec les mâles de *C. fumiferana*. Huit autres espèces de Tortricidae ont été capturées suffisamment fréquemment pour que l'on puisse croire au pouvoir d'attraction de la phéromone pour ces espèces: *Choristoneura conflictana* Walk., la Tordeuse du tremble, six espèces d'*Acleris* et une espèce de *Gretchena*. Parmi ces espèces, *C. conflictana* peut facilement être confondue avec *C. fumiferana*. Tout indique cependant que les mâles de *C. conflictana* ne sont pas attirés par la phéromone et qu'ils se sont pris au piège par mégarde. Ils sont très semblables aux mâles de *C. fumiferana*, mais peuvent facilement en être distingués avec un peu d'attention.

[Traduit par la rédaction]

Introduction

Traps baited with the synthetic sex pheromone of the spruce budworm [*Choristoneura fumiferana* (Clemens)], a 95:5 blend of *E*:Z-11-tetradecenal (*E*:*Z*-11-14:Al) (Sanders and Weatherston 1976; Silk et al. 1980), are now being used extensively for monitoring changes in population densities of *C. fumiferana* (Allen et al. 1986; Sanders 1990). The synthetic pheromone also has been under investigation as a control agent for disrupting mating behavior (Sanders and Seabrook 1982). An important side issue to this work is the need to know what other insects are affected by the attractant. The usefulness of traps would be greatly reduced if large numbers of other species of Lepidoptera are captured, especially if they can be mistaken for *C. fumiferana*. In addition, the broad dissemination of the attractant to disrupt mating of *C. fumiferana* could affect the population dynamics of other species if they are also affected by the same compounds.

E- and *Z*-11-14:Al are the major components of the pheromone of the western spruce budworm, *C. occidentalis* Freeman (Silk et al. 1982), as well as of *C. fumiferana*. In traps baited with *E*:*Z*-11-14:Al in Washington, Oregon, and California, Daterman et al. (1977) recorded significant captures of 11 species of Lepidoptera in addition to *C. occidentalis*. Two were sibling species of *C. occidentalis*: *C. viridis* Freeman = *C. retiniana* (Walsingham) and *C. lambertiana* (Busck), both of which can easily be confused with *C. occidentalis*.

Neither of these species is sympatric with *C. fumiferana* and therefore presents no problems of confusion with *C. fumiferana* in the east. The jack pine budworm (*C. pinus pinus* Freeman) is sympatric with *C. fumiferana*. However, the major components of its pheromone are *E*:*Z*-11-tetradecenyl acetate and *E*:*Z*-11-tetradecenyl alcohol (Silk et al. 1985), and catches of male *C. p. pinus* are inhibited by the presence of *C. fumiferana* pheromone (Sanders et al. 1977). The occasional male *C. p. pinus* that is found in a trap baited with *E*:*Z*-11-14:Al has therefore probably blundered in and can readily be distinguished from the *C. fumiferana* males by the chestnut and silver coloration.

Weatherston et al. (1978) reported on the tortricid moths captured in traps baited with various blends containing *Z*-11-14:Al in central Ontario and near Fairbanks, Alaska. In Europe, Booij and Voerman (1985) screened a wide variety of *E*:*Z*-11-14:Al blends for attraction to Lepidoptera. However, no reports have been published on forest Lepidoptera that might be affected specifically by *C. fumiferana* traps in eastern Canada.

Therefore, in 1979, traps baited with a 95:5 blend of *E*:*Z*-11-14:Al were deployed near Sault Ste. Marie throughout the summer, to determine what other species of forest Lepidoptera are attracted by the synthetic attractant of *C. fumiferana*. In 1990 this work was expanded to include sites throughout Ontario. In addition, records have been kept of any occurrence of unusually high captures of other species of Lepidoptera in trapping experiments, which have been carried out annually since 1978.

