ATTEMPTED ERADICATION OF THE CORN EARWORM FROM ST. CROIX, U.S. VIRGIN ISLANDS

Production Research Report No. 125

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with
University of Georgia
Agricultural Experiment Stations

ATTEMPTED ERADICATION OF THE CORN EARWORM FROM ST. CROIX, U.S. VIRGIN ISLANDS

By J. Wendell Snow, R. L. Burton, A. N. Sparks, and W. W. Cantelo, *entomologists*,
Entomology Research Division, Agricultural Research Service

During the summers of 1968 and 1969, research was undertaken on St. Croix, U.S. Virgin Islands, to study the population dynamics of the corn earworm (*Heliothis zea* (Boddie)) and to attempt to eradicate the species by the sterile-male technique.

The island is 84 miles square—about 22 miles long and up to 6 miles wide. The nearest land is St. Thomas, 40 miles to the north (*10*).[1] February, the coolest month, averages 75.6° F., and August, the hottest, averages 81.2° (*9*). Most of St. Croix receives 35–45 inches of rain per year, but the distribution of rainfall varies considerably and much of the island has long periods without rain (*4*).

At one time agriculture was the principal source of income for the island, but it has been replaced by tourism and industry. Because few acres remain in cultivation, an almost total dependence on imports for foodstuffs has resulted.

The island offers a diversity of habitats, including valleys suitable for diversified cropping, arid cactus and thorny bush-covered mountains, and mountainous areas with abundant trees, shrubs, and grass. Several sections of dense rain forest are present, as well as flatlands once rich in sugarcane production.

A survey for the corn earworm was conducted in 1967 by routinely maintaining virgin female traps on the island (*6*). Population estimates and distribution data for the species (*5*) showed that the earworm was present in low numbers and concentrated within limited corn acreages during much of the year. The daily emerging male population was estimated as ranging from 426 to 638 during the survey.

These estimates were used to predict rearing needs for eradication attempts in 1968 and 1969. These attempts failed in the primary objective of eradicating the species; however, much data were obtained on population dynamics, ecology, and procedures for conducting this type of program. This information should benefit future work in the area.

PROCEDURES

Rearing Pupae

Insects to be released on St. Croix were produced at the Southern Grain Insects Research Laboratory at Tifton, Ga. In 1968 they were reared individually in 1-ounce plastic cups filled with a modified bean diet (*1, 2*). In 1969 a CSM base diet [2] was utilized.

Cups of diet were infested with eggs, and pupae were machine collected after 20 days. Production was to be maintained by infesting 30,000 cups per day with the expectation of

[1] Italic numbers in parentheses refer to Literature Cited, p. 12.

[2] Burton, R. L., unpublished data.

releasing 6,000 corn earworm males per day on St. Croix.

Shipping Pupae

The pupae were collected and separated according to sex. The males were packed in cardboard boxes (2,000 to 2,500 pupae per box), which were filled with vermiculite or wood shavings and shipped airmail or airfreight to St. Croix. Shipment usually required 2 days. The shipping container (fig. 1) had a hollow tube in the center to provide air circulation for dissipation of pupal metabolic heat. On arrival at St. Croix, pupal mortality was recorded, and a 200-pupae sample was selected to determine the percentage of undamaged corn earworm adults emerging from each shipment.

Adult Emergence and Treatment

After the sample was taken, the boxes of pupae were placed on shelves in an emergence room, 8 by 18 by 7 feet, in 2-inch-deep cardboard boxes covered with dry wood shavings or damp vermiculite (fig. 2). Cheesecloth was

BN-37273

FIGURE 1.—Container used to ship corn earworm pupae.

BN-37274

FIGURE 2.—Pupal holding equipment and cheesecloth drying area for corn earworm moths.

hung from the central area of the room on poles around the emergence boxes to provide drying surfaces for newly emerged moths. This procedure reduced greatly the numbers of crimped-winged moths. The room was held at 78° F. and a relative humidity of 80 to 90 percent. A 13-hour-day and 11-hour-night period was programed with incandescent lights.

