Effect of Sterile Boll Weevils (Coleoptera: Curculionidae) and Insecticide in Isolated Small Plots in Florida[1]

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ABSTRACT In the spring and summer of 1989, insecticide and sterile boll weevils, *Anthonomus grandis* Boheman, were applied to plots of cotton on two private research farms at Vero Beach, Florida to suppress the native boll weevil population. Plots were treated weekly with azinphosmethyl followed by the release of about 500 sterile boll weevils per acre two days later. Egg hatch was 5% on the Mobay farm where serially planted plots of cotton were destroyed soon after blooming. On the Ciba-Geigy farm egg hatch averaged 32% prior to the formation of bolls 2.5 cm (1 in.) or larger in diameter and 77% when bolls were larger than 2.5 cm in diameter. Normally, egg hatch in fields with no sterile weevils is about 94% so their effect in preventing or significantly lowering the reproductive activity of native females entering the cotton fields was demonstrated. After natives began emerging from the clumped areas where oviposition had taken place, the effectiveness of the sterile weevils was significantly diminished.

The Ciba-Geigy research farm had received more than 30 applications of azinphosmethyl during the 1988 growing season, and the Mobay farm had received 6 applications of methomyl. In 1989, 16 pheromone baited traps placed around the perimeter of each farm in 1989 captured an average of 12 (Mobay) and 37 (Ciba-Geigy native weevils per week before and during the treatment period. At Ciba-Geigy 41% of the trapped weevils were sterile compared to 34% at Mobay. In 1990, 16 pheromone traps placed around the Mobay and Ciba-Geigy farms averaged 0 and 4 weevils per week, respectively, during the growing season.

KEY WORDS Pheromone, population suppression, diflubenzuron, azinphosmethyl, methyl parathion, *Anthonomus grandis,* boll weevil.

Irradiation was the first method used to sterilize the boll weevil, *Anthonomus grandis,* Boheman, but dosages of irradiation large enough to produce sterility also caused high mortality (Davich and Lindquist 1962). Other methods of sterilization were investigated, but irradiation appears to be the best method currently available. Mortality could still be considered high, but irradiated weevils were able to function effectively in the field. Radiation alone will sterilize males, but to assure sterility in females, additional treatment with a chemosterilant such as diflubenzuron is necessary (Earle et al. 1978). Sterile boll weevils consistently reduce egg hatch in small isolated plots of cotton

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(Villavaso et al. 1979, Villavaso and Thompson 1984) and commercially grown cotton with native infestations (Villavaso et al. 1986, 1989). However, native weevils have never been eradicated from any area by the release of sterile weevils. In 1989 the state of Florida was engaged in a program to eradicate the boll weevil. Commercially grown cotton was limited to the northern part of the state, but a small amount of cotton (<25 acres) was grown on private research farms in the Vero Beach area of southern Florida which is at least 320 km (200 mi.) from the commercially grown cotton. All cotton grown near Vero Beach was infested with a native population of boll weevils. This very limited acreage with excellent isolation seemed to be an ideal place to attempt to eradicate a native population by the release of sterile weevils. The pattern of serial planting dates and crop destruction used on the farms and the absence of immigration from untreated areas provided an unique opportunity to study the effectiveness of sterile weevils under heretofore untested conditions.

Materials and Methods

Test were conducted on the Ciba-Geigy and Mobay agrichemical research farms near Vero Beach, Florida during the spring and summer of 1989. Sixteen boll weevil traps baited with 10 mg of grandlure were placed around the perimeter of fields where cotton was planted in 1988 or 1989. Captured weevils were removed and counted weekly, and pheromone was replaced biweekly. The same procedure was followed in 1990.

In 1988 late season populations on the Ciba-Geigy farm were especially large and 38 applications of azinphosmethyl (31), methyl parathion (3), parathion (3), or oxamyl (1) were made between July 18 and November 23. Because plots on the Mobay farm were destroyed about the time small bolls formed, the boll weevil populations were not as large as those on the Ciba-Geigy farm, and from September to November, 1988, the Mobay plots received six applications of methomyl.

In 1989, cotton on the Ciba-Geigy farm was planted in five 0.8 hectare (2 acre) plots every 3 - 4 weeks. After large bolls (>2.5 cm diameter) had formed, but before they opened, the cotton was mowed down. Cotton on the Mobay farm was planted in five 0.1 - 0.2 ha. plots (1/4 - 1/2 acre) about every 3 weeks. It was destroyed soon after blooming and no later than when small bolls (<2.5 cm diameter) had appeared.

