LABORATORY REARING OF THE FALL ARMYWORM¹,²,³

W. DERYCK PERKINS

Southern Grain Insects Research Laboratory, Agricultural Research, Science and Education Administration, USDA, Tifton, GA 31794

ABSTRACT

At the Southern Grain Insects Research Laboratory, capability for rearing the fall armyworm, (FAW), Spodoptera frugiperda (J. E. Smith), has increased from a few hundred per day in 1960 to 10,000 per day in 1978. The potential capacity is 100,000/day if use is made of multi-cell form-fill-seal equipment presently available. Cost of rearing 1,000 FAW pupae increased from $16.50 in 1967 to $31.60 in 1978. The 1978 cost can be reduced 56% by using form-seal equipment.

The fall armyworm, (FAW), Spodoptera frugiperda (J. E. Smith), has been successfully reared for 18 years (250 generations) at the Southern Grain Insects Research Laboratory. The colony was initially established from larvae collected during the summer of 1960 from Bermudagrass in the vicinity of Tifton, GA. These insects were fed on corn sprouts and plant parts (whorls) from young corn. As the larvae became older and required more food, mature ears of corn were used to supplement the diet.

Although larvae developed well on the plant material and adult emergence and oviposition proved successful, large quantities of insects could not be produced. Entomogenous diseases perpetuated by the use of fresh plant material also became a problem at times.

In 1962, additional insects were collected from the field and added to the colony. During the following 3 years, the culture was subjected to intense selection pressure in an effort to increase fecundity. In 1965, the culture was converted to a meridic diet (Burton 1967).

¹Lepidoptera: Noctuidae.
²In cooperation with the University of Georgia College of Agriculture Experiment Stations, Coastal Plain Station, Tifton, GA 31794. Received for publication 19 January 1978.
³Mention of a commercial or proprietary product does not constitute endorsement by the USDA.
Rearing Procedure

Egg Production: Moths are allowed to emerge in the 1-oz. clear plastic cups in which they are reared. The moths are sorted by sex, and pairings are made by placing 8-10 pairs in each 1-gallon cylindrical cage lined with wax impregnated paper. A 1-oz. souffle cup containing a dental roll saturated in a beer-ascorbic acid solution (1.5 gm/828 ml beer) is placed in the cage; a paper towel cover that serves as an oviposition site is held in place by the cardboard ring portion of the container. The cages are maintained in an environmental chamber with fluorescent lighting for 14 h/24 h day. Temperature and relative humidity are held constant at 78-80°F and 65-70% RH, respectively.

For 5 days, eggs are collected daily by placing the cages in a cooling compartment so the moths are immobilized and then removing the paper towel cover with eggs attached. An air filtering system removes moth scales from the working environment. Any moths escaping during the process are attracted to the fluorescent lighting in the cooling compartment so that they can be recaptured easily. After each collection of eggs, the cages are immediately returned to the environmental chamber. A centrifugal dust collector (Harrell and Perkins 1971) is used to remove moths from the cage after the 5th day of egg collection.

Egg masses are clipped from the towel and liners on which they are attached, placed in small clear plastic bags, and held in the same environmental conditions as the adults (78°F and 65% RH). Three days are allowed for hatching; then the bags of larvae are placed in a chamber maintained at 55-60°F until they are used for infesting artificial diet. If larvae must be separated from unhatched eggs, the egg masses are placed in a dark container and a transparent plastic bag is used to cover the opening. As the eggs hatch, the larvae will move upward and into the clear plastic bags.

Larval Stage: Several artificial diets are available that provide adequate nutrition for good larval development (Shorey and Hale 1965, Vanderzant 1967). Three diets that have been successfully used at this laboratory are: the casein wheat germ diet (Burton 1967), the pinto bean (Burton 1969) and the WSB diet (Burton and Perkins 1972). All appear to be equal (Perkins et al. 1973) in providing quality insects though there is considerable difference in cost. Cost and availability are, therefore, the major factors involved in selecting 1 of these diets. The casein wheat germ diet is highest in cost, followed by the pinto bean diet. WSB diet is presently unavailable. We, therefore, use the pinto bean diet formulated and dispensed as described in Burton (1969) and Burton and Cox (1966).

An artist's brush is used to place 3 first-instar larvae in each cup. After the diet is infested and the rearing cups are capped, trays are stacked and secured in bundles of 4-8 trays; these are carried into an environmental room where they are held at 82-84°F and 65-70% RH for the duration of larval development, through the pupal stage, and until adult emergence. As moths begin to emerge in the cups, the cups are moved to another room where they are sorted and paired for use in egg production.

The technique described is relatively simple and is adequate for rearing from 5000-10,000 insects per day when a packing machine is used to dispense the diet into the cups (Burton and Cox 1966). Other methods are needed if greater numbers of insects are required.
MECHANIZATION

The acceptance of artificial diets (Adkinson et al. 1960, George et al. 1960) for insect rearing opened the way for mechanization. Two devices were developed at the Tifton laboratory to aid in diet handling and infestation. The first was a 6-quart stainless steel pressure cooker (Burton et al. 1966) that was adapted to dispense diet into glass shell vials. The second device was a means of placing individual larvae into vials containing diet (Burton et al. 1966); this eliminated the need for the artist-brush method of transferring larvae. Later, disposable plastic cups and paperboard caps replaced the glass vials and cotton plugs, but the plastic cups were still placed into Cel-Pak trays by hand and filled with the desired amount of diet by using the pressure cooker filler.

