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SELECTION OF PHEROMONE TRAP AND ATTRACTANT DISPENSER LOAD TO MONITOR BLACK ARMY CUTWORM, *Actebia fennica*

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Abstract—Catch rates of black army cutworm moths, *Actebia fennica* (Lepidoptera: Noctuidae), were determined for different types of traps and different dispenser loads of sex attractant. Of the five traps tested, highest catch (~35 males/per night) was obtained with Uni-Traps, whereas Pherocon 1CP, Delta and Hara traps rapidly became saturated at ~9, 6, and 11 males/per night, respectively. Multi-Pher traps, like the Uni-Traps, have a covered vertical cone with a large collecting bucket but only catch about 1/3 of the number of moths (~9 males/per night) as the Uni-Traps, thus reducing potential saturation. Red rubber septa loaded with 500 μg of attractant blend gave a consistent catch for at least 60 days; 1000 and 2000 μg loadings lasted for a minimum of 90 days. Polyvinylchloride and red rubber septa dispensers containing 100 μg of attractant had similar catch rates, which decreased rapidly with age. Based on these trap and lure-loading experiments, Multi-Pher traps baited with 1000 μg of attractant in a red rubber septum were selected for future calibration studies between catch density and population fluctuations on susceptible sites. Two years of monitoring results also are reported.

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INTRODUCTION

Black army cutworm, *Actebia fennica* (Tauscher), recently has been recognized as an economic pest of forest regeneration (Ross and Ilnytzky, 1977). It has been a minor problem in agriculture for many years, causing damage to alfalfa, clover, barley, creeping fescue, and blueberries (Wood and Neilson, 1956). The first outbreak of significance to forestry occurred in eastern British Columbia in 1973 (Ross and Ilnytzky, 1977). Prior to that date there were only three recorded minor outbreaks in British Columbia, dating back to 1943; since 1983 outbreaks have occurred annually. Occasional outbreaks also have occurred on regenerated sites in Ontario and Newfoundland.

Females lay their eggs in the soil from mid-July to early September. The eggs hatch in autumn and first- or second-instar larvae overwinter in the soil. Spring feeding commences as soon as the snow disappears, resulting in patches of denuded herbaceous growth by June. Pupation occurs in June or early July followed by a flight period that can occur between July 1 and September 30, depending on the developmental season.

High densities of black army cutworm often appear one or two years after forest sites are burned by wild or prescribed fires. Planted seedlings are consumed, along with other herbaceous plants. Damage is usually evident for two successive years and then the population returns to endemic levels.

An early-warning system to predict impending high populations before feeding commences would allow land managers to take appropriate action to avoid damage. A pheromone-trap monitoring system is being developed to meet this need (Struble et al., 1989). This paper describes tests conducted to select an appropriate trap and lure for such a system. For this, a lure is required that retains a constant rate of capture throughout a flight period of at least 60 days (Humble et al., 1989) and a trap that catches sufficient moths to indicate an impending outbreak, without becoming saturated.

METHODS AND MATERIALS

Trapping studies were carried out 16 km southeast of Smithers, British Columbia, in the Telkwa River Valley in 1985 and 50 km northeast of Smithers near Torkelsen Creek in 1986. Each area consisted of several square km of a regenerated site, which had been cut and burned two years previous to our studies. Larval populations in 1985 and 1986 were high and caused patches of severe defoliation of vegetation and destruction of conifer seedlings. Thus, numbers of moths caught in this study are representative of catches made under outbreak conditions.

Traps were hung in rows from stakes at a height of 1 m with 40 m between traps and at least 100 m between rows. The order of treatments was randomized along each row and a "guard" trap, baited with 105 μg of attractant, was placed at the ends of each row to reduce concentrating immigrating moths. Catches in guard traps were not analyzed. When traps and the first dispenser load tests were run in 1985, trap positions were randomized daily. When dispenser loads were being tested in 1986, the tests were so large that a modified design had to be used in order to complete changes on a daily basis. Therefore, dispensers were initially randomized and then advanced one position daily.

Data for trap-nights were deleted from the analysis whenever there was interference with the trap because of vole or wasp predation, trap breakage, etc. This resulted in a variable number of replications in any one test. Uni-Traps were used exclusively during dispenser load tests. Counts were made daily, and the captured dead moths were discarded to prevent both possible reduction of attraction (Sanders, 1986) and having to count the same moths repeatedly.