Moths were collected each morning using a hair dryer and plastic cylinder. This equipment was first used by Dicke and reported by Guthrie et al. (*3*). Fifty normal appearing moths were collected in each container. The containers were placed in a refrigerator kept at 45° to 50° F. to chill the moths so as to prevent physical damage during radiation.

After chilling, up to 500 moths were placed in each precooled thermos bottle and irradiated for 23 minutes to give a 32,000 rad dosage. Our data showed that pupae could not be treated, because emergence of adults developing from eggs isolated on the same day required at least 9 days. This would have necessitated treating many young pupae, which are extremely sensitive to radiation. After treatment the males were sprayed with a 0.1 percent solution of a dye, Rhodamine B or a similar marker, and carried to sites for release that night. Moths appeared normal and in excellent condition following this treatment.

BN-37272

FIGURE 3.—Release cage for sterile males of corn earworm.

Release Cage

The release cage (fig. 3) was a 2½-foot cube constructed principally of ½-inch outdoor plywood. Important features were (1) a large area for holding moths so little damage would occur from activity, (2) two doors in each plywood side–a large one for cleaning and a smaller one for placing males in the cage, and (3) two sides with a double thickness of wire screen. The inside screen was permanently fastened ½-inch hardware cloth, and the outside screen was 18 by 24 mesh wire hinged on a door.

Treated insects were placed in the release cage in the morning. The outside mesh screen prevented their escape and allowed them to become acclimated to the outside environment. Between 7 and 8:30 each evening after bird activity, the outside screen door was opened and the insects flew from the cage. The ½-inch hardware cloth gave protection from such enemies as mongooses and lizards and yet allowed the insects to escape.

Release Sites

Seven release sites were established (only six in 1968) over the island (fig. 4). The circle around each site in the illustration represents a radius of 3 miles. Most areas of the island were within 3 miles of a release cage except for a section of the east and west end. These areas are rather barren, and traps located there in 1967 and 1968 failed to capture males. Sterile males were released from cages at each location each day. More were released in areas of high natural populations.

Virgin Female Traps

Virgin female survey traps were established on the island each year. They were constructed

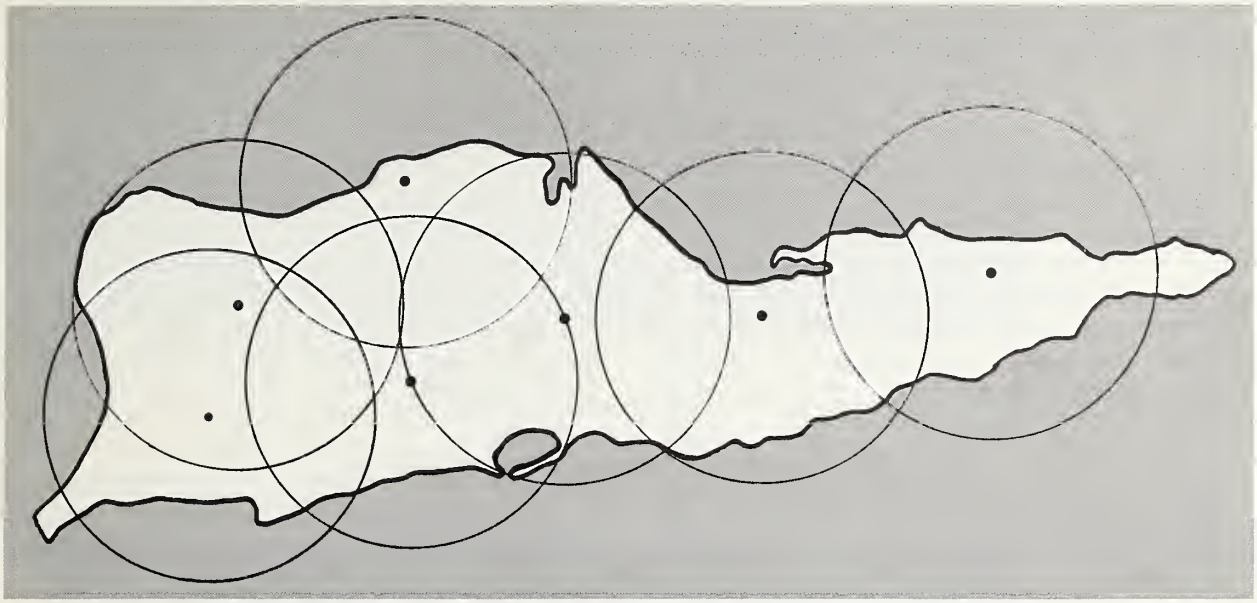

FIGURE 4.—Seven sites on St. Croix for releasing sterile males of corn earworm.

