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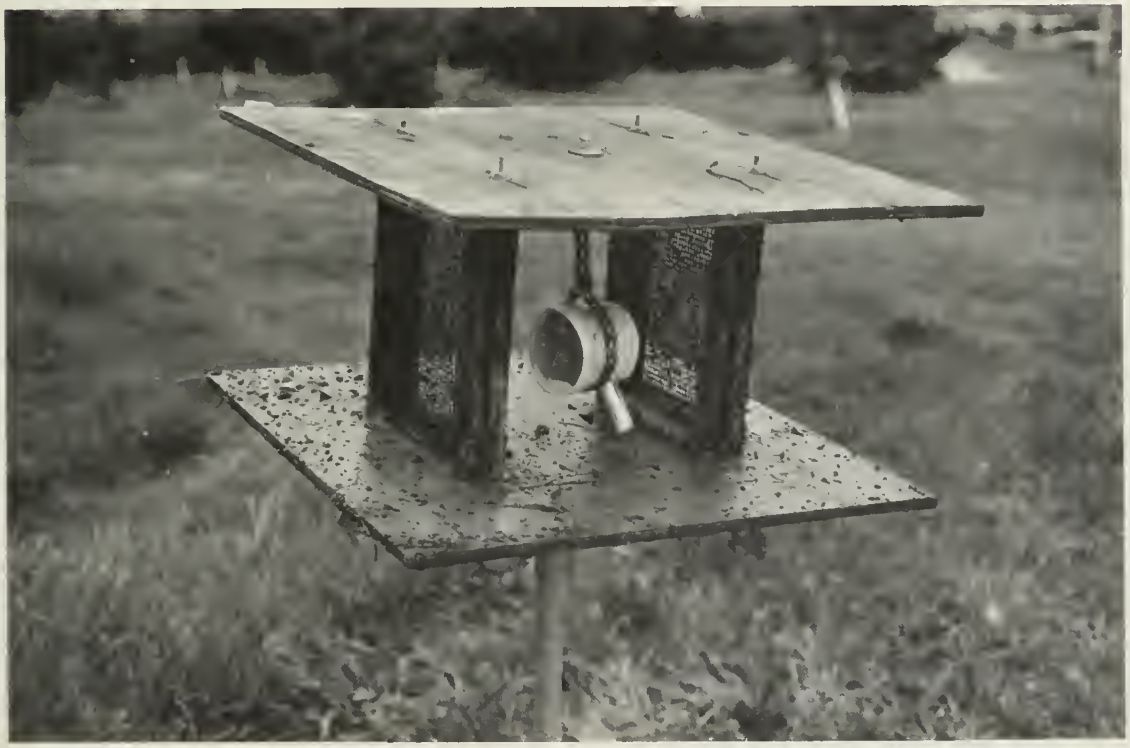

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The life history of the black cutworm, *Agrotis ipsilon* (Huf.), (BCW) is not fully known for the north-central United States where the cutworm in the destructive larval stage attacks seedling corn during May and early June. The origin of these larvae continues to be the subject of debate. Puttler et al. (1973) suggested that the damaging larvae overwinter, but information based on developmental thresholds and temperature-dependent development times (Luckmann et al. 1976) suggested they could arise from eggs laid in the spring.

This study was undertaken to develop and test a method for early season detection of BCW adults and to determine whether eggs laid at the time of the first flight could produce 3rd instar larvae by the time seedling corn is present. Swier et al. (1976) demonstrated that virgin female BCW would attract male BCW to sticky traps, and previous investigators have successfully used similar traps to study other insect populations (Swailes et al. 1975, Wong et al. 1972). A sticky trap baited with virgin female BCW was evaluated throughout the cropping season along with a black light trap to determine which method was the better indicator of adult BCW presence and density.

In order to compare catches in the black light and the virgin female traps it was desirable to find a field location and situation where both traps were highly effective at indicating adult numbers during the entire season. After preliminary investigation, an abandoned orchard in Urbana, Illinois, was chosen as a suitable place for a black light trap. The area was in permanent sod, and since it was being converted from an orchard to a tree nursery, it contained some apple trees plus a diversity of other trees and shrubs. Within this area, studies were conducted to situate a virgin female trap to maximize its efficiency yet retain practicality for field use.