Materials and Methods

In 1979, five Pherocon 1CP sticky traps (Trécé Inc., Salinas, CA) baited with 95:5 *E*:*Z*-11-14:Al formulated in polyvinylchloride pellets at a concentration of 0.03% w/w (Sanders 1981), and five unbaited traps, were deployed from 2 April until 29 October in the Forestry Canada insectary grounds near Sault Ste. Marie, Ontario. They were hung at a height of 2 m in a mixed hardwood–softwood stand. The lures were replaced on 5 June. Every week the sticky trap-bottoms were replaced and the captured insects were counted and tentatively assigned to species. Representative specimens of those species for which a total of five or more individuals were captured throughout the season were removed from the traps by dissolving the adhesive in hexane and were mounted on insect pins. At the end of the summer the pinned specimens were sent to the Centre for Land and Biological Resources Research (CLBRR), Agriculture Canada, Ottawa, Ont., where they were identified by A. Mutuura.

In 1990, two Multi-pher I traps (Le Groupe Biocontrôle, Ste. Foy, Que.) baited with 95:5 *E*:*Z*-11-14:Al formulated in Biolures (Consep Membrane Inc., Bend, OR) and two new unbaited Multi-pher I traps were deployed in each of the 14 districts in Ontario operated by the Forest Insect and Disease Survey (FIDS) Unit of Forestry Canada, Ontario Region (Fig. 1). The traps were deployed and serviced by the FIDS ranger assigned to the district and were hung at a height of about 2 m in balsam fir [*Abies balsamea* (L.) Mill.] or white spruce [*Picea glauca* (Moench) Voss] trees near each ranger's cabin. The traps were left out from the middle of May until the end of September (actual dates varying with location). Approximately every week, the ranger emptied the contents of each trap into a brown paper bag. The bags were then returned to the laboratory in Sault Ste. Marie for examination. Moths were counted and tentatively assigned to species. If, at the end of the season, the combined catch of a species from all sites and dates totalled five or more, specimens were pinned for subsequent identification. Identifications were carried out by P.D. Syme (FIDS Unit, Forestry Canada, Sault Ste. Marie) or by P.T. Dang (CLBRR, Agriculture Canada, Ottawa).

During experiments in 1987 to test various formulations of *E*:*Z*-11-14:Al, Multi-pher I traps were deployed in a white spruce plantation in Kirkwood Township near Sault Ste. Marie. Within the plantation there were many aspen (*Populus tremuloides* Michx.) which were infested by the large aspen tortrix (*Choristoneura conflictana* Wlk.). The traps were