Type of Trap. Three types of nonsticky and two types of sticky traps were evaluated. The nonsticky traps were: Uni-Trap (International Pheromone Systems Limited, Wirral, Merseyside, United Kingdom), a white, yellow, and green trap; Multi-Pher (Bio-Contrôle Services, Ste. Foy, Quebec, Canada), a green and white trap but also available as all green; and Hara (Hara Products, Swift Current, Saskatchewan, Canada), a double cone, totally white trap. Squares of insecticide strip, approximately 2.5 cm^2, containing 18.6% dichlorvos (Zoecon Industries Limited, Port Perry, Ontario, Canada), were placed inside each of these traps. The sticky traps were Pherocon 1CP (Trécé, Salinas, California) and Delta (made by T.G.G. from 2-liter cardboard milk cartons and coated inside with Tangle-trap from Tanglefoot Co., Grand Rapids, Michigan). In initial tests the Hara, Pherocon, and Delta traps reached saturation after only a few nights of exposure. These were therefore eliminated from future consideration and performance of the Uni-Trap and Multi-Pher traps was further tested using a matched-pair design baited with a septum load of 105 μg. The test was run for two nights with the position of each pair exchanged on the second night. There were 15 pairs, resulting in 30 trap-nights for each type of trap.

Quantity of Attractant per Dispenser. Two types of pheromone dispensers were used. The first consisted of a red rubber septum (A.H. Thomas Co., Catalog No. 1780-J07, Philadelphia, Pennsylvania) impregnated with a hexane dilution of 105 μg of (Z)-7-dodecenyl acetate (Z7-12:Ac) and (Z)-11-tetradecenyl acetate (Z11-14:Ac) each, at a ratio of 1:20. In 1985 0.15% of (Z)-5-tetradecenyl acetate (Z5-14:Ac) also was added, but subsequent tests indicated this ingredient had little or no effect on catches (Struble et al., 1989); therefore, it was deleted from the mixture in 1986. The hexane was allowed to evaporate before the septa were stored at 0°C until required. The second type of dispenser was polyvinylchloride (PVC) rods (5 × 3 mm diam.) (Daterman, 1974) containing 100 μg (0.4% w/w) of pheromone. Both types of dispensers were pinned under the lid or inside of each trap.

Two tests were run to compare dispenser load. In the first test, carried out in 1985, dispenser loads of 50, 100, 500, and 1000 μg were placed in rubber septa and used without aging. Six traps per treatment were run for five nights. In the second test, run in 1986, pheromone dispensers were aged for 0, 30, 60, and 100 days before use. Red rubber septa containing 100, 500, 1000, and 2000 μg of the two acetates at a ratio of 1:20 were placed inside cone-orifice traps, with the cone openings blocked to prevent insect entry, and aged outdoors near Lethbridge, Alberta, starting on April 9, 1986. The PVC dispensers, containing 100 μg of pheromone, were aged inside a Stevenson screen within an unheated shadehouse in Victoria, British Columbia, starting on May 9, 1986. Temperatures were recorded at each site and the degree-days above 0°C were calculated for each aging period. When the dispensers had aged for a specific period, they were sealed in separate containers and stored at −15°C until used in field tests. Two additional traps baited with unmated females reared from field-collected larvae were added to this test. Each treatment was exposed for 26 trap-nights.

Data were transformed, after the method of Iwao and Kuno (1968), using the formula $y = \log(\sqrt{0.163x} + \sqrt{0.163x + 1})$. Bartlett's test of homogeneity of variance indicated no significant differences after transformation. An analysis of variance and Tukey's comparison of means was carried out on the transformed data.

Assessment of Traps under Operational Conditions. In 1987 and 1988, all-green Multi-Pher traps baited with 1000 μg of the two-component pheromone were used to monitor adult populations in eastern and northeastern British Columbia. Each trap was hung 1 m high within burned areas, which had been restocked with conifer seedlings, with the intent of evaluating the traps as tools to detect populations in the autumn before damaging populations occurred. Traps were left out for the entire flight period and captured moths were sorted and counted volumetrically (Shepherd and Gray, unpublished data).

RESULTS AND DISCUSSION

Type of Trap. The mean catches per trap night for the Uni-Trap and Multi-Pher traps were significantly different: 17.9 (SD = 13.7) and 5.8 (SD = 5.4) moths, respectively ($P < 0.005$, Wilcoxon matched-pairs signed-ranks test). This indicated that the Multi-Pher trap could adequately detect damaging populations at lower trap densities than the Uni-Traps and, therefore, would be less likely to become saturated before reaching action threshold densities. Incidental to these trap tests, it was found that large numbers of bumblebees were attracted to yellow or white traps. Use of all-green traps reduced this problem.