MATERIALS AND METHODS

Black cutworm female moths used in the traps were obtained from a laboratory colony established in December, 1976, with eggs from a female caught in a black light trap (Fig. 1) at Urbana, Illinois. Beginning in March, 1977, females captured in the black light trap were periodically introduced into the lab-

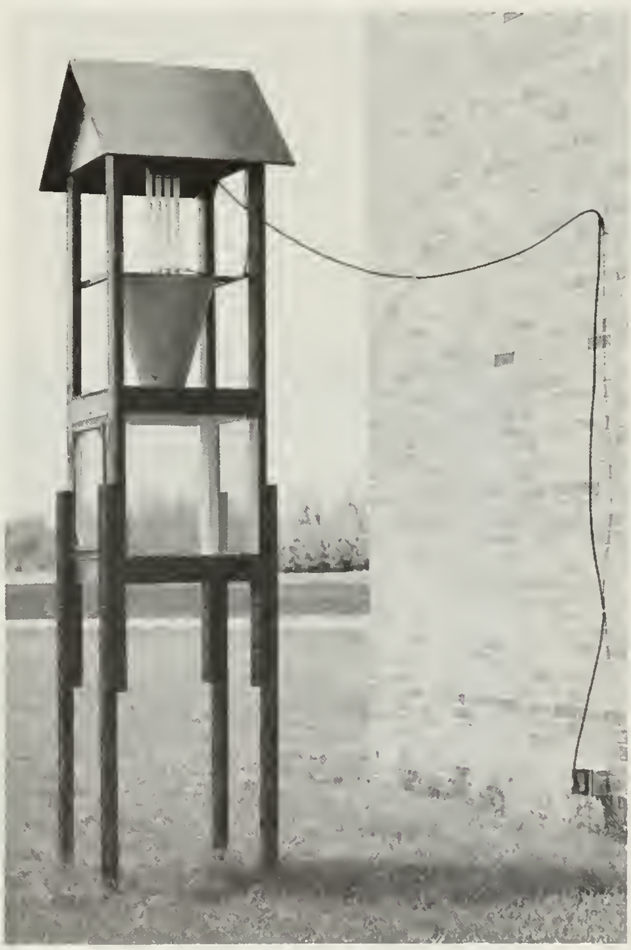

Fig. 1.—Black light trap located at the Natural Resources Studies Annex of the Illinois Natural History Survey, Urbana, Illinois. This trap supplied most of the feral stock introduced into the lab colony, and an identical trap was located in the abandoned orchard.

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oratory culture to assure that the colony was never more than one generation removed from feral stock. The procedure for culturing was similar to that described by Reese et al. (1972).

The virgin female trap was modified from a design described by Wong et al. (1972). The base and roof platform were constructed with 1.27-cm plywood and waterproofed with a clear polyurethane coating. Both platforms were expanded to squares of 60-cm sides. Tack Trap, a product of Animal Repellent, Inc., Griffin, Georgia, was applied to the upper surface of the lower platform and to the two lateral hardware cloth screens and wooden supports. The Tack Trap was changed once a week due to a build-up of other insects (mainly Diptera) and debris. Two 3-day-old females were placed within a disposable 1-pint cylindrical paper Fonda carton from Bush Brothers, Inc., Champaign, Illinois, in which the top and bottom were replaced with 0.75-mm mesh nylon screening. The carton was positioned laterally in the center of the trap and held in place by a strap of metal plumbers' tape which was fastened to the under surface of the roof (Fig. 2). A hole cut in the side of the paper carton accommodated a vial containing 10-percent honey water. At least twice a week the carton was replaced with a new one containing fresh females depending on the longevity of the females and if they were calling as indicated by males caught.

Two height-comparison tests were completed; the first was done in conjunction with a study on locational effects on catches. The first test compared virgin female traps placed on the soil surface, and at 1.0, 1.5, and 2.0 m above ground. The traps were positioned at different locations (Table 1) and were spaced at least 50 m apart and each was at least 50 m from the orchard black light. The trap height was changed randomly at each location once a week. To facilitate an easy adjustment to the desired height, metal pipes (0.95 cm inside diameter) were attached to traps and inserted into larger metal pipes (1.90 cm inside diameter) embedded 1 m in the ground. The trap in the tree was hung by rope so that it could be lowered or raised easily. The test consisted of six replicates, each replicate representing a week of daily examinations of each trap.