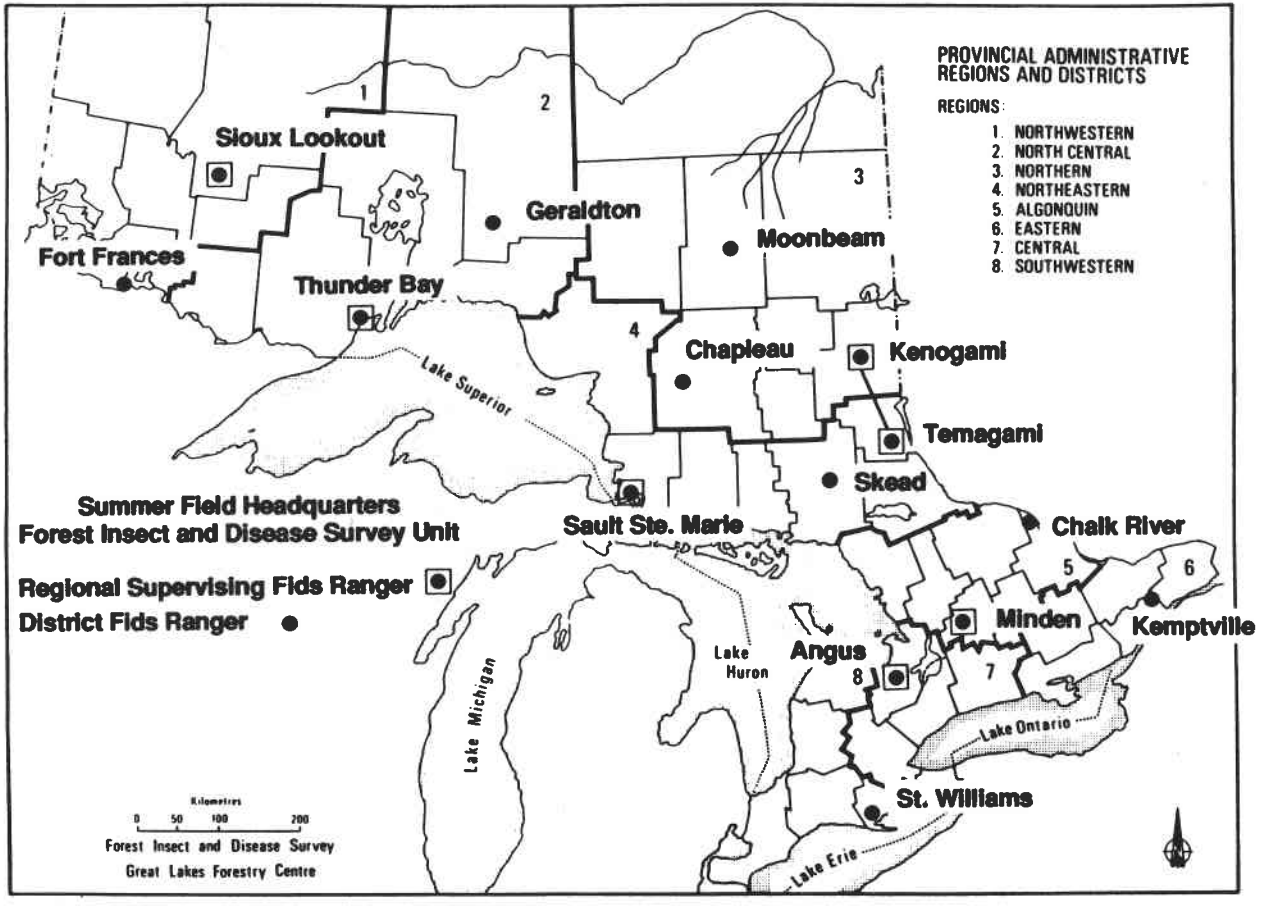

FIG. 1. Map of Ontario showing trapping locations: 1, Fort Frances; 2, Sioux Lookout; 3, Thunder Bay; 4, Geraldton; 5, Sault Ste. Marie; 6, Chapleau; 7, Skead (Sudbury); 8, Moonbeam; 9, Temagami; 10, Chalk River; 11, Kemptville; 12, Minden; 13, Angus; 14, St. Williams.

TABLE 1. Total numbers of Tortricidae caught every 2 weeks throughout 1979 near Sault Ste Marie, Ontario, in five Pherocon 1CP traps baited with a 95:5 blend of *E*:*Z*-11-tetradecenal, the known sex attractant for *Choristoneura fumiferana*

	May		June			July		Aug.		Sept.		Oct.	
	4	18	1	15	29	12	26	9	23	6	20	4	18
Choristoneura fumiferana	0	0	0	0	11	Sat.*	Sat.	Sat.	40	0	0	0	0
Acleris maccana	23	5	1	1	1	0	0	0	0	0	2	1	0
Acleris sp.prob. *fuscana*	3	15	40	28	4	0	0	0	0	0	1	1	0
Acleris curvalana	0	0	0	0	0	0	0	4	0	1	0	0	0

*Denotes trapping surface saturated (i.e. covered by moths), numbers therefore meaningless.