Quantity of Attractant per Dispenser. The first test on the quantity of attractant in septa resulted in the highest mean catch occurring with 100 μg; slightly fewer were caught with 50 μg and progressively fewer were caught with higher quantities (Figure 1). The catch at 1000 μg was less variable than the 500-μg and 2000-μg lures and was significantly different ($P < 0.05$, Tukey's comparison of means) than that for 50 and 100 μg.

In the second test the average catch per night for female-baited traps was 17.2 (SD = 25.4) males, while that for fresh 100-, 500-, 1000-, and 2000-μg septa were 35.2 (SD = 30.5), 24.1 (SD = 16.1), 24.6 (SD = 18.1), and 21.5 (SD = 16.6) males, respectively. The relative variability of the catch in traps with females (CV = 148%) was greater than that for any of the four dispenser loads (CV = 87, 67, 74, and 77%, respectively). Thus the fresh synthetic dispensers attracted higher numbers per night and were more consistent in their catch than females due, in part, to their age and attractiveness.

The results of using PVC dispensers containing 100 μg of attractant and aged 0, 30, 60, and 90 days are included in Figure 2. This test is not strictly comparable to the test using septa as it was run at a different time and thus

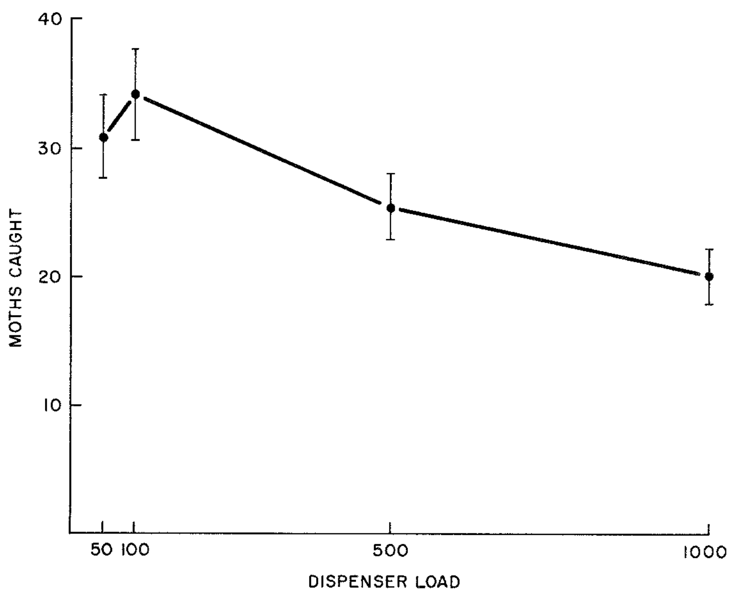

FIG. 1. Effect of dispenser load (μg) on average moth catch per night (N = 30 trap-nights per treatment).

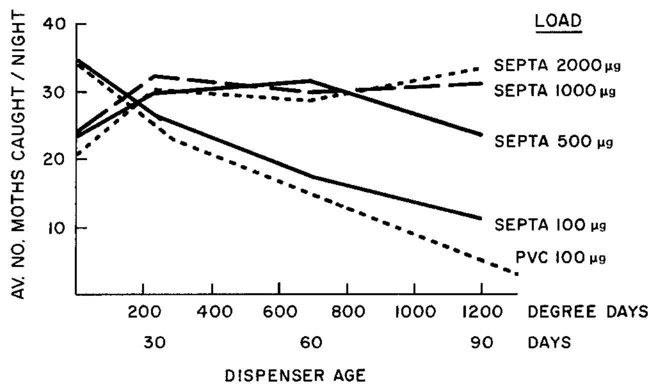

FIG. 2. Effect of dispenser age and load (μg) on average moth catch per night (N = 17–22 trap-nights per treatment).

exposed to different conditions, but the relative decrease with age appears to be similar with PVC as with rubber septa.

When exposing the pre-aged dispensers containing different quantities of attractant, the septum with 100 μg of attractant again gave a slightly higher initial catch than the other dosages. However, after 60 and 90 days of aging, 100 μg produced significantly lower catches than higher dosages aged for the same period of time ($P = < 0.05$, Tukey's comparison of means) (Figure 2). Catches in traps with 500, 1000, and 2000 μg/septum remained relatively consistent after 60 days and, even after 90 days of aging, catches were not reduced for traps with 1000- and 2000-μg dispensers. The reason for the consistency over time at higher dosages is not clear, but two other species of Noctuidae, responding to different attractants and traps, responded in a similar way (Struble, 1981; Struble and Byers, 1987). Thus, baits of 1000 or 2000 μg gave constant catch rates, which is ideal for a trap monitoring system. Based on the results of these experiments, a trap/lure combination of a totally green Multi-Pher trap and a septum lure with 1000 μg of pheromone was recommended for further field evaluation.

