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CONTROL OF *CULICOIDES* SAND FLIES, FORT KOBBE, CANAL ZONE IN 1968[1]

R. M. ALTMAN,[2] C. M. KEENAN[3] AND W. G. PEARSON[3]

Prior to 1951 *Culicoides furens* (Poey) were a severe problem at Fort Kobbe, Canal Zone and other adjacent military installations. The principal breeding area was an intertidal mangrove swamp (Farfan swamp) located on the west bank of the Pacific entrance to the Panama Canal. In 1950 the United States Army and the Panama Canal Company installed tide gates at the mouth of the swamp to exclude the salt water. Ditches were dug in the swamp to facilitate drainage of rain water. The area gradually became a well drained grassland and as reported by Blanton *et al.* (1955), this effectively reduced the breeding of *C. furens*.

From November 16, 1967 to February 23, 1968 the Dredging Division of the Panama Canal Company cleaned the channel of the Pacific entrance to the Canal and dumped enormous quantities of mud and sea water into Farfan swamp. The salt water killed most of the vegetation in approximately 900 acres of the swamp and when the water evaporated a large quantity of salt was left in the soil. The mud from the dredging operation blocked the drainage system and permitted the formation of many shallow pools.

Large numbers of *Culicoides* spp. rapidly developed in the swamp and became a severe problem in the adjacent residential areas. Based on horse trap collections, *Culicoides guyanensis* Floch and Abonnenc was the predominant species until the week of April 21 when there was an abrupt change and *C. furens* become more numerous. The rainy season started May 6 and there was an increase in the population of both species. The occurrence of *C. guyanensis* in large numbers was a radical change from the observations of Woke (1954) and Wirth and Blanton (1959). A detailed discussion of this event is presented in another publication.

Plans were made to restore the drainage system, but the mud was so fluid that ditching was impossible. It is anticipated that once the drainage system is re-established, the ground will not become stabilized for several years. Temporary con-

[1] Mention of a proprietary product does not necessarily imply endorsement of any products mentioned by the U.S. Army or by the U.S. Department of Agriculture.

[2] Environmental Health Division, Office of the Chief Surgeon, H.Q. USARSO, Ft. Clayton, C.Z. Present address: Armed Forces Pest Control Board, Walter Reed Army Medical Center, Washington, D.C. 20012.

[3] Environmental Health Division, Office of the Chief Surgeon, H.Q. USARSO, Fort Clayton, C.Z.

trol measures using a variety of chemical and physical measures are described in this paper.

LARVAL CONTROL. To locate the breeding sites, mud samples were taken from several areas in the swamp. Grids were established in four areas with 100 well marked collecting stations 50 feet apart in rows separated by the same distance. Additional samples were collected in connection with specific tests. The mud samples were collected and processed using the method described by Bidlingmeyer (1957).

Insecticide resistance in *Culicoides furens* larvae had been reported by Smith *et al.* (1959) so insecticide susceptibility tests were conducted with dieldrin, Abate and Dursban prior to selecting insecticides for larviciding. A modification of the World Health Organization technique for testing mosquito larvae was used in conducting the tests by placing 224 ml of tap water in a 400 ml glass beaker and adding 1 ml of an ethanol solution of the insecticide. Following this, 25 ml of water containing 20 *Culicoides* spp. larvae was added to the test beaker. The beakers were held at room temperature and examined after 24 hours. The larvae tested were a composite sample from throughout the swamp. No attempts were made to identify the larvae so the ratio of *C. guyanensis* and *C. furens* is unknown. The insects were susceptible to all three insecticides. The results of the tests are shown in Table 1.

TABLE 1.—Susceptibility of *Culicoides* spp. larvae collected in Farfan swamp to selected insecticides.

Insecticide	No. Replications	LD 50 p.p.m.	LD 90 p.p.m.
Dieldrin	11	.02	.086
Abate	8	.00252	.0092
Dursban	8	.000628	.0024

A large quantity of 6.25 percent dieldrin granules was available so the entire swamp was treated with this chemical. The insecticide was applied April 9 with a C-123 airplane from the United States Air Force Special Aerial Spray Flight, Tactical Air Command, Langley Air Force Base, Virginia. Only two hours of flying time were required to apply 13,000 pounds of insecticide to 1,000 acres of the swamp.