deployed on 19 June and at the first check on 22 June many male *C. conflictana* moths were found in the traps. Counts of both *C. conflictana* and *C. fumiferana* were made in two experiments. In one, 15 traps baited with rubber septa loaded with 10 µg 95:5 *E*:*Z*-11-14:Al and five unbaited traps were deployed in a 4 × 5 grid with 20 m between traps. In a second grid, 15 traps were baited with plastic vials loaded with an unspecified quantity of 95:5 *E*:*Z*-11-14:Al (International Pheromone Systems, Wirral, UK) and five traps were unbaited. Further experiments were carried out in the same area in 1988. In these, rubber septa were used as baits in Multi-pher I traps and treatments were as follows: (A) 10 µg *Z*-11-14:Al alone [the known pheromone of *C. conflictana* (Weatherston et al. 1978)]; (B) 1 µg 95:5 *E*:*Z*-11-14:Al; (C) 10 µg 95:5 *E*:*Z*-11-14:Al; (D) 100 µg 95:5 *E*:*Z*-11-14:Al; (E) to (G) combinations of (A) with each of the others; and (H) unbaited check traps. The traps were deployed on 15 June and checked and emptied on 17 June, 21 June, and finally, 8 August. Differences among treatments were assessed by carrying out an analysis of variance on the cumulative catches, and subjecting the means to Tukey's procedure (Steel and Torrie 1980).

Results

In the 1979 experiments near Sault Ste. Marie with Pherocon 1CP traps, a considerable number of Geometridae and a few Noctuidae were captured. However, all these were quite distinct from *C. fumiferana*, and because the emphasis was on insects of the family Tortricidae that might be confused with *C. fumiferana*, no records were kept of the species or numbers of the Geometridae. In addition to *C. fumiferana*, five or more individuals of three species of Tortricidae were captured (Table 1): *Acleris maccana* (Tr.), *Acleris* sp. probably *fuscana* (Barnes and Busck), and *Acleris* (=*Croesia*) *curvalana* (Kft.), the blueberry leaftier.

After all the collections were in for the 1990 experiments, the Lepidoptera were tentatively separated out into 91 species. Ranked by family, these were as follows: Geometridae 34; Noctuidae 24; Tortricidae 19; Gelechiidae 3; Lymantriidae 2; Pterophoridae 2; Pyralidae 2; Alucitidae 1; Arctiidae 1; Argyresthiidae 1; Lasiocampidae 1; Oecophoridae 1. Of these only nine species, in addition to *C. fumiferana*, met the criterion of a total of five or more individuals in all traps combined. These are by family as follows: Tortricidae—*Acleris chalybeana* (Fernald), *A. maximana* (Barnes and Busck), *A. obtusana fuscana* (Barnes and Busck), *Acleris curvalana* or *A. semipurpurana* (Kft.), or both (these last two species are very similar in appearance and no attempt was made to differentiate them); Noctuidae—*Palthis angulalis* (Hbn.); Lymantriidae—*Lymantria dispar* L. (the gypsy moth); Lasiocampidae—*Malacosoma disstria* Hbn. (the forest tent caterpillar); and

TABLE 2. Numbers of male Lepidoptera caught in 1990 at weekly intervals in traps deployed from mid-May through September at 14 locations throughout Ontario. Only species for which a total of five or more were caught are listed. Numbers in parentheses denote catches in unbaited, check traps

	Julian date																	
Species	139	146	153	160	167	174	181	188	195	202	209	216	223	230	237	243	250	257
Choristoneura fumiferana	0	0	0	1	3	16	72	150 (4)	224 (5)	500 (11)	272 (4)	223 (1)	15	3	6	0	0	0
Acleris chalybeana	2	3	3	8 (4)	7	0	0	0	0	0	0	0	0	0	0	0	0	0
A. maximana	4	3	9	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A. fuscana	61	149	111 (1)	49 (2)	25 (1)	6	9	0 (1)	3	1	1	1	0	1	0	0	1	0
A. curvalana/semipurpurana	0	0	0	0	18	5	52	73	28	7	6	6	2	3	1	0	0	0
Lymantria dispar	0	0	0	0	0	0	0	0	0	7	24	75	74	38	0	0	0	0
Malacosoma disstria	0	0	0	0	0	0	0	0	12 (29)	8 (22)	9 (17)	2 (2)	1	0	0	0	0	0
Palthis angulalis	0	0	0	0	1 (1)	2 (2)	1 (7)	3	0 (2)	0	0	0	0	0	0 (1)	0	0	0
Trichoptilus lobidactylus	0	0	0	0	0	0	0	1	4	2	0	0	0	0	0	0	0	0

