OBSERVATIONS ON THE IMPORTANCE OF FLIGHT RANGE IN THE CONTROL OF *CULICOIDES* IN THE PANAMA CANAL ZONE

SAMUEL G. BREELAND [1] AND JOHN P. SMITH, JR.
Health Bureau, Canal Zone Government

INTRODUCTION. During the week of April 6, 1959, a large-scale control effort was directed against the saltmarsh sandfly, *Culicoides furens* (Poey), on the Atlantic side of the Isthmus of Panama. A total of 18 tons of granular dieldrin was applied by aircraft to approximately 1,800 acres of densely foliated mangrove swamp, the predetermined breeding grounds of the species. The application was at the rate of 20 pounds of 6.25 percent formulation per acre, or 1.25 pounds of actual toxic chemical per acre. This treatment, with some additional acreage, was repeated in February 1960. The limits of the respective applications are shown in Figure 1. The difference in results of the two treatments was profound and is the subject of this paper.

TREATMENT NUMBER ONE—APRIL 1959. For several months before and after the application of insecticide, the treated areas were carefully monitored to determine the population levels of *C. furens* by soil sampling for larvae and by collecting adults from emergence cages. Data obtained from these sources were supplemented by light trap and biting collections.

In comparing overall data obtained during the eight months (August 1958–March 1959) before treatment to those of the eight months (April 1959–November 1959) following treatment, it is apparent that adequate control was achieved. Soil samples positive for *C. furens* larvae dropped from 40 percent to less than 10 percent with a corresponding 10 to 1 reduction in the number of larvae per positive sample; emergence cage results showed a reduction in adult emergence from 6.8 specimens per cage week to 0.1 per cage week of operation; adult catches from four light traps located in the populated vicinities of Coco Solo, France Field, Margarita, and Coco Solo Hospital dropped from an average of 90 to less than 20 specimens per trap night; and standardized biting rates dropped from 70 per man-hour to 18 per man-hour. The monthly results are recorded graphically in Figure 2. In areas which were not treated, the *C. furens* population remained at pretreatment levels or higher throughout the posttreatment period as shown in Figure 3. Thus, for a period of eight months, April–November 1959, Atlantic side residents of the Canal Zone enjoyed a freedom from sand fly pestilence unlike any they had previously known. However, this "freedom" was purely relative, and short-lived, for by November, three of the four indices in the treated areas began to rise rather dramatically. By December, positive soil samples climbed from a negligible number to almost 40 percent; light trap catches from less than 10 per trap night to more than 70 per trap night; and the all important biting index from less than 2 per man-hour to 65 per man-hour. Emergence of adults remained low (see Figure 2). Meanwhile, in the untreated areas, emergence shot skyward to 240 per cage week, and the biting index increased from 42 per man-hour to 71 per man-hour (see Figure 3).

Because of the rise in trap catches and biting rates in the treated areas, without a corresponding rise in adult emergence in spite of an increased larval population, it was apparent that large numbers of adults were migrating from untreated areas.

TREATMENT NUMBER TWO—FEBRUARY 1960. By February 1960, the seriousness of the situation was such that a second application of dieldrin was applied over

[1] Now with the Vector Control Branch, Division of Health and Safety, Tennessee Valley Authority, Wilson Dam, Alabama.