The second test compared heights at 1.0, 1.5, 2.0, 3.0, and 4.0 m. Because of the difficulty of maneuvering the taller heights these traps remained at their initial height location for the duration of the test. The 3-m trap rested on the peak of the roof of a small building, while the 4-m trap hung from an isolated mature apple tree. The test consisted of three replicates of one week per replication. Traps were checked daily for BCW males.

The primary virgin female trap was positioned at a height of 2 m (Fig. 3) and located at one edge of a sodded area containing mature apple trees and adjacent to cultivated fields used for the production of soybeans and corn. The black light trap was

Fig. 2.—Virgin female sticky trap, showing carton for holding black cutworm females. The upper surface of the lower platform and the two lateral hardware cloth screens and supports are covered with Tack Trap.

omnidirectional and equipped with four 15-watt (43.2 cm length) black light fluorescent bulbs. It was positioned approximately 3 m above the ground and 100 m from the primary virgin female trap. There was a shed between the two traps which blocked the light of the black light from reaching the virgin female trap. The comparison began 1 March, and traps were checked daily through 7 November 1977.

The temperature records needed to calculate centigrade-degree-day development and other weather information were obtained from the Illinois State Water Survey, Urbana. Developmental threshold and rates of development for each stage of the BCW were taken from Luckmann et al. (1976). Centigrade-degree-days were calculated from the daily temperature, using the methods of Arnold (1974).

RESULTS AND DISCUSSION

Trap Height and Location

A steady increase in male BCW catches was observed with increasing trap heights. This trend was shown by both tests 1 and 2 which were run at different times during the season (Fig. 3). The lines in Fig. 3 representing these tests on trap heights illustrate clearly the relation, except for a dip at 1.5 m in test 2. Swier et al. (1976) captured the most BCW males at 1.5 m above the soil surface and found a significant drop in catches at 3.1 m. Contrary to his findings, mean catch was higher for 2, 3, and 4 m in this study (Fig. 3). However, this study was conducted in an orchard where some vegetation was as high as 10 m. Swier's work was done next to an alfalfa field where foliage was 0.46 m high. Saario et al. (1970) studied trap elevation in relation to the type of vegetation associated with a virgin female cabbage looper, *Trichoplusia ni*, sticky trap. They found more males were captured by a trap at an elevation of 2 m above the soil surface in a broccoli planting than at other heights. Average plant height in the field was 1–1.3 m, whereas, traps placed on the trunks of citrus or eucalyptus trees tended to have increased efficiency at an elevation of 4 m as compared with 1 m and 2 m. Saario and colleagues have suggested that the horizontal surface produced by the top of vegetation in a broccoli field (or an alfalfa field) may provide visual orientation for the flying males. Likewise, in an orchard area the trees may act as a visual stimulus for pheromone orientation. Thus, males would fly higher in a wooded area as compared to a flat field situation.

Due to the difficulty of maneuvering traps to higher elevations no attempt was made to find the height at which moth catch in the orchard would be greatest. The purpose of these tests was to find a height that would be practical for field use and would reliably indicate adult numbers during the entire season. The 2-m trap caught the most moths in early spring and was outperformed by only the 4-m trap later in the summer (Fig. 3). Also the trap at this height was easier to manipulate than one at 3 or 4 m. Thus, the 2-m height was used as the trap height for the seasonal comparison.