Boll weevils were sterilized by immersing them in an aqueous solution of diflubenzuron (0.4% at approximately 30°C) for 10 minutes followed by a single dose of 100 Gy (10,000 rad) of gamma irradiation from a ^{137}Cesium source (Villavaso et al. 1989). They were then placed in 474 cc cylindrical cartons (500 per carton), packaged in a styrofoam ice chest and shipped by air to Vero Beach. Weevils reached their destination about noon the following day. They were released at sunset or soon thereafter that day. From 500 to 1000 sterile boll weevils per acre per week were sprinkled by hand over the plots in 1989. We tried to distribute the weevils in a way that would give uniform coverage of the cotton plants.

Each plot was searched weekly for the presence of squares that appeared to have been oviposited in by boll weevils. These squares were dissected under a microscope (10X) to see if they contained an egg or a larva. Eggs were plated onto moistened black filter paper and incubated for 4 days (30°C) to determine percentage egg hatch. Larvae found in the squares were considered to be hatched eggs. Thus, if we found 4 larvae and 6 eggs, 1 of which hatched on the filter paper, egg hatch was reported as 5 of 10 or 50%.

Eggs laid by sterile females were differentiable from those laid by natives because the sterile weevils had been reared on a dyed diet that imparted a pink color to the weevils and to their eggs. Since virtually none of the eggs laid by the diflubenzuron-dipped sterile females hatch, counting them as part of the total hatch would result in inflated estimates of suppression of hatch. Thus, only eggs and larvae originating from the native females were used to calculate hatch. Pink eggs were counted and their numbers were noted; however we have not been able to make a correlation between the number of pink eggs found in the field and competitiveness or effectiveness of the sterile weevils (Villavaso 1982). Pink eggs do indicate that sterile females remained in the field and oviposited.

Postirradiation survival, a measure of the vigor of sterile males, was measured on 8 samples. Ten to twenty males were caged individually in 2.5 cm screened plastic cubes on cotton squares on greenhouse plants at Mississippi State, MS. Mortality of the caged weevils was monitored daily as surviving weevils were moved to fresh squares.

In 1990 weekly releases of about 500 sterile weevils per acre began on March 24 in the Mobay plots to suppress or eradicate the surviving population. Azinphosmethyl or cyfluthrin was applied weekly, sometimes biweekly, during the first few weeks of the 1990 growing season. Sterile weevils were not released at the Ciba-Geigy farm in 1990.

Results and Discussion

The number of boll weevils captured per farm per week during 1989 averaged 37 (range 2-147) at Ciba-Geigy, and 12 (range 0-65) at Mobay. These relatively large numbers for the small acreage under study indicated that the native population was substantial and probably too large to expect eradication in one season (Fig. 1-2). At the Ciba-Geigy farm 230 of the 555 trapped adults sampled (41%) were sterile, and at Mobay 62 of 180 (34%) were sterile as determined by the presence of red dye.

LT_{50}, the day on which mortality reached or exceeded 50%, averaged 7.8 days with a low of 6 days (1 sample) and a high of 10 days (1 sample). Egg hatch in the very young cotton on the Mobay farm averaged only 5% (5/92) over the course of the test. Hatch in the young cotton at Ciba-Geigy was 32% (52/162), but increased to 77% (330/430) as the cotton grew, and boll diameter increased to greater than 1 in. Hatch observed in the young cotton at both Mobay and Ciba-Geigy was much lower than the 94% normally seen when no sterile weevils are present. The reproductive potential of the native population was significantly suppressed by the sterile weevils. The differences in hatch between the Ciba-Geigy young and old cotton were significantly different from each other (77 and 32%; Chi-square = 104; df = 1) as were the differences in hatch

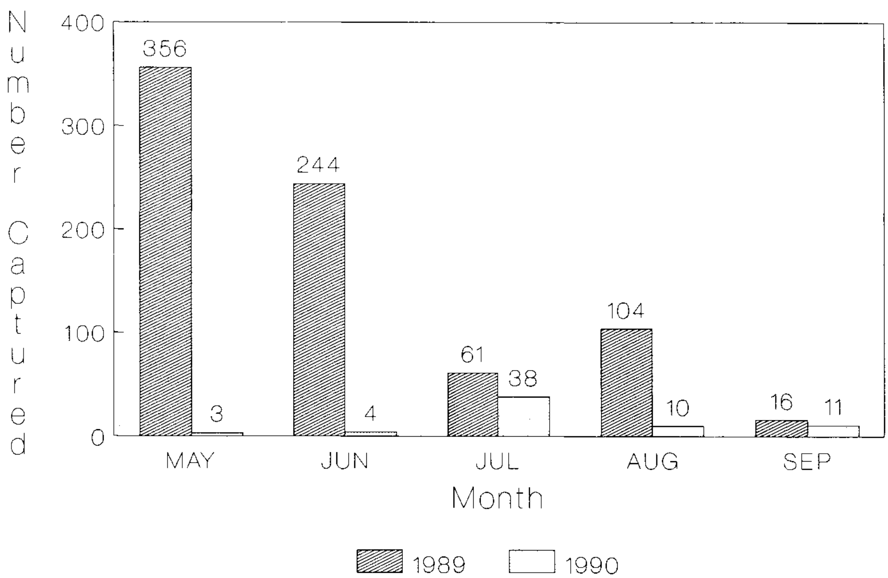

Fig. 1. Numbers of Boll Weevils captured in pheromone-baited traps: Ciba-Geigy Research Farm, Vero Beach, FL – 1989, 1990.