of quart plastic containers with openings in each end and coated inside with a thin layer of Stikem, a sticky material. Virgin females were retained within the trap in smaller plastic cages, $1\frac{7}{16}$ by 2 inches, secured in the trap with paper clips (*7*). Thirty-one of these traps were maintained over general terrain on the island and 10 to 20 traps in cornfields (fig. 5). The 31 traps were permanently located, whereas the cornfield traps were rotated as a field of corn matured and other fields became attractive. The number of traps per cornfield ranged from one to three depending on field size. All traps were placed on fences or stakes about 4 feet high. They were serviced, and data were collected on Monday, Wednesday, and Friday to determine the ratio of sterile to natural males.

Light Traps

On occasion, light traps were used, which had a 15-watt blacklight lamp (*8*) installed 10 feet above the soil level. These traps had a collection basket of $\frac{1}{8}$-inch mesh hardware cloth. They were used principally to trap tobacco horn-

FIGURE 5.—Location of virgin female traps in cornfields and over general terrain on St. Croix for corn earworm survey.

worms (*Manduca sexta* (Johannson)) in other research studies. A total of 250 light traps, about three per square mile, were operated on the island.

1968 ERADICATION PROGRAM

The 1968 eradication program was conducted from May through September. The first group of sterile corn earworm males were released on June 24 and the last on September 8. An average of 1,287 sterile males were released daily; however, none were released on numerous occasions. Production and shipment problems were so great that significant ratios of sterile to natural males were never obtained. These factors, coupled with a late start and high corn acreage, caused the failure of the 1968 program. This conclusion was easily accepted, since natural females were readily caught in light traps and shown to be fertile. Large samples of corn earworm eggs were obtained from corn silks and they hatched.

1969 ERADICATION PROGRAM

The ecological habitat of St. Croix was more conducive to an eradication program in 1969. The survey with virgin female traps (fig. 5) was begun on April 1, and the first releases of sterile corn earworm males were made on April 16. Maturity of a 10-acre cornfield in late March resulted in high captures (St. Croix standards) of natural males in the early part of April. After mid-April this population appeared lower than at any time during the previous 2 years. No more than 3 to 4 acres of corn were available at any one time from this date until late July. The striking concentration of adults within the limited corn acreage was noted again (*5*).

Sterile-Male Release

The number of sterile males released daily is shown in table 1. These data demonstrate the periodic decline in production that the Tifton laboratory experienced at monthly intervals. During these slumps in rearing, the insects that were produced had a high mortality in all stages and were low-quality insects that produced very few eggs. The rearing slumps generally lasted for 3 to 4 days but affected the number of sterile males released 1 month later for 7 to 10 days. The slumps occurred on St. Croix (1,100 sterile males or less released daily) from April 26 to May 3, May 17 to 24, and June 17 to 25 (fig. 6). This last slump actually began on June 12, as over half the insects failed to fly from the release cage. A final slump on July 12 was so serious it became impossible to continue the project. The cause of the decline in production was not determined, but it may have been related to a noninclusion virus or a particularly virulent strain of *Nosema*.

Males Captured and Eggs Collected

Table 1 also shows the capture of natural and sterile males and the number of eggs collected, including those not hatching because of parasitism by *Trichogramma* spp. and sterility. Figure 6 shows the ratio of sterile to natural males and the average number of eggs per silk. A ratio of 27:1 was obtained by April 21 to 22, and 56.5 percent of the collected eggs were sterile on April 25 to 27 (table 1). This was the only time during the entire program that production of sterile eggs was readily detectable. The first slump in sterile-male releases began on April 26 and the ratio of sterile to natural males was reduced to 4:1. No effects were noted on oviposition or viability rates during this period.