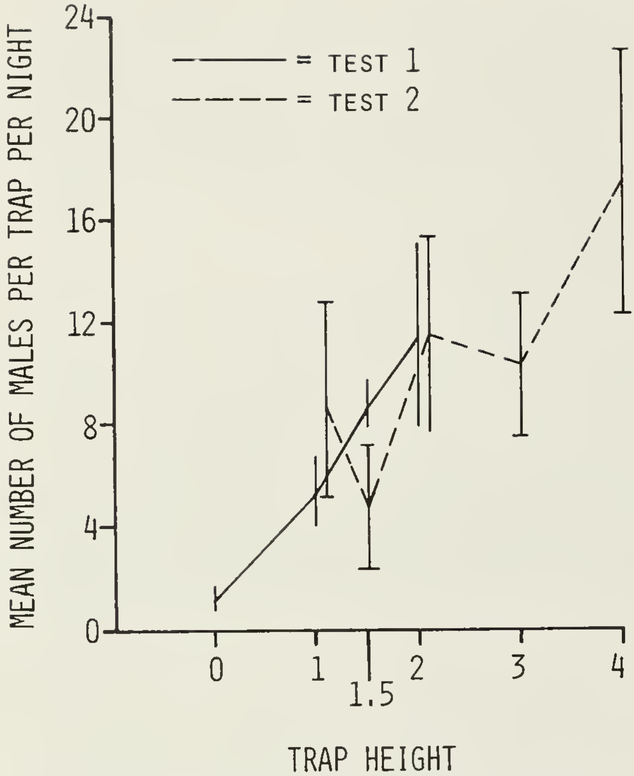

Fig. 3.—The efficiency at various heights of a sticky trap baited with virgin female black cutworms. Mean of 0 height is significantly different at $P = 0.001$ level from other heights.
Vertical lines = ± SE of mean.
Test 1—Total males captured = 1,128
20 April–2 June 1977.
Test 2—Total males captured = 1,062
14 June–6 July 1977.

The density of vegetation surrounding a trap (within 5–10 m) affects trap efficiency (Table 1). The trap which performed poorly was located in the midst

Table 1.—Effects of location on the mean number of black cutworm males caught by a virgin female sticky trap.

Trap location[a]	Mean No. of BCW males[b c] caught/night
1	3.25 a
2	6.40 a b
3	7.25 a b
4	12.28 b

[a] Trap location 1 = trap surrounded by dense small trees and shrubs (3 m)
2 = surrounded by trees (10 m)
3 = outskirts of orchard next to soybean and cornfields
4 = hung from tree limb in open vegetation
[b] Mean separation by Duncan's NMR test. Mean in column followed by same letter not significantly different ($P = 0.05$).
[c] Mean no. is calculated from data for 32 nights.

of low shrubs and trees (2–3 m) perhaps impeding pheromone dispersal or obstructing flight. This is consistent with the finding of Saario et al. (1970) who found decreased efficiency with traps baited with virgin female cabbage loopers located in the midst of foliage. The other trap locations were surrounded by vegetation but not as dense as the low shrubs and trees.

Spring Appearance

The first BCW was caught on the night of 14 March and the second moth on the night of 15 March 1977. These first two males were found in a virgin female trap resting on the sodded surface in the orchard. From their positions away from the edge of the sticky surface it was evident that the males flew into this trap. The moths were in mint condition and easily identifiable; body scales were intact, giving the appearance of newly emerged males. These moths have been preserved and are on deposit in the permanent entomology collection of the Illinois Natural History Survey. The earliest date that the presence of BCW adults had been recorded by the black light over several years was 28 March.

The daily temperatures during the week prior to the first catches were warm, averaging 12.5°C. The temperatures on the 14th and 15th had highs of 20.6°C and 21.2°C and lows of 2.2°C and 5.6°C, respectively. There were southerly winds of up to 4.3 m/s every day during the week preceding 15 March.

No more BCW moths were captured until 27 March when the 2-m virgin female trap attracted two males. During the week prior to this date there had been a steady southerly wind at approximately 3 m/s. Fourteen males were captured in the 2-m trap on the night of 28 March. During that day there was a rainstorm with strong winds from the south up to 6.9 m/s and the daily temperature reached a high of 17.2°C and a low of 12.8°C. During 25–31 March, 1–7 April, and 8–14 April, the 2-m virgin female trap captured 24, 37, and 26 moths, respectively. The black light trap caught three males and one female, one female, and one male, respectively, during the same periods (Fig. 4).

Using 10.4°C as a developmental threshold, 9 centigrade-degree-days had accumulated at Urbana between 1 January and 14 March 1977. Only 30 centigrade-degree-days had accumulated prior to the first peak of males during the first week of April. If these early moths overwintered at Urbana, they must have done so as mature pupae. Temperatures and centigrade-degree-day accumulation were sufficient to activate a local population. However, there were strong southerly winds in March and April which may have brought these moths to central Illinois from more southerly areas.