TABLE 3. Numbers of male Lepidoptera caught in 1990 in traps deployed from mid-May through September at 14 locations throughout Ontario (see Fig. 1 for names of locations). Only species for which a total of five or more moths were caught are listed. Numbers in parentheses denote catches in unbaited, check traps

	Location													
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Choristoneura fumiferana	171	263 (3)	378 (20)	511 (2)	10	1	3	24	32	5	69	8	3	17
Acleris chalybeana	0	0	5	0	0	0	1	1	1	6	0	0	9 (4)	0
A. maxima	0	0	8	0	1	0	0	1	3	1	0	0	4 (1)	0
A. fuscana	18	67	21	17	2 (1)	8 (2)	45 (1)	216 (1)	7	4	1	1	5	6
A. semipurpurana/curvalana	0	1	1	1	1	0	13	2	0	2	3	139	27	1
Lymantria dispar	0	0	0	0	0	0	0	0	0	0	0	0	0	218
Malacosoma disstria	0 (2)	6 (6)	0	0	0	0	26 (64)	0	0	0	0	0	0	0
Palthis angulalis	0	0 (1)	6 (2)	1	0	0 (2)	0	0 (3)	0 (1)	0 (2)	0 (1)	0 (1)	0	0
Trichoptilus lobidactylus	2	0	0	0	0	0	5	0	0	0	0	0	0	0

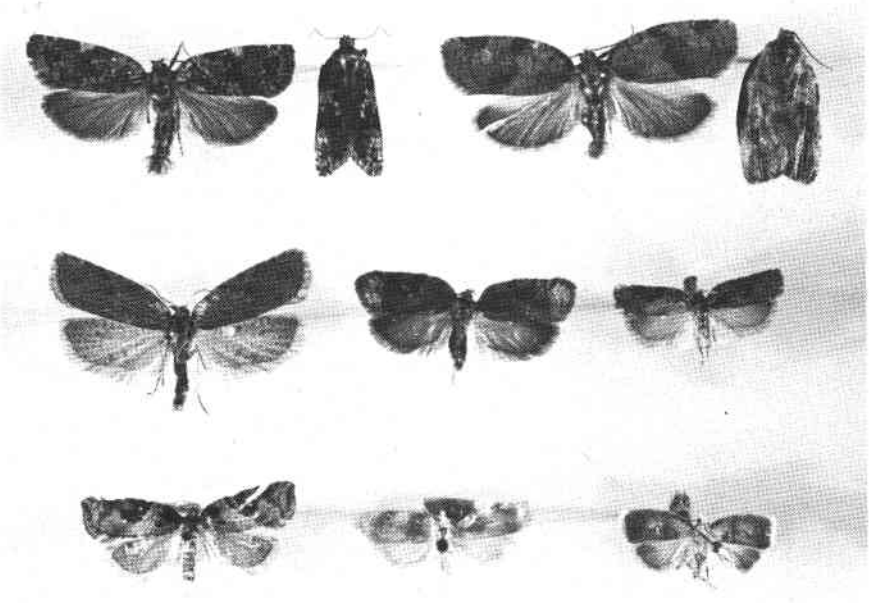

FIG. 2. Male moths of the species of Tortricidae that occurred in sex pheromone traps baited with the pheromone of the spruce budworm in Ontario. Top row: left—*Choristoneura fumiferana*, right—*C. conflictana*; middle row: left to right—*Acleris maximana*, *A. chalybeana*, *A. fuscana*; bottom row: left to right—*A. maccana*, *A. curvalana*, *A. semipurpurana*. Note the differences in size and in the shape of the forewings, attributes that can safely be used to differentiate the species.

Pterophoridae— *Trichoptilus lobidactylus* (Fitch). The number of specimens of each species and the dates on which they were captured are shown in Table 2, and the locations where they were captured in Table 3.