Following the first slump, the greatest number of sterile males was released from May 4 to 16, and ratios of sterile to natural males were as high as 50:1. Captures of natural males were very low during this period and reduced numbers of eggs were collected until only one was found from May 14 to 20.

During the second slump from May 17 to 24, eggs were again collected. The actual ratio at this low period cannot be determined because of a corresponding shortage of females for use in the virgin female traps. No traps were operated from May 19 to 22. Eggs that hatched

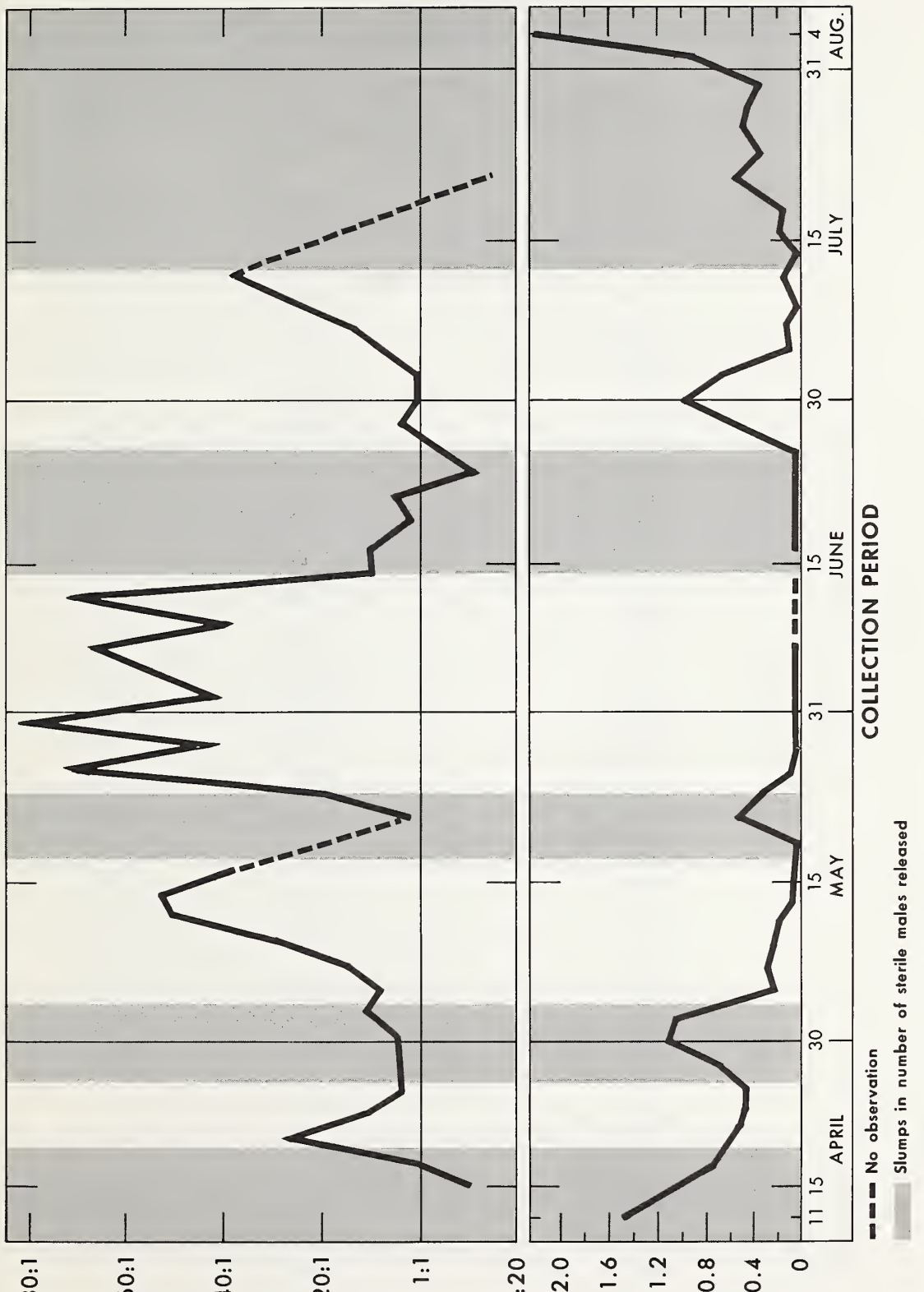

FIGURE 6.—Ratio of sterile to natural males and eggs per silk during 1969 corn earworm eradication study on St. Croix.

