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THE EFFECT OF HEIGHT AND DENSITY OF SEX PHEROMONE TRAPS ON CAPTURES OF MALE FRUITTREE LEAFROLLER, *ARCHIPS ARGYROSPILUS* AND THREELINED LEAFROLLER, *PANDEMIS LIMITATA* (LEPID.: TORTRICIDAE)

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When sex pheromone traps in the upper third of a standard apple tree were compared with traps at head height, the upper traps captured far more fruittree leafroller moths (*Archips argyrospilus* (Walker) than the lower traps. The results with threelined leafroller (*Pandemis limitata* (Rob.) were reversed; traps at head height captured nearly twice as many moths as traps in the upper portion of a tree. Trap captures increased with trap/area up to 1 trap/ha. This density is probably sufficient for monitoring purposes.

The development of monitoring programs for lepidoptera using sex pheromones is dependent upon a number of factors. The most important of these are the release rate of the pheromone, the use of efficient traps, the proper placement of traps and the trap density. Unless these procedures are standardized for each insect species, it is not possible to draw sound conclusions on population levels or develop treatment thresholds based upon trap captures.

A number of studies have been made on codling moth trap density (Riedl and Croft 1974; Riedl 1980), and on the effect of trap height on codling moth captures (Riedl *et al.* 1979; McNalley and Barnes 1980). There is little information on this subject with respect to leafrollers. As part of the study on the establishment of monitoring programs for the important species of leafrollers attacking tree fruits in British Columbia, the effect of trap height and trap density on captures were evaluated in apple orchards.

MATERIALS AND METHODS

The traps used in all of the field experiments were Zoecon 1C traps (Zoecon Corporation, Palo Alto, California). Madsen and Vakenti (1973) demonstrated that this trap design was the most efficient for trapping male fruittree leafrollers. The lures for both fruittree leafroller and threelined leafroller were also obtained from Zoecon Corp. and consisted of rubber cap stoppers containing 5 mg of the synthetic sex pheromone of each species. The lures were pinned to the top inside portion of each trap and replaced at monthly intervals. Trap bottoms were replaced when the sticky surface became contaminated with moth wing scales or other debris. All traps were examined at weekly intervals, when the trapped males were recorded and removed.

Trap height — This experiment was located in 2 apple orchards in the Kelowna area where the fruittree leafroller is dominant and in 2 orchards in the Oliver-Osoyoos area about 100 km south, where the threelined leafroller is most abundant (Madsen and Madsen 1980). In each orchard, 6 locations were selected, at about 1 trapping site per 0.3 ha. At each site, a trap was placed at head height on a convenient limb and another in the upper third of the same tree on a rope and pulley arrangement. On alternate weeks, the top traps were removed from 3 of the locations and left in place in the other 3. Therefore, each week the low and high traps were

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TABLE 1. Effect of trap height on captures of male fruittree leafroller moths with sex pheromone traps.

Dates	Orchard 1 Av. moths/trap			Orchard 2 Av. moths/trap		
	High traps (low traps in place)	Low traps (high traps in place)	Low traps (high traps removed)	High traps (low traps in place)	Low traps (high traps in place)	Low traps (high traps removed
June 16	2.6	1.6	-	2.3	0.6	-
June 23	60.6	7.0	63.6	30.6	3.3	34.6
June 30	56.6	10.6	61.3	26.3	2.6	31.3
July 8	55.3	16.3	59.6	31.6	5.3	37.6
July 15	21.6	2.3	30.3	12.3	1.6	13.3
July 21	5.3	1.6	6.3	3.6	0.6	4.6

in direct competition at 3 of the sites while in the other 3, only the low traps were operational.

Trap density — Two apple orchards were selected for this test, one in the Kelowna area for fruittree leafroller and the other in the Oliver-Osoyoos area for the threelined leafroller. Each orchard was divided into 2 sections, one containing a single trap per ha and the other 3 traps at a density of 1 per 0.3 ha. The position of the traps was interchanged weekly to avoid the possibility that one location was consistently exposed to higher leafroller populations. To minimize migration of moths from outside the test area, traps were installed in the remainder of the orchard at a density of 1 trap per ha.

RESULTS AND DISCUSSION

Table 1 shows the fruittree leafroller captures in the trap height experiment. When the upper and lower traps were in direct competition, the upper traps captured considerably more moths than the lower traps. This indicates that most of the moth activity occurs in the upper third of the trees and is supported by the observation that most of the over-

TABLE 2. Effect of trap height on captures of male threelined leafroller moths with sex pheromone traps.

Dates	Orchard 1 Av. moths/trap			Orchard 2 Av. moths/trap		
	High traps (low traps in place)	Low traps (high traps in place)	Low traps (high traps removed)	High traps (low traps in place)	Low traps (high traps in place)	Low traps (high traps removed)
June 10	0	0	-	0	0	-
June 17	2.0	4.6	6.0	4.0	9.3	12.3
June 24	3.3	15.0	21.6	6.3	15.6	18.3
July 2	4.0	5.0	7.0	8.3	27.6	31.3
July 9	2.6	5.3	6.0	5.6	14.3	16.6
July 17	2.0	5.6	8.6	3.3	9.6	11.3
July 22	1.6	4.0	5.3	2.0	6.6	8.3
July 29	1.3	3.3	3.6	1.0	4.0	5.6
Aug. 6	0	0.6	1.0	0	0.3	1.3

TABLE 3. Effect of trap density on captures of male fruittree leafroller and threelined leafroller moths in sex pheromone traps.

	Orchard A fruittree leafroller			Orchard B threelined leafroller	
Date	1 trap/0.3 ha[1]	1 trap/ha	Date	1 trap/0.3 ha[1]	1 trap/ha
June 9	0	0	June 4	0	0
June 16	1	2	June 10	0	2
June 23	41	79	June 17	3	12
June 30	52	131	June 24	14	36
July 8	21	56	July 2	9	25
July 15	10	22	July 9	6	20
July 21	1	2	July 17	3	8
July 28	1	3	July 22	1	4
Aug. 5	0	0	July 29	0	0

[1] Average of 3 traps

wintering eggs of this species are found on the upper limbs and branches of apple trees. When the low traps were not in competition with high traps, they captured nearly as many moths as the high and low traps combined indicating that males will respond to lures at head height. For monitoring purposes, it is probable that traps in the lower portion of the tree will adequately reflect population levels. If a trapping-out or male disruption program is contemplated, it would be desirable to install the lures in the upper third of apple trees where the moth activity takes place.

The data on the effects of trap height on threelined leafroller are shown in Table 2. The results with this species are different from those obtained with fruittree leafroller. When upper and lower traps were in direct competition, the lower traps captured more than twice as many moths as the upper traps. This result was unexpected because observations show that the larvae of this species are most abundant in the new growth at the tops of trees. Very little, however, is known about the mating behaviour of the threelined leafroller. The data indicate that traps installed at head height would be adequate for monitoring purposes and for control by trapping-out or mating disruption.

The data on trap density are summarized in Table 3. With the codling moth, Riedl and Croft (1974) found that trap catches increase with trap area until the area served by the trap exceeds the range of pheromone attraction. In our study, one trap per ha captured about twice as many moths as one trap per 0.3 ha. Although we did not investigate trap density beyond 1 ha, the indications are that a density higher than 1 per ha would not be needed to monitor populations of either fruittree leafroller or threelined leafroller.

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