Photographs of the adult male moths of the six species of *Acleris* identified in 1979 and 1990 together with male *C. fumiferana* and male *C. conflictana* are shown in Figure 2.

During experimental trapping in 1987, Multi-pher traps baited with the IPS vials containing a 95:5 blend of *E*:Z-11-14:Al captured 162.9 ± 67.2 (mean ± SD) male *C. conflictana*, and unbaited traps captured 353.0 ± 32.1. In a nearby plot, traps baited with rubber septa captured 0.76 ± 1.01, and unbaited traps 86.0 ± 73.7. In the 1988 experiments (Table 4), traps baited with Z-11-14:Al alone (treatment A) caught significant numbers of male *C. conflictana* even though defoliation by *C. conflictana* was noticeably less than in 1987. Addition of the 95:5 blend (treatments E, F, and G) reduced catches to the same level as those in unbaited traps (treatment H), or those in traps baited with 95:5 blends of *E*:Z-11-14:Al, the pheromone of *C. fumiferana* (treatments B, C, and D). In traps baited with the 95:5 blend alone, catches of *C. fumiferana* increased with concentration, but none were captured in traps baited with Z-11-14:Al alone. Addition of septa containing Z-11-14:Al to the traps containing the 95:5 blend reduced catches of *C. fumiferana* when the combined blend emitted by the two septa contained 50% or more of the Z-isomer (treatments E and F), but the combination of 100 µg of the 95:5 blend with 10 µg of the Z-11-14:Al (treatment G), which gave an emitted blend calculated to be 86.4 *E*- : 13.6 Z-isomer, still captured large numbers of male *C. fumiferana*, although the numbers were not significantly different from those with the other mixtures, probably because of the high variability and small sample.

In 1992, large numbers of a small tortricid were found in Multi-pher I traps deployed northeast of Sault Ste. Marie. These were tentatively identified by P.D. Syme as *Gretchena semialba* McD., which feeds on alder (*Alnus* spp.).

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TABLE 4. Numbers of male *Choristoneura conflictana* and *C. fumiferana* caught in 1988 near Sault Ste Marie, Ontario. Baited traps contained one or more rubber septa loaded with *Z*-11-tetradecenal or a 95:5 blend of *E*:*Z*-11-tetradecenal. Traps were deployed on 15 June and collected 8 August. Each treatment was replicated five times

		C. conflictana	*C. fumiferana*
A	10 µg *Z*-11-14:Al	34.8 ± 14.5 a	0 b
B	1 µg 95:5 *E*:*Z*-11-14:Al	0.6 ± 0.5 b	13.6 ± 13.3 b
C	10 µg 95:5 *E*:*Z*-11-14:Al	0.4 ± 0.5 b	57.6 ± 23.7 b
D	100 µg 95:5 *E*:*Z*-11-14:Al	0.2 ± 0.4 b	302.0 ± 117.3 a
E	A + B	1.8 ± 1.1 b	0.4 ± 0.5 b
F	A + C	0.2 ± 0.4 b	0.4 ± 0.6 b
G	A + D	0 b	58.8 ± 61.5 b
H	Unbaited	2.4 ± 1.5 b	0 b

Numbers in each column followed by a different letter are significantly different (Tukey's test, $p = 0.05$).

Discussion

Using the criterion of five or more individuals captured, a total of 10 species other than *C. fumiferana* were caught in *C. fumiferana* traps deployed throughout the summers of 1979 and 1990 in Ontario and a further two species were captured in significant numbers in other years. Geometridae have been deliberately excluded from this survey because roughly equal numbers occurred in unbaited as in baited traps, which implies that they were not attracted by the chemicals, and because none of them are likely to be confused with *C. fumiferana*.