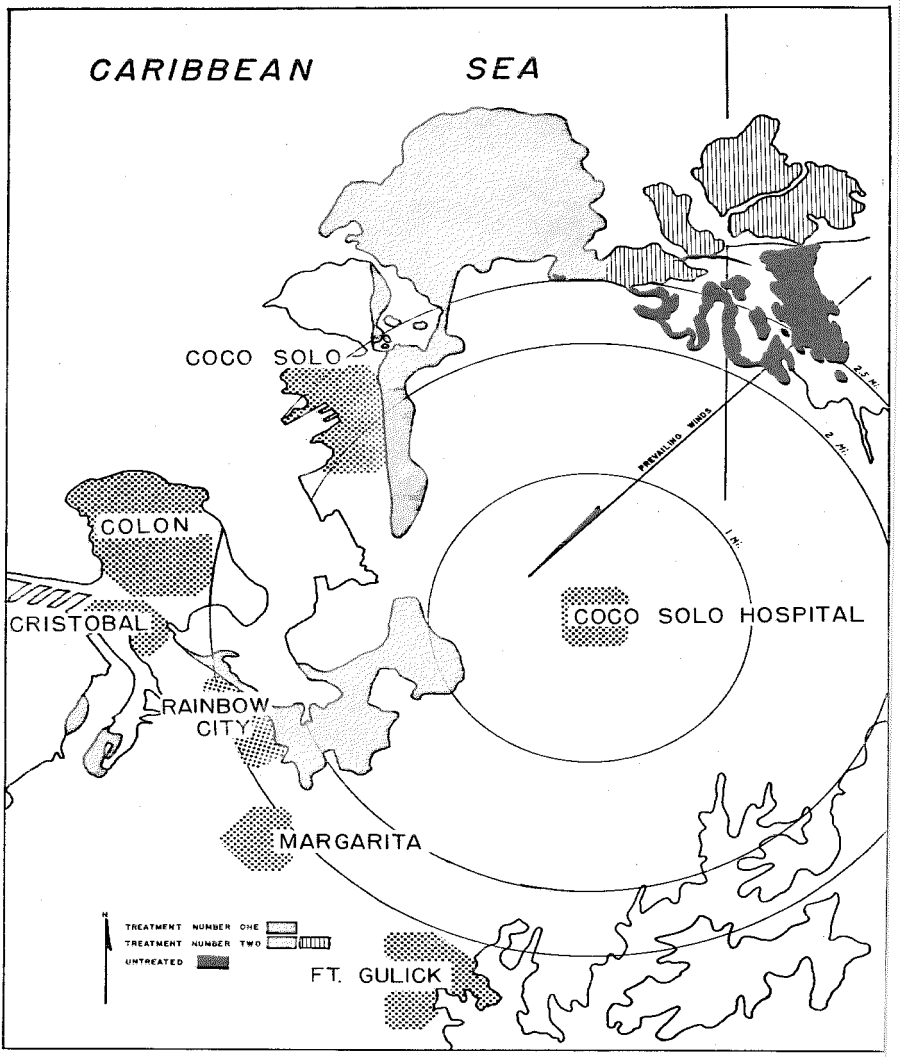

FIG. 1.—Breeding areas of *Culicoides furens* near the Atlantic entrance to the Panama Canal Zone showing limits of insecticidal treatments (Distances from laboratory at Coco Solo Hospital are indicated by concentric circles).