Labor requirements for this procedure were prohibitive when large numbers of insects were needed. When increasing numbers of Lepidoptera were needed for pheromone studies (Sekul and Sparks 1967, 1976), a food packaging machine was purchased (Burton et al. 1966). With the aid of this machine, up to 10,000 cups of diet could be processed each day. Also, attachments made it possible to use the machine to infest diet with larvae and cap the cup in 1 operation (Burton and Harrell 1966). Later, a machine was devised to collect the pupae from plastic cups (Harrell et al. 1968). The cost of rearing 1,000 FAW pupae with this equipment was $16.50 in 1967, but inflation had increased the cost to $31.60 by 1978 (Table 1).

MULTI-CELL FORMING EQUIPMENT

Labor and containers still comprised 66% of the total cost of FAW rearing in 1978. Thus, further mechanization is needed to economically mass produce the quantity of insects required for research on biological control of the FAW.

An inline form-fill-seal machine was purchased in 1971 and adapted for mass rearing the corn earworm, Heliothis zea (Boddie), (Sparks and Harrell 1976). This machine forms plastic into a continuous web of cells at the rate of 544 cells/minute, heat-seals a cover material over the formed cells, and shears the web into desired lengths. Also, diet-filling equipment and an egg-

<table>
<thead>
<tr>
<th></th>
<th>Plastic cup method</th>
<th>Form seal method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinto bean diet</td>
<td>$3.61</td>
<td>$3.84</td>
</tr>
<tr>
<td>Container material</td>
<td>7.16</td>
<td>1.44</td>
</tr>
<tr>
<td><strong>Labor:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diet preparation, infesting, handling</td>
<td>8.26</td>
<td>1.05</td>
</tr>
<tr>
<td>Egg production</td>
<td>1.30</td>
<td>1.99</td>
</tr>
<tr>
<td>Collecting pupae or adults</td>
<td>4.26</td>
<td>2.05</td>
</tr>
<tr>
<td>Operating cost</td>
<td>—</td>
<td>.36</td>
</tr>
<tr>
<td>Miscellaneous expense</td>
<td>7.00</td>
<td>3.60</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$31.60</strong></td>
<td><strong>$14.33</strong></td>
</tr>
</tbody>
</table>
Infesting station were fabricated and synchronized to make a continuous automated process. In 1974, this equipment was modified for mass rearing the boll weevil, *Anthonomus grandis* Boheman (Harrell et al. 1977). Three consecutive years (1975, 1976, 1977) of heavy FAW infestation have increased interest in developing new and better means for control. The form-seal equipment is now being considered for use to mass rear FAW needed for biological control studies.

The use of form-seal equipment could reduce the cost of rearing FAW by 55% based on a daily production of 100,000 pupae. The greatest single savings results from a reduction in labor and an 80% reduction in the cost of container material.

Other improvements in FAW rearing methodology are essential. In the immediate future, efforts will be made to find more efficient techniques for egg production and automated larval injection into rearing cells. Adequate storage facilities that maintain the proper environmental conditions are essential. Although equipment and facilities have been designed for this purpose, additional work will be required to maximize the use of storage space.

All figures given in this paper are based on less than the 80% efficiency realized with the present plastic cup rearing method. As mechanization processes are refined, it is reasonable to expect 70-75% efficiency as with other species reared by the new method.

**Literature Cited**


——. 1969. Mass rearing the corn earworm in the laboratory. USDA, ARS 33-134, 8 p.


MONITORING ADULT POPULATIONS OF THE FALL ARMYWORM1,2

EVERT R. MITCHELL
Insect Attractants, Behavior, and Basic Biology Research Laboratory,
Agricultural Research, Science and Education Administration,
USDA, P. O. Box 14565, Gainesville, FL 32604

ABSTRACT

Blacklight traps and pheromone-baited cylindrical electric grid traps were used to monitor seasonal populations of the fall armyworm, Spodoptera frugiperda (J. E. Smith), in Louisiana and Florida, respectively. Disposable sticky traps baited with pheromone, (Z)-9-dodecen-1-ol acetate, also have been used extensively in surveys for the adult fall armyworm (FAW) in Georgia and Florida. These traps are relatively inexpensive, easy to transport and assemble, and they can be deployed in situations where electric power is unavailable. Sticky traps are generally most effective in capturing FAW males when positioned ca. 1 m above the ground in and around preferred hosts such as corn, peanuts, and improved, highly fertilized grasses such as coastal bermuda.

The number of adult fall armyworms, Spodoptera frugiperda (J. E. Smith), in any area is influenced by many factors including time of year, distribution and abundance of wild and cultivated hosts, cropping patterns, weather, and dispersal from or immigration into the area. It is desirable to have a simple, inexpensive procedure for sampling adult fall armyworms (FAW) which will reveal significant fluctuations in population density and which can be used in conjunction with a developmental model and meteorological data to forecast potential outbreak situations. This paper reviews the different types of traps currently used for sampling adult FAW.

LIGHT TRAPS

Blacklight traps have been used for years as a tool for surveying many insect pests including the FAW (Hinton 1974). This species is one of 20

1Lepidoptera: Noctuidae.
2This paper reports the results of research only. Mention of a pesticide does not constitute a recommendation for use by the USDA nor does it imply registration under FIFRA as amended. Also, mention of a proprietary product does not constitute an endorsement by the USDA.