between the Ciba-Geigy young and the Mobay cotton (32 and 5%; Chi-square = 25; df = 1). The percentage of pink eggs was 42% (738/1747) at Ciba-Geigy and 74.8% (288/385) at Mobay. The greater percentage of pink eggs at Mobay suggests that the sterile to native ratio was greater there than the Ciba-Geigy and thus lower egg hatch would have been expected.

We are of the opinion that sterile weevils were effective in preventing reproduction by most of the native females entering the cotton fields. However, some native females were able to locate native males and mate with them. Mated females tend to lay their eggs in relatively small clumps in the field (Pieters and Sterling 1974, Mitchell et al. 1976), and emerging adults would tend to be much closer to each other than to sterile weevils that had been released rather uniformly throughout the field. Thus, it was unlikely that there would be more than a few, if any, sterile weevils falling into a clump. Thus, the sterile to native weevil ratio in the clumps was probably much lower than that of the field as a whole, and sterile weevils would not be very effective under these conditions. Once this occurs, further releases of sterile males for eradication is probably futile, but the males would still be effective in lowering the number of new clumps that would have occurred in their absence.

The Ciba-Geigy farm had been heavily treated with azinphosmethyl and the Mobay farm had received 6 applications of methomyl late in 1988. Even with the insecticide applications and crop destruction practices conducted in 1988, the number of weevils overwintering weevils emerging in the spring of 1989 was substantial (Fig. 1 and 2). The combination of weekly applications of azinphos-

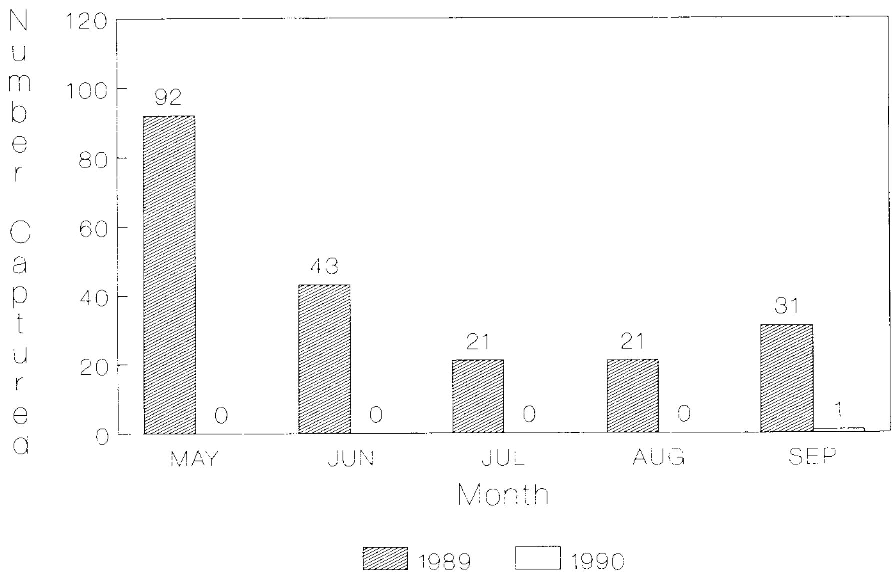

Fig. 2. Numbers of boll weevils captured in pheromone-baited traps: Mobay Research Farm, Vero Beach, FL – 1989, 1990.

methyl and sterile boll weevils applied in 1989 along with crop destruction had a significant impact on the number of weevils emerging in 1990. In 1990, the season after weekly treatment of the plots with aziphosmethyl and sterile weevils, 3.7 weevils per week were captured in the Ciba-Geigy plots between 8 May and 1 October (Fig. 1). During the first week of October, 1990, the older plots were destroyed and trap captures increased significantly. Fifty-one weevils were captured in October, 114 in November, and 102 in December. A total of 1539 weevils were captured for all of 1989 compared with 335 in 1990. At the Mobay farm only 1 native weevil was captured in 1990 (Fig. 2). Unlike the Ciba-Geigy farm, the Mobay farm was also treated with sterile weevils during the 1990 season. Biweekly to weekly applications of azinphosmethyl were also made. This combination apparently prevented reproduction in 1990. No natives were captured in traps during the 1990 season. The azinphosmethyl - sterile weevil combination appears to have had a significant impact on the boll weevil population at both locations.

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