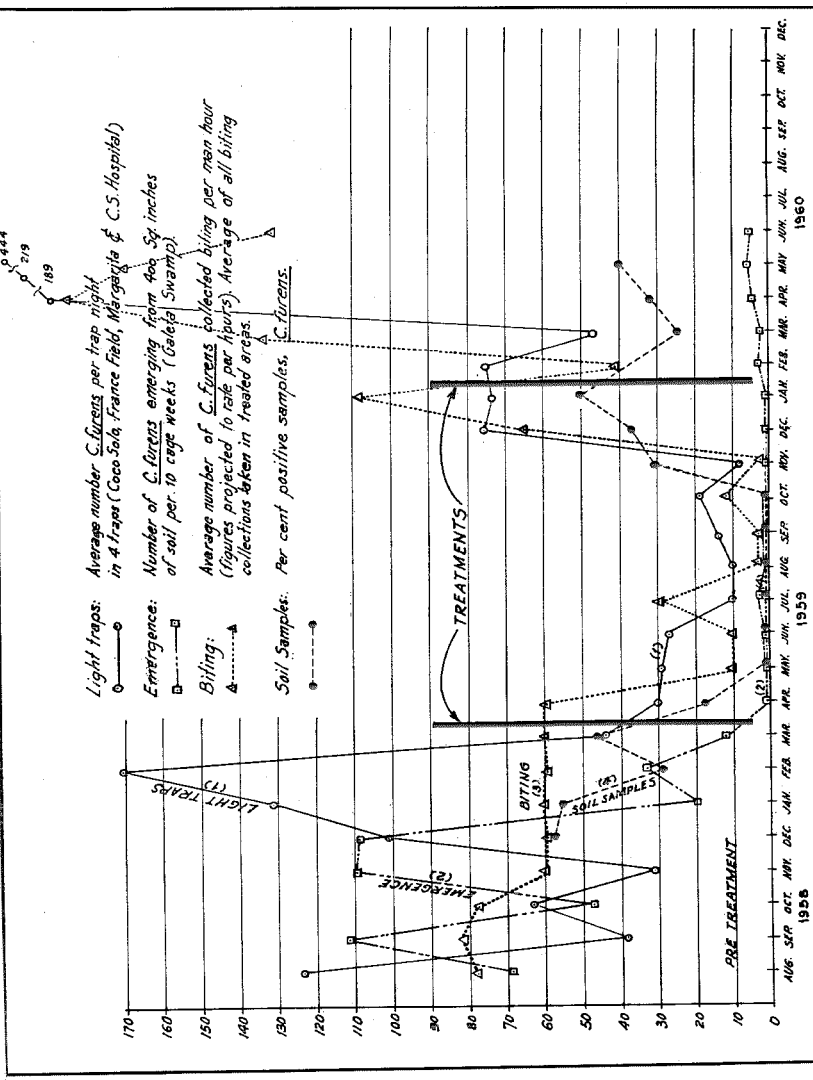

FIG. 2.—Population levels of *Culicoides furens* as measured by various indices before and after larviciding with granular dieldrin: April 1959 and February 1960.

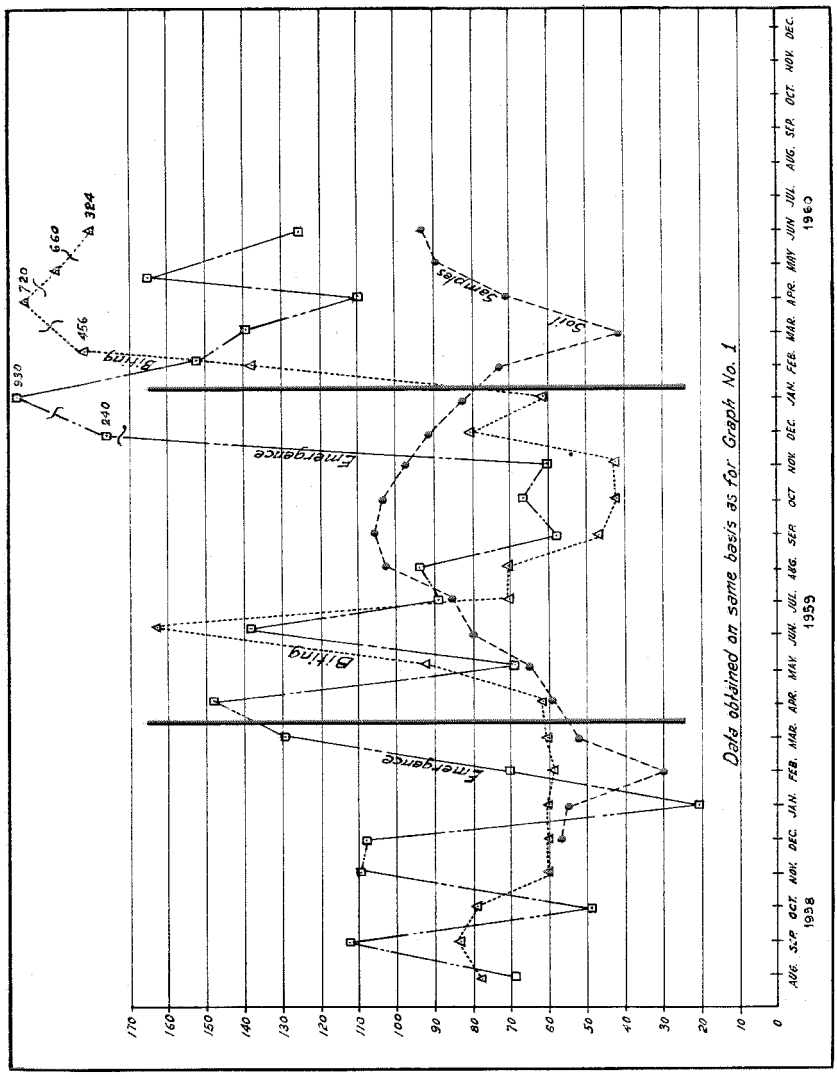

FIG. 3.—Population levels of *Culicoides furens* as measured by various indices in untreated areas.

the entire area plus an area not included in the first treatment (see Figure 1). This time the results were extremely disappointing. By April, the light trap and biting collections soared to astounding numbers (189 per trap night and 180 bites per man-hour, respectively). The fact that positive soil samples did not rise proportionately and emergence cage results were actually negligible (see Figure 2) strengthened the earlier hypothesis that the rather low *C. furens* production in the treated areas could not possibly account for the high nuisance level and that outside sources must be involved. This hypothesis gained strength when field and laboratory tests substantiated the effectiveness of the insecticide employed in the February treatment and when soil samples and emergence cages yielded 70 percent positives and 14 specimens per cage week in the untreated areas as compared to 30 percent positives and less than one specimen per cage week, respectively, in the treated areas.