TABLE 1.—*Summary of sterile males released, males captured, and eggs collected of corn earworm during trapping period on St. Croix, 1969*

Date	Sterile males released	Males captured		Silks collected	Eggs collected		
		Natural	Sterile		Total	Parasitized	Sterile
	Number	*Number*	*Number*	*Number*	*Number*	*Percent*	*Percent*
April		BEFORE RELEASE					
1–2	------	65	-----	50	61	13.1	4.9
3–6	------	16	-----	50	31	6.5	3.2
7–10	------	18	-----	100	146	6.2	13.0
11–14	------	19	-----	-----	-----	-----	-----
		AFTER RELEASE ON APRIL 16					
16	50	11	0	-----	-----	-----	-----
17	250						
18	350						
19	500	12	13	10	7	0	0
20	1,400						
21	1,500	2	54	40	26	0	11.5
22	1,850						
23	2,250	4	43	90	47	2.1	23.4
24	1,400						
25	1,200						
26	1,100	4	16	100	46	6.5	56.5
27	750						
28	900	4	18	82	52	0	25.0
29	1,000						
30	1,000	5	23	26	29	0	20.7
May							
1	750						
2	1,000						
3	850	2	22	30	25	0	16.0
4	1,500						
5	1,750	4	32	80	18	0	38.9
6	2,450						
7	2,700	7	105	117	35	5.7	20.0
8	3,100						
9	3,000						
10	3,000	3	84	110	25	8.0	12.0
11	3,500						
12	5,000	1	50	125	46	2.2	28.3
13	2,850						
14	2,350	0	52	240	1	0	10.0
15	1,375						
16	2,000						
17	700	1	37	200	0	-----	-----
18	950						
19	750	(1)	(1)	200	0	-----	-----
20	500						
21	600	(1)	(1)	205	101	0	14.9
22	350						
23	750						
24	900	3	63	115	39	0	15.4
25	1,725						

See footnotes at end of table.

TABLE 1.—*Summary of sterile males released, males captured, and eggs collected of corn earworm during trapping period on St. Croix, 1969*—Continued

Date	Sterile males released	Males captured		Silks collected	Eggs collected		
		Natural	Sterile		Total	Parasitized	Sterile
	Number	*Number*	*Number*	*Number*	*Number*	*Percent*	*Percent*
26	2,150	0	72	200	15	0	6.7
27	2,300						
28	3,250	0	44	150	1	0	0
29	2,900						
30	2,250						
31	2,260	1	84	100	0	-----	-----
June							
1	2,250						
2	1,625	1	44	60	0	-----	-----
3	1,925						
4	2,100	0	56	120	0	-----	-----
5	2,500						
6	3,125						
7	3,200	0	68	(2)	-----	-----	-----
8	2,000						
9	2,000	1	40	(2)	-----	-----	-----
10	2,000						
11	2,000	1	71	(2)	-----	-----	-----
12	1,750						
13	1,500						
14	1,750	3	31	(2)	-----	-----	-----
15	2,300						
16	2,650	2	20	40	0	-----	-----
17	1,100						
18	1,100	1	3	94	0	-----	-----
19	500						
20	450						
21	100	1	5	165	0	-----	-----
22	300						
23	150	20	2	50	0	-----	-----
24	300						
25	800						
26	1,300	11	8	307	20	0	10.0
27	1,500						
28	1,950	13	42	155	89	0	9.0
29	1,850						
30	2,350						
July		24	36	220	197	1.0	9.1
1	3,450						
2	4,900	49	62	149	100	3.0	2.0
3	4,500						
4	4,100						
5	3,500	6	54	170	19	0	5.3
6	1,200						

See footnotes at end of table.