Assessment of Traps under Operational Conditions. By 1987 the populations at Smithers and Telkwa had collapsed but new populations were located near McBride, Golden, Clearwater, and Invermere, British Columbia where monitoring was carried out in 1987 and 1988 (Tables 1 and 2). The trap catches ranged from 0 to 1667 with a mean of 692 in 1987, and ranged from 89 to 1161 with a mean of 227 in 1988. Flight commenced in early July and lasted until late September; over 50% occurred in August during both years. Preliminary results indicate that when low catches (<350 moths) were obtained, there was no risk of seedling damage and restocking could proceed the next spring. When

TABLE 1. SELECTED PHEROMONE TRAP CATCHES AND SUBSEQUENT POPULATION LEVELS OF LARVAE AT 10 LOCATIONS IN INVERMERE AND GOLDEN FOREST DISTRICTS, BRITISH COLUMBIA

Trap location	Male moths caught 1987	Larval populations 1988
1	0	None
2	56	None
3	144	None
4	198	None
5	449	Trace
6	636	Trace
7	776	Trace
8	939	Light
9	1181	Moderate
10	1667	Large

TABLE 2. SELECTED PHEROMONE TRAP CATCHES AND SUBSEQUENT POPULATION LEVELS OF LARVAE AT 8 LOCATIONS IN INVERMERE AND MCBRIDE FOREST DISTRICTS, BRITISH COLUMBIA

Trap location	Male moths caught 1988	Larval population 1989
1	89	None
2	156	None
3	373	None
4	397	Light
5	434	Light
6	486	Light
7	986	Light
8	1123	Light

high catches (>600 moths) were obtained, there was a potential for seedling damage and follow-up surveys should be conducted the following spring prior to planting. Evaluation of the monitoring system is continuing to further define these action thresholds.

REFERENCES

DATERMAN, G.E. 1974. Synthetic sex pheromones for detection survey of European pine shoot moth. U.S.D.A. Forest Service Res. Pap. PNW-180. 12 pp.

HUMBLE, L.M., SHEPHERD, R.F., and MAHER, T.F. 1989. Biology, outbreak characteristics and damage caused by the black army cutworm (Lepidoptera: Noctuidae), pp. 82–88, *in* R.R. Alfaro and S. Glover (eds.). Insects Affecting Reforestation: Biology and Damage, Proceedings, Symposium IUFRO and International Congress of Entomology, July 3-9, 1989, Vancouver, British Columbia. Forestry Canada, Victoria, British Columbia.

IWAO, S., and KUNO, E. 1968. Use of the regression of mean crowding on mean density for estimating sample size and the transformation of data for the analysis of variance. *Res. Popul. Ecol.* 10:210–214.

ROSS, D.A., and ILNYTZKY, S. 1977. Black army cutworm, *Actebia fennica* (Tauscher), in British Columbia. Can. For. Serv., Pac. For. Res. Cent., Inf. Rep. BC-X-154. 23 pp.

SANDERS, C.J. 1986. Accumulated dead insects and killing agents reduce catches of spruce budworm (Lepidoptera: Tortricidae) male moths in sex pheromone traps. *J. Econ. Entomol.* 79:1351–1353

STRUBLE, D.L. 1981. A four-component pheromone blend for optimum attraction of redbacked cutworm males, *Euxoa ochrogaster* (Guenee). *J. Chem. Ecol.* 7:615–625.

STRUBLE, D.L., and BYERS, J.R. 1987. Identification of sex pheromone components of darksided cutworm, *Euxoa messoria*, and modification of sex attractant blend for adult males. *J. Chem. Ecol.* 13:1187–1199.

STRUBLE, D.L., BYERS, R.J., SHEPHERD, R.F. and GRAY, T.G. 1989. Identification of sex pheromone components of the black army cutworm, *Actebia fennica* (Tauscher) (Lepidoptera: Noctuidae) and a sex attractant blend for adult males. *Can. Entomol.* 121:557–563.

WOOD, G.W., and NEILSON, W.T.A. 1956. Notes on the black army cutworm, *Actebia fennica* (Tausch.) (Lepidoptera: Phalaenidae) a pest of low-bush blueberry in New Brunswick. *Can. Entomol.* 88:93–96.