SURVEYS FOR BREEDING IN REMOTE AREAS. It was reasoned that the nearest *possible* breeding source to laboratory headquarters at Coco Solo Hospital was approximately one mile distant in the "8 o'clock" area just inside the 1-mile circle on the map, figure 1. However, this area supported an extremely low population throughout the period of study. This

TABLE 1.—Number of *Culicoides furens* collected at different time intervals in light traps at Coco Solo Hospital, Panama Canal Zone, June 1959 and January-May 1960

Date	Time			
	6–9 p.m.	9–12 p.m.	12–3 a.m.	3–6 a.m.
1959				
June 1/2	0	10	6	6
2/3	2	4	1	9
3/4	0	6	4	13
8/9	1	0	1	5
13/14	8	45	23	13
1960				
January 20/21	35	8	5	1
27/28	0	1	0	0
28/29	0	0	0	27
February 4/5	23	11	12	39
10/11	26	45	11	14
16/17	32	48	38	99
24/25	3	5	15	22
March 2/3	1	4	0	2
8/9	3	0	42	176
17/18	1	41	6	36
22/23	89	7	89	87
23/24	99	77	160	402
29/30	1	4	130	141
30/31	0	14	15	13
April 7/8	1	3	17	13
14/15	60	8	80	21
15/16	138	7	76	12
17/18	23	0	1	34
19/20	2	0	81	531
May 3/4	132	89	171	137
18/19	10	8	70	5
25/26	2	15	0	13
Total	692	460	1054	1871
Av./trap night	25.6	17.0	39.0	69.3

TABLE 2.—Number of *Culicoides furens* collected in light traps operated simultaneously at various heights at Coco Solo Hospital, Panama Canal Zone, January-May 1960

Date	Height of trap in feet			
	1	8	45	90
January 19/20	0	0	0	0
February 2/3	0	10	107	15
February 25/26	41	73	203	4
March 3/4	3	12	0	0
March 10/11	13	270	331	15
March 16/17	12	68	39	0
April 5/6	0	2	1	0
April 13/14	9	333	221	0
April 20/21	8	308	4	0
April 28/29	1033	2077	2582	361
May 4/5	305	1444	1388	283
May 11/12	5	28	0	10
Total	1429	4715	477	688
Av./trap night	119.1	392.9	406.3	57.3

meant that the areas adjacent to Rainbow City and Coco Solo, both from 1.5 to 2.0 miles away, were the nearest probable source of breeding, but one of these areas (Coco Solo) was situated crosswind and the other (Rainbow City) downwind from the hospital traps. Thus *C. furens,* from either of these areas, must fly at least 1.5 miles *against the wind* to land in the hospital trap. It naturally followed that if the species could *fly* 1.5 miles *against the wind,* it could certainly *drift* greater distances *with the wind.* Consequently, our attention was directed to rather large areas of mangrove swamp northeast of the hospital at distances of from two to three miles. These areas, outlined on the map, figure 1, were untreated and were in the path of prevailing winds during the dry season (December, 1959–May, 1960).

Soil sampling in these remote and untreated areas northeast of the hospital yielded a high percentage of positives, while a like number of samples in the treated areas southwest and downwind from the hospital yielded a negligible percentage of positives.

FLIGHT STUDIES. The survey findings led to a study of wind direction and velocity as related to light trap catches at the Coco Solo Hospital. Canal Zone wind notes showed that, for the past 42 years, 80 percent of winds above 15 mph had come from the northeast for the months of January, February, and March. This fact, coupled with the results from soil sampling, led to the supposition that the large numbers of *C. furens* adults were indeed coming from those untreated areas lying northeast of the hospital as shown in Figure 1.

Light traps at Coco Solo Hospital were operated at time intervals on certain dates depending upon availability of traps, during June 1959 and from January to June 1960 as follows: 6–9 p.m.; 9–12 p.m.; 12–3 a.m.; and 3–6 a.m. The results, as recorded in Table 1, show that the 6–9 period averaged 25.6 per trap night; the 9–12 period, 17.0 per trap night; the 12–3 period, 39.0 per trap night; while the 3–6 period averaged 69.3 per trap night.