Both adult and larval populations declined after the dieldrin application, however, dry season climatic conditions possibly had a greater effect on the reduction because the breeding sites dried up.

Two percent Abate in Celaton granules was applied on May 29 with a dispenser obtained from the U. S. Army Medical Equipment Research and Development Laboratory, Fort Totten, New York, which was mounted on a UH-1D helicopter. The insecticide was applied to 900 acres of the swamp at the rate of 6 pounds (0.12 lb. actual) per acre. Dieldrin granules were also applied to a small portion of the swamp on that date. There was no apparent reduction in larvae or adults from these treatments. See Figures 1 and 2.

Three plots were selected for treatment with 1 percent Dursban granules and 25 sample sites were marked in each plot. Pre-treatment mud samples were taken on June 12 and plots B and E were treated on June 18 with 1 percent Dursban granules at the rate of 6 pounds (.06 lb. actual) per acre. This application was also made with the Fort Totten dispenser. Plot E contained approximately 3 acres and plot B 20 acres. Plot D served as an untreated control. Excellent reduction was obtained in plot E, but the number of larvae increased in plot B. The latter was possibly caused by the diluting effect of the several inches of water which covered plot B soon after the insecticide was applied. The results of these tests are shown in Table 2.

On August 15 approximately 1,500 acres of the swamp were sprayed between 0600–0700 hours with undiluted fenthion, 8 pounds per gallon, at the rate of 4 ounces per acre. The application was made with locally fabricated spray equipment mounted on a U.S. Army H-13 helicopter.

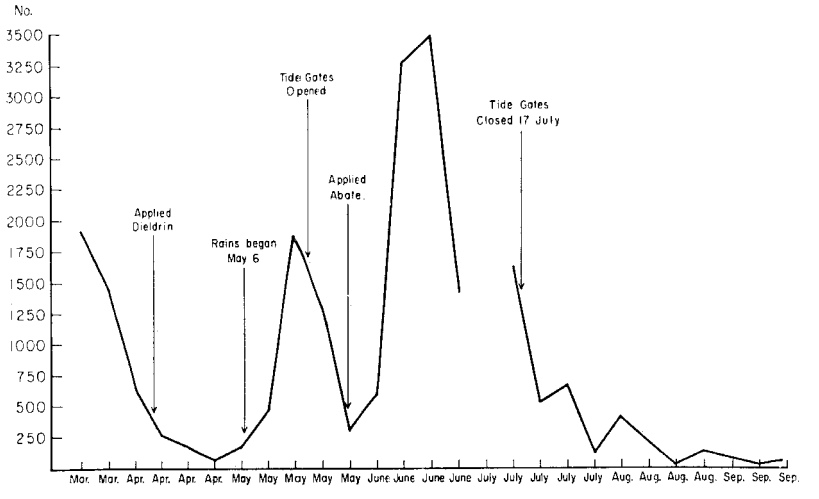

FIG. 1.—Weekly average of *Culicoides* spp. collected on each adhesive paper in horse-baited traps at Fort Kobbe, Canal Zone, March 19–September 26, 1968.

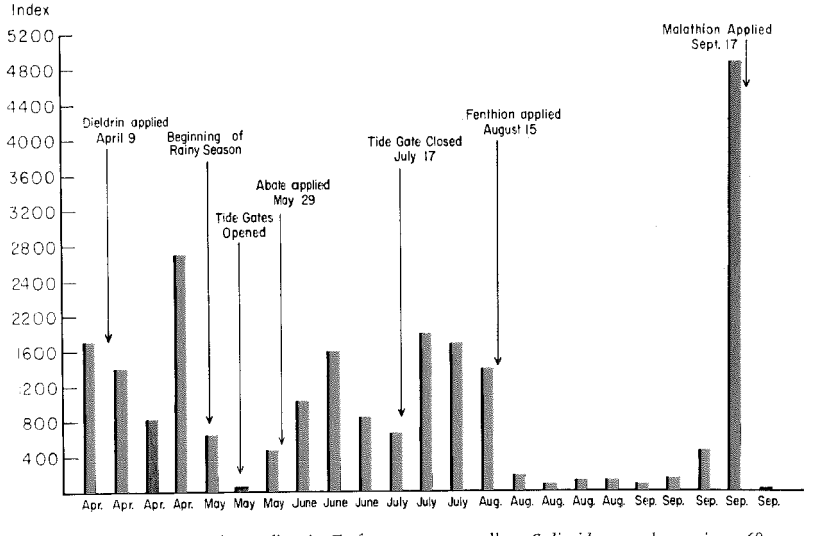

FIG. 2.—Index of mud sampling in Farfan swamp to collect *Culicoides* spp. larvae in 1968. Index=% positive samples x average larvae/positive sample.