Seedling corn damaged by 3rd and 4th instar BCW

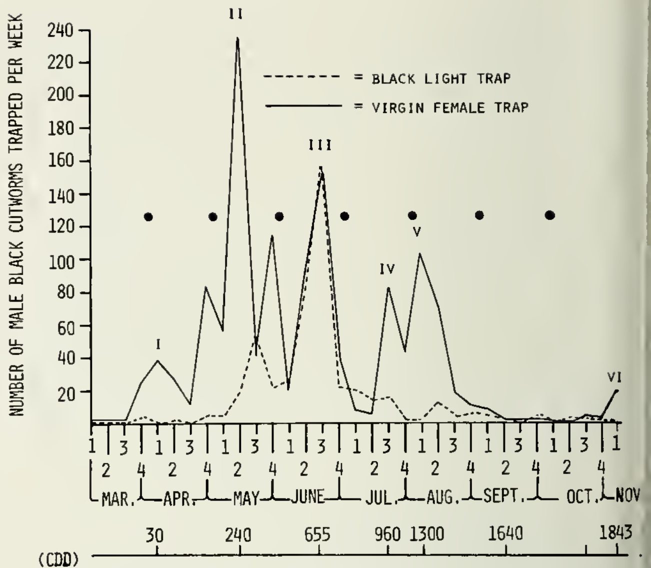

Fig. 4.—The seasonal collection of male black cutworm moths by a black light trap and a sticky trap baited with virgir female black cutworms during 1977 in an orchard area being converted into a tree nursery at Urbana, Illinois. The black dots represent the full moons and CDD are the accumulatec centigrade-degree-days (base 10.4°C).

larvae was found in a field near the study area or 11 May. Centigrade-degree-day accumulation from 1 April to 11 May was 210, an amount sufficient foi development from oviposition to 3rd and 4th instai (Luckmann et al. 1976). It is not likely that the larvae which damaged corn at Urbana on 11 May overwintered as early instar larvae or eggs, and i seems more probable that they were the progeny o the adults flying very early in the season. The fac that the early males were attracted to the virgin fe males demonstrates sexual activity, and since tw females were captured in the black light trap ir March and early April, mating and oviposition coul have occurred during this early season flight (Fig. 4)

Efficiency of the Black Light

For the entire season 2.6 times more males wer captured by the trap containing virgin females thai by the black light. More importantly it attracted times more males during March through May. Th black light failed to detect the earliest adult BCV or reflect the density of the early spring flight in lat March and early April.

During mid-June the black light and the virgi female trap did have identical peaks (Fig. 4). A environmental factor may have inhibited the moth attractancy to a black light during other peaks. Wi liams et al. (1956) observed reductions in light tra captures during periods of a full moon. He suggeste the moonlight competed with the light from th traps, reducing trap efficiency. Agee et al. (197 noted that *Heliothis zea* catches increased in the period of the new moon and decreased sharply 2–3 days prior to the full moon and 1–2 days thereafter in a black light. A similar trend was previously observed for BCW, but a significant difference between new and full moon catches could not be demonstrated (Hanna & Atraies 1970). In our study, black light catches were very low at every full moon (Fig. 4), even when the virgin female trap was catching high numbers.

Generations per Season

For the codling moth, *Laspeyresia pomonella*, three peaks of male catches in pheromone traps were interpreted as corresponding to the emergence of three generations (Batiste et al. 1973, Metcalf 1975). Miyahara et al. (1977) detected five generations of *Spodoptera litura* using a virgin female trap of that species. Thus, sex pheromone traps appear to be good indicators of activity in the field.

Only 210 degree-days accumulated between peak I and peak II in Fig. 4, while according to Luckmann et al. (1976) an average of 643 is required for a generation. Thus, the second flight of moths which occurred in early May could not have emerged as progeny from the flight which occurred in early April.

There is sufficient degree-day accumulation for development of a generation between peaks I and III and again between peaks III and V. Also, there is sufficient temperature accumulation for a generation between II and IV. The moths beginning to appear at VI could have come from IV or V and may be a merging of the two populations. Because temperatures were very cold after 7 November, the study was terminated at that time.

The data presented in Fig. 4 depict events only for 1977. We do not know whether two overlapping populations always occur and whether the number of generations per year is consistent, but the results presented here are based on events that did occur and which contribute to our knowledge about this important pest.

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