Traps, when available, were placed at 1, 8, 45, and 90 feet on the hospital water tank during this period and yielded the following results (see Table 2): 1′—119.1 per trap night; 8′—392.9 per trap night; 45′—406.3 per trap night; and 90′—57.3 per trap night. The large numbers collected at 45′ and moderate numbers at 90′ indicate that the specimens were airborne as opposed to just "flitting around."

Table 3 shows the wind direction and velocity in mph (anemometer—92′ above

TABLE 3.—Wind direction and velocity at 1-hour intervals at Cristobal, Canal Zone (anemometer—92′) and numbers of *Culicoides furens* captured from light traps at 45′ and 90′, Coco Solo Hospital, 1960

Date	Time												Specimens collected at	
	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.	12 p.m.	1 a.m.	2 a.m.	3 a.m.	4 a.m.	5 a.m.	6 a.m.	45′	90′
Jan. 19/20	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		
	16	17	19	19	19	20	18	18	16	18	18	18	0	0
Feb. 2/3	NE	NE	NE	E	NE	NE	NE	NE	NE	NE	NE	E		
	10	8	6	3	1	2	1	1	4	3	4	3	107	15
Feb. 25/26	NE	NE	NE	NE	NE	NE	NE	NE	NE	E	E	E		
	13	14	15	11	11	9	9	10	6	3	3	3	203	4
Mar. 3/4	NE	N	N	N	N	N	N	N	N	N	N	N		
	12	12	11	13	13	14	15	15	17	17	16	16	0	0
Mar. 10/11	N	N	N	N	NW	NW	NE	NE	N	W	SW	W		
	13	13	13	12	10	10	8	10	3	4	6	6	331	15
Mar. 16/17	N	N	N	N	N	N	N	N	N	N	NE	NE		
	12	12	11	11	9	9	10	10	11	11	9	10	39	0
Apr. 5/6	N	N	N	N	N	N	N	N	N	N	N	N		
	15	16	17	17	15	17	16	17	17	18	17	18	1	0
Apr. 13/14	NE	NE	NE	NE	NE	N	N	N	N	N	N	N		
	13	12	13	14	12	13	12	13	13	13	14	13	221	0
Apr. 20/21	N	N	N	N	N	N	N	N	N	N	N	N		
	13	13	13	12	13	12	13	13	12	13	12	11	4	0
Apr. 28/29	N	N	N	N	NW	N	E	E	E	S	SW	SE		
	8	6	5	6	6	6	3	2	1	3	4	3	2582	361

ground) at Cristobal, Canal Zone, and the number of *C. furens* collected during the night at the 45′ and 90′ levels for the pertinent dates. This table shows a correlation of numbers of *C. furens* collected with the wind velocity and direction on the particular night of the collection. For example, on the nights of February 2–3, February 25–26, March 10–11, March 16–17, April 13–14, and April 28–29, *C. furens* was well represented in the 45′ trap. On these nights northeasterly and/or easterly winds were recorded and wind speeds were high during the evening hours gradually subsiding to calmness during the 3–6 a.m. period or were reasonably calm through the night. On the other hand, practically no specimens were taken on the nights of January 19–20, March 3–4, April 5–6, and April 20–21 when wind speeds were relatively high all night, not subsiding to favorable speeds during the 3–6 a.m. period. Furthermore, on two of these nights (April 5–6 and April 20–21), neither northeasterly nor easterly winds were recorded at any hour.

CONCLUSIONS. From the foregoing evidence, it is postulated that *C. furens* is able to migrate from its breeding area by being carried in rather severe winds (15–18 mph) and that the species may literally fill the air over a wide area during these periods; then when wind speeds subside to the point that it can continue its flight, it resumes its normal flight behavior, in this case a positive phototactic response. It seems that during the dry season months (December-May) the *Culicoides* problem in this area of the Canal Zone is due to large numbers of the pests being transported by the wind from distant breeding areas.

SUMMARY. A large-scale treatment with granular dieldrin satisfactorily controlled *Culicoides furens* in the Panama Canal Zone for an eight-month period (April–November) in 1959. A similar treatment in February 1960 gave unsatisfactory results. This was believed to be due, not to the failure of the treatment itself, but rather to the *infiltration* of adults from remote, untreated areas in the Canal Zone and the Republic of Panama. Studies of wind velocity and direction correlated with light trap catches yield strong circumstantial evidence which indicts the wind as the vehicle by which the species was disseminated during the dry season of 1959–60