TABLE 2.—Effect of application of 5–6 lb./acre of 1% Dursban granules to Farfan Swamp, C.Z. on the abundance of *Culicoides* spp. in samples of mud.[1]

Test Area	Time of Collection	Total No. of Larvae	No. of Positive Samples	Percent of Samples Positive
B	Pretreatment	141	13	52
	Post Treatment	393	13	52
E	Pretreatment	1631	24	96
	Post Treatment	65	7	28
D	Pretreatment	169	18	72
	Post Treatment	164	21	84

[1] Pretreatment collections made June 12, 1968; areas B and E treated on June 18. Area D was used as an untreated control. Post treatment collections made on June 25; a total of 25 mud samples were taken in each collection.

The sprayer pump was set to deliver 40 pounds per square inch of presure while using six 80015 Spraying Systems nozzle tips. The aircraft was flown at 60 knots and 150 ft. elevation. The effective swath width was 225 feet. The average number of droplets was 12/sq. in. as determined by oil sensitive dye cards. Fifty pre-treatment mud samples were collected 14 August and 43 were positive with a total of 667 *Culicoides* specimens. On 19 August, of 50 mud samples taken in the same area, 24 were positive with a total of 60 *Culicoides* specimens. The results of this experiment are shown in Table 3 and Figure 2.

A small area with heavy breeding was treated September 17 with undiluted technical (95 percent) malathion at the rate of 4 ounces per acre. The insecticide was applied with the H-13 helicopter spray equipment previously described. Excellent reduction was obtained. The results are shown in Figure 2.

TABLE 3.—Effect of application of 4 ounces/acre of technical Fenthion to Farfan Swamp, C.Z. on the abundance of *Culicoides* spp. in samples of mud.[1]

Date Samples Were Collected	Total No. of Larvae	No. of Positive Samples	Percent of Samples Positive
Jul 31	842	44	88
Aug 14	667	43	86
Aug 19	60	24	48
Aug 21	36	16	32
Aug 26	70	17	34

[1] Area treated in August 15, 1968; a total of 50 mud samples were taken in each collection.

WATER MANAGEMENT. The first heavy rain of the year fell on May 6. Prior to that date there had been little rain at Fort Kobbe. During the entire month of March there was only 0.44 inch, during April 0.94 inch; there were showers the first five days of May but only 0.09 inch of rain. From May 6–9 there were 4.16 inches of rain. During the dry season a large sand bar had blocked the tide gates thus creating a dam which impounded the rain water in the swamp. The water rapidly covered several hundred acres including the heaviest breeding areas. This resulted in a decrease in the larval population in the areas sampled. See Figure 2. There was, however, a constant increase in the adult population after the rains started. See Figure 1.

In order to expose the maximum breeding area for the granular Abate treatment, the tide gates were opened May 21. There was a rapid increase in the number of positive mud samples. See Figure 2. Adult emergence cages were placed in several sites throughout the swamp and *Culicoides guyanensis* emerged in one cage in less than 48 hours after the area was drained.

MacLaren *et al.* (1967) had demonstrated that *Culicoides furens* could be controlled on the Atlantic side of the isthmus by flooding the breeding areas. Their experiences and the reduced breeding caused by the unintentional flooding of the Farfan swamp suggested that the population could be reduced by flooding the swamp. On July 17 the tide gates were sealed and by September 15 approximately 700 acres of the swamp were covered by water. This materially reduced the problem as shown in Figure 1. Due to the gradual slope of the edges of the swamp, there were breeding areas around the im-

pounded water which continued to support some larvae. The latter required occasional applications of insecticide.