TABLE 1.—*Summary of sterile males released, males captured, and eggs collected of corn earworm during trapping period on St. Croix, 1969*—Continued

Date	Sterile males released	Males captured		Silks collected	Eggs collected		
		Natural	Sterile		Total	Parasitized	Sterile
	Number	*Number*	*Number*	*Number*	*Number*	*Percent*	*Percent*
7	1,050	2	31	274	33	3.3	18.2
8	1,000						
9	1,000	0	28	218	10	0	30.0
10	1,125						
11	1,600						
12	1,000	1	38	205	22	4.5	9.1
13	800						
14	280	(1)	(1)	273	9	0	11.1
15	100						
16–17	0	(1)	(1)	180	29	0	10.3
18–20	0	(1)	(1)	180	34	2.9	8.8
21–22	0	26	2	268	136	0	8.8
23–24	0	20	0	175	61	0	8.2
25–27	0	28	0	212	88	(3)	------
28–29	0	19	0	187	78	(3)	------
30–31	0	31	0	168	58	(3)	------
August							
1–3	0	53	0	125	108	(3)	------
4–5	0	64	0	100	216	(3)	------

[1] Female bait not available.
[2] No silks.
[3] Eggs not held for hatch.

were found for approximately 1 week and then disappeared again with the release of more sterile males and the subsequent improvement in the ratio of sterile to natural males. The lack of eggs in the field continued until June 25. The highest ratio of 84:1 was obtained during this period. No corn silks were available for sampling from June 6 to 15.

During the third slump, which began on June 12, eggs were found by June 25 and throughout the remainder of this eradication program. The last release of sterile males was on July 15, shortly after the final slump of July 12.

DISCUSSION

We contend that the release of sterile males on St. Croix and the subsequent high ratio of sterile to natural males resulted in an elimination of egg production rather than in the production of sterile eggs. Instead of eradication, this program resulted in cycling the natural population because of slumps in sterile-male releases. Figure 6 shows this relationship clearly. However, when analysis was applied to the number of eggs and ratios obtained, the rela-

tionship was not linear. This is because the production of eggs was affected not only by the current ratio but also by the ratio of 30 days before. However, the on-and-off relationship in egg production is readily seen. A definite tendency for egg production to decrease or stop under high ratios and to begin or increase after loss of ratios is evident. The effects of no egg production from May 26 to June 24 is seen to affect the number of eggs from July 4 to 31, when reduced numbers of sterile males or none were released in this period.

In this eradication attempt, evaluation was extremely difficult because of limited corn acreage and the low natural population. Only two to three small patches of corn were available at any one time for sampling during April to late June and five to nine patches during the remainder of the study. We are sure that all corn on the island was under observation because of our continuous searches. Thus on many occasions only a few silks were available for sampling for any given day. Despite the limited corn acreage, the earworm still preferred and was concentrated within these fields. An additional consideration is that if corn were readily available and eggs easy to locate, the study could never have been undertaken with our limited daily releases.

The phenomenon of no eggs rather than sterile eggs suggested that some error might exist in our evaluation. To verify this, the validity of our ratio estimates was determined by operating an independent virgin female trapping survey with 32 traps installed over the island and comparing ratios with those of our other survey. Both surveys gave similar ratios, indicating that enough males were trapped to give a reliable ratio estimate. However, this did not eliminate the possibility of nonattractiveness of the test females (U.S. culture) to the wild males of St. Croix. To determine this, light traps and virgin female traps were operated in the same cornfields. Unless both traps were equally attractive, the ratios of sterile to natural males should differ. In this survey, the results did not conflict, indicating that the test females were equally attractive to natural and released sterile males.

The real proof of the low natural population was established through operating 250 light traps, which were maintained for tobacco insect research. Approximately three traps per square mile were located throughout the island. None were in or adjacent to cornfields. From May 28 through June 5 the light traps captured three natural males, 125 sterile males, and two females, whereas virgin female traps caught two natural males and 172 sterile males. The ratios were 42:1 and 86:1, respectively. If catches in virgin female traps near release cages are eliminated, the ratio reduces to 47:1, which is comparable to 42:1 established with the light traps. The low numbers of natural insects captured in the two types of traps adequately proved the validity of ratio estimates and the low density of the natural population. In addition, collections on wild host plants did not reveal corn earworm eggs or larvae. The two females captured had mated, but one was dead and the other died before egg production.