Sex pheromones have been identified for five of the 12 species other than Geometridae that were caught in significant numbers: *L. dispar*, *M. disstria*, *A. curvalana*, *A. semipurpurana*, and *C. conflictana*. A total of 218 male *L. dispar* (gypsy moth) were captured in the baited traps, but none in the unbaited check traps. This implies that male gypsy moths are attracted to *E*:*Z*-11-14:Al. However, *E*:*Z*-11-14:Al bears little affinity to the pheromone of the gypsy moth, (7R,8S)-*Z*-7,8-epoxy-2-methyl-octadecane (Bierl et al. 1972), so the evident attraction of male gypsy moths to the *E*:*Z*-11-14:Al is surprising. A total of 32 *M. disstria* were captured in the baited traps and 72 in the unbaited traps. This implies that male *M. disstria* were not attracted by the *E*:*Z*-11-14:Al, but were blundering into the traps. The lower catches in the baited traps may, in fact, be an indication of repellency.

A blend of *E*:*Z*-11-14:Al has been identified as the major component of the pheromone of both *A. curvalana* (Lonergan et al. 1989) and *A. semipurpurana* (Grant et al. 1981). However, although their flight periods overlap that of *C. fumiferana*, the size and color of these species precludes any danger of confusion with *C. fumiferana* (Fig. 2). The pheromone of *C. conflictana* has been identified as 100% *Z*-11-14:Al (Weatherston et al. 1976), the minor component of the pheromone of *C. fumiferana*.

The pheromones of the other six species captured in the *C. fumiferana* traps (*Palthis angulalis*, *T. lobidactylus*, *G. semialba*, and the four species of *Acleris*: *A. maximana*, *A. maccana*, *A. fuscana*, and *A. chalybeana*) have not been identified, but the fact that significant numbers were caught suggests that *E*- or *Z*-11-14:Al, or both, may be components of their pheromones.

Of all the species captured in the traps baited with the sex pheromone of *C. fumiferana*, only two, *Acleris maximana* and *Choristoneura conflictana*, are likely to be confused with *C. fumiferana* (Fig. 2). The other 10 species are quite distinct in size, shape, and, in some cases, coloration, and should not lead to any confusion. Relatively few *A. maximana* were captured in 1990 and none in 1979. Possibly the traps were not deployed early enough in 1979 to catch them, or possibly the *E*:*Z*-11-14:Al is not the complete pheromone blend. It is evident that the flight period of *A. maximana* is early in the year, and therefore it is unlikely

to be captured in traps that are deployed during only the flight period of *C. fumiferana*. Even if some moths of this species are caught, they can be distinguished from male *C. fumiferana* by their slightly smaller size, their uniform dark coloring, and their narrower, more tapered outline (Fig. 2). Male *C. conflictana* present a more serious problem. They can easily be confused with male *C. fumiferana* and their flight period overlaps that of *C. fumiferana*, although it begins slightly earlier. Its sex pheromone, *Z*-11-14:Al, is also found in the pheromone of *C. fumiferana*, but the other component of the sex pheromone of *C. fumiferana*, the *E*-isomer, reduces the catches of *C. conflictana* (Weatherston et al. 1978). The high catches recorded in this study in 1987 and 1988 are therefore surprising. An examination of the data, however, suggests that male *C. conflictana* moths were not attracted by the *E*:*Z* blend. In the 1987 experiment, the highest catches were in the unbaited check traps compared with the baited traps. This was true in both the experiment with the rubber septa and the experiment with the IPS vials. Moreover, the higher release rate from the IPS vials compared with the septa caused a greater reduction in catches. The 1988 experiment (Table 4) confirmed that *C. conflictana* are attracted by the *Z*-isomer, and that catches are inhibited by the presence of the *E*-isomer. This leads to the conclusion that the male *C. conflictana* moths either were blundering into the traps or were attracted visually to the traps and that, either way, the presence of the *E*-isomer resulted in lower catches. Although morphologically very similar, male *C. fumiferana* can be distinguished from male *C. conflictana*: *C. fumiferana* are slightly smaller; they have a more distinct wing pattern, which includes a pale costal spot and a dark longitudinal bar in the middle of the forewing that is often still visible even in badly worn specimens; and they have different shaped forewings which gives them a narrower, tapering outline in the resting position, as can be seen in Figure 2.

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