ADULT CONTROL. The same method reported by Carpenter (1951) was used for measuring adult population densities. Sheets of white bond paper (8 x 10½ inches) were treated with castor oil on one side and mounted on plywood boards. These were set in an upright position in a horse-baited trap and left overnight. Two or four papers were used in each trap and three traps were operated from 2 to 7 nights each week from March 19 to June 27. Only one trap was operated from July 8 to September 12 and two were operated from the latter date until September 26. The weekly averages of the collections are shown in the graph, Figure 1.

Approximately 1,500 acres of the swamp were sprayed with undiluted fenthion, 8 pounds per gallon, or undiluted technical malathion on a number of occasions in an effort to control the adult *Culicoides*. The rate of application was 4 ounces per acre using the H-13 spray equipment described above. Fenthion was applied on March 22 and August 15. Malathion was applied on March 27, April 4, May 10, July 18 and August 1. In most instances the adult population was reduced for several days, but it would then increase to annoying levels. The results of these applications are shown in Table 4.

DISCUSSION. The experience at Fort Kobbe vividly demonstrates the tenuous ecological balance that exists between insect populations and their environment in the tropics. It further illustrates the difficulty in correcting engineering errors and controlling *Culicoides* sand flies.

Temporary larval reduction was obtained in some areas with aerial applications of granular Dursban. A similar application of granular Abate was ineffective and the results of the dieldrin application are inconclusive.

The adult populations were materially reduced for several days by ULV application of fenthion and malathion and both chemicals also gave excellent larval reduction on two occasions.

The best solution to the *Culicoides* sand fly problem at Fort Kobbe was water management combined with ULV aerial spray with fenthion or malathion when required. It is highly desirable that the drainage system be re-established in the swamp so that the swamp can convert to the state that existed from 1951 to November 1967.

SUMMARY. Between November 16, 1967 and February 23, 1968, mud and salt water from a dredging operation was dumped into a swamp located on the west bank of the Pacific entrance to the Panama Canal. This killed the vegetation in 900 acres and blocked the drainage ditches, creating an environment favorable for the

TABLE 4.—Average number of *Culicoides* spp. on each adhesive paper placed in horse-baited trap number 2 at Fort Kobbe, C.Z. Area treated with undiluted insecticide at rate of four ounces/acre on date indicated.

Date	Number *Culicoides*	Date	Number *Culicoides*
Mar 19	1801	May 8	587
Mar 20	1744	May 9	577
Mar 21	462	May 10 (malathion)	
Mar 22 (fenthion)	46	May 13	242
Mar 23	109	May 14	870
Mar 25	691	May 15	3679
Mar 26	2895	Aug 8	625
Mar 27 (malathion)	4113	Aug 13	110
Mar 28	363	Aug 15 (fenthion)	260
Apr 2	56	Aug 16	240
Apr 3	315	Aug 20	37
Apr 4 (malathion)	66	Aug 22	36

breeding of *Culicoides guyanensis* and *C. furens*. Aerial applications of granular dieldrin (6.25 percent) at the rate of 13 pounds per acre possibly contributed to a brief reduction of the insects. Granular Abate (2 percent) at the rate of 6 pounds per acre was ineffective. Aerial ultra low volume applications of undiluted technical fenthion and malathion at the rate of 4 ounces per acre reduced the adults temporarily and on at least two occasions also reduced the larvae. Effective control was obtained by flooding the entire swamp with fresh water and ULV air spray of the marginal areas with fenthion or malathion.

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OPERATING THE JEFFERSON COUNTY (TEXAS) MOSQUITO CONTROL DISTRICT

G. A. THOMPSON

Director, P.O. Box 458, Nederland, Texas 77627

It is necessary to visualize the county, its surrounding areas, climate and unique problems to understand the operation of the Jefferson County (Texas) Mosquito Control District.

The Texas Land Office lists the area of the County as 1,387 square miles. There are over 200 square miles of salt marshes and about 150,000 acres of land involved in rice production.

Beaumont is a deep-sea port, about 40 miles by water, from the Gulf of Mexico. The highest land in Beaumont is 25 feet above mean sea level. Flood stage of the Neches River at Beaumont is 5 feet above mean sea level.

Port Arthur, a deep-sea port, about 12 miles inland is only slightly above sea level. Few, if any, of its drainage systems are above sea level.

The land along the Gulf of Mexico, from the beach to the Intracoastal Waterway, has a maximum natural elevation of 2 feet. Located in the northwest corner of the Gulf, the area is greatly affected by wind tides. Not to be confused with