Natural females for mating to laboratory-reared sterilized males were obtained by collecting ears of corn with final instar larvae and placing them under pyramidal cages, where 18 moths emerged 2 to 3 weeks later. Seven were females. They were caged with five laboratory-reared sterile males. Four of the females locked in copulation and produced no eggs, one female did not mate, one mated but did not lay eggs, and the seventh mated and laid 200 eggs, which did not hatch. If these results occurred in the field, then the sudden termination of egg production rather than production of sterile eggs is understandable. Actually such a phenomenon works for, rather than against, an eradication attempt.

In a later test at Tifton, it was determined that over 60 percent locking was occurring in crosses between sterile males and natural females (unpublished data). The locking factor was important in this St. Croix study. Actually it may be responsible for the near success of the 1969 eradication program, since it eliminates sperm-level competitiveness. Since moths that lock are reproductively dead, they add no more to the population.

SUMMARY

Eradication of the corn earworm (*Heliothis zea* (Boddie)) from St. Croix, U.S. Virgin Islands, was attempted in 1968 and 1969, using the sterile-male release method. Although both attempts failed in the primary objective of eradicating the species, valuable biological and ecological data were obtained. Many problems were encountered in the 1968 attempt, including insect production, inconsistent releases, and larger-than-normal corn acreages. These factors led to the unsuccessful program.

In 1969 these problems were minimized, except for periodic slumps in the rearing and release programs. The high ratios of sterile to natural males caused the elimination of oviposition rather than the production of sterile eggs. The overall effect was a cycling of the natural population of St. Croix with the Tifton, Ga., rearing program. The high degree of locking between the released population and the native females probably accounts for the lack of sterile-egg production and the near success of the 1969 program.

LITERATURE CITED

(1) Burton, R. L.
1967. mass rearing the fall armyworm in the laboratory. U.S. Dept. Agr. ARS 33–117, 12 pp.

(2) ———
1969. mass rearing the corn earworm in the laboratory. U.S. Dept. Agr. ARS 33–134, 8 pp.

(3) Guthrie, W. D., Raun, E. S., Dicke, F. F., and others.
1965. laboratory production of european corn borer egg masses. Iowa State Jour. Sci. 40: 65–83.

(4) McKinzie, W. E., Scott, B. F., and Rivera, L. H.
1965. soils and their interpretations for various uses. 67 pp. U.S. Soil Conserv. Serv., Kingshill, St. Croix, U.S. Virgin Islands. [Processed.]

(5) Snow, J. W., Cantelo, W. W., and Bowman, M. C.
1969. distribution of the corn earworm on st. croix, u.s. virgin islands, and its relation to suppression programs. Jour. Econ. Ent. 62: 606–611.

(6) ——— Cantelo, W. W., Burton, R. L., and Hensley, S. D.
1968. populations of fall armyworm, corn earworm, and sugarcane borer on st. croix, u.s. virgin islands. Jour. Econ. Ent. 61: 1757–1760.

(7) ——— and Copeland, W. W.
1969. fall armyworm: use of virgin female traps to detect males and to determine seasonal distribution. U.S. Dept. Agr. Prod. Res. Rpt. 110, 9 pp.

(8) Stanley, J. M., Lawson, F. R., and Gentry, C. R.
1964. area control of tobacco insects with blacklight radiation. Amer. Soc. Agr. Engin. Trans. 7: 125–127.

(9) U.S. Weather Bureau.
1965. puerto rico and united states virgin islands (includes swan island). *In* Decennial Census of the United States Climate: Climatic Summary of United States, Supplement for 1951–60, Climatography of United States No. 86 (series). No. 45, 40 pp. Washington, D.C.

(10) Zube, E. H.
1968. the islands. 71 pp. U.S. Dept. Int., Washington, D.C.

Washington, D.C. Issued April 1971

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 — Price 15 cents

☆U.S. GOVERNMENT PRINTING OFFICE: 1971 O—407–112