NOTES ON *CULICOIDES FURENS* (POEY) AT FORT KOBBE, CANAL ZONE

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For a great many years *Culicoides furens* (Poey) has been very troublesome at certain Army installations and civilian communities on both the Atlantic and Pacific slopes of the Canal Zone in Panama. The writers have observed and studied this condition at Fort Kobbe and the breeding areas adjacent to this installation. This same area was studied by Carpenter, whose observations were published in 1951. Subsequent investigations, which are reported in this paper, were a continuation of Carpenter's works with additional emphasis placed on the control aspects of the problem.

CULICOIDES AS VECTORS OF DISEASE. A number of authors have incriminated various species of *Culicoides* and other biting Heleidae as vectors of the causative organism of several diseases, Buckley (1933–34) (1938); Causey (1938); Dutoit (1944); Sasegham (1918); Sharp (1927–1928); Steward (1933); and Wilcocks (1917). The writers have had no experience with transmission studies with *Culicoides* as disease vectors. In all probability there are a number of species which are capable of acting as vectors of filarial worms and other pathogens. Certain species of *Culicoides* are so abundant and widely distributed that their potentialities as vectors should be investigated.

EFFECTS OF *Culicoides* BITES. Large populations of *Culicoides,* such as are found at several places in Panama and such as the senior author saw in Valdez, Alaska, can be so annoying as to be almost unbearable. These biting gnats are voracious feeders, undeterred by all reasonable attempts of the unwilling host to protect himself. They easily pass through the mesh of ordinary window screens, bed nets and head nets, and will bite through any clothing which is light enough to be comfortable in the tropics. Repellents have been almost useless, giving only very temporary relief.

Individual sensitivity to these bites is variable, but during the periods of peak adult populations, it is quite common for women and children to request medical treatment for secondary infections resulting from sandfly bites. The bare legs of women and children are bitten to a greater extent than the legs of men which are ordinarily protected by clothing. Also, it appears that newly arrived Caucasians react more violently to multiple bites than do long time residents of the Canal Zone and Panama. The characteristic lesions and inflammation which result when sensitive persons are exposed to large numbers of *Culicoides* are locally known as "Kobbe leg" because of the high incidence among newly arrived dependents residing at that Army post.

SPECIES COMPLEX. When the senior writer began work in Panama (1951) there were twelve species of *Culicoides* reported from Panama. Extensive surveys throughout the entire road system of this country have revealed a great many more species (Wirth and Blanton, 1953). Fort Kobbe has an almost pure colony of *Culicoides furens.* This has been a great time saver as the taxonomic difficulties encountered in separating Panama species would retard the work had any other area known to the writers been selected for study.

Fort Kobbe is situated on the west side of the Pacific entrance to the Panama Canal. Although the terrain is dominated by numerous steep hills there are several salt marshes on two sides of the post. The largest of these marshes is the Farfam Swamp which lies on the NE side of the

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post. This swamp, approximately 2,200 acres in size, is used by the Dredging Division of the Panama Canal Company as a disposal area for the spoil from hydraulic dredging operations. Although separated from the bay by a dike, this area was subjected to tidal inundations prior to 1950. Most of the swamp was covered during the time of the monthly high tides which, at this location, are often in excess of 18 feet. As a result of this periodic flooding with salt water the area was bare of vegetation and the soil was highly saline. The work of Woke (1954) in this and similar areas demonstrated that *Culicoides* larvae are extremely abundant in the zones which are flooded by the few extremely high tides which occur each month but which are too high to be flooded daily.

In August 1950, as a result of the efforts of R. E. Fontaine, W. D. Reed, Stanley Carpenter, John P. Smith, and others, tidegates were installed in the spillway structure so as to exclude seawater from the swamp. It was expected that the long term result of this installation would be the conversion of the salt water swamp to a fresh water swamp as the rainfall was estimated to be heavy enough to leach all the salt out of the swamp in a few years' time.

LARVAL STUDIES. *Methods.* Carpenter (1951) tried out the techniques for determining larval incidence used by Painter (1934), Dove *et al.,* (1932), and Hill (1947). After trying several methods he sampled larval populations by collecting about 400 cc. of mud from known locations, and placing this mud sample in wide mouthed jars. The jars were given a number, carried to the laboratory and flooded with tap water, and allowed to stand overnight. The following morning the water which accumulated on top of the sediment was gently agitated and drawn off with a pipette. Counts were based on the number of larvae found in six syracuse watch glasses examined with low power microscope. This same method was used by the 25th Medical Detachment for obtaining the larval counts reported in this paper.

Carpenter established 552 definite locations near Fort Kobbe which were positive for larvae at one or more times during the wet season of 1950—(June-December). These collecting stations remained positive until the onset of the dry season. Since 1950 the ecological picture has changed drastically. Prior to the installation of tidegates, the swamp was so boggy that it was almost impossible to walk anywhere except along established trails. Vegetation was very sparse with many large bare areas scattered throughout the swamps. Most of these areas are now dry and overgrown with a dense stand of mangrove 10 to 15 feet high. These ecological changes have affected the larval population immensely. The relative importance of these changes is difficult to assess, but the combined effect of dryness, reduced salinity and increased shade has resulted in reduced numbers of larvae. Woke (1954), Carpenter (1951), and the writers have found larvae in shaded areas, but only rarely. In January 1952 larvae were found only along the water's edge on the banks of the Farfan River. Of 98 samples tested in September 1952, only one was positive and only one larva was found. This is a contrast from former samples, many of which had 500 or more larvae.

Larval sampling was continued periodically through the years 1951 to 1954. During the years of 1952 and the first half of 1953 it was very difficult to find any larvae and the large numbers observed before the tidegates were installed are still conspicuously absent. Because of the extremely low population which prevailed in 1952 and 1953, no attempt was made to sample all the stations established by Carpenter, but random samples were consistently negative. Not only did the control measures cause a satisfactory reduction in the numbers of larvae but also a change in the larval habitat.

ADULT STUDIES. *Methods.* The same method as reported by Carpenter (1951),

for measuring population densities has been continued. In fact, some of the horse-baited traps as employed by Carpenter are still in the same location. 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 upright position in a horse-baited trap and left overnight.

The adult *Culicoides* were attracted to the horse and in flying around a number would come in contact with the castor oil treated papers and become glued to the paper. These papers were brought into the laboratory and the total *Culicoides* were counted, using a grid beneath the paper. Six papers were used in each trap and at times four horse traps were operated four nights each week. These were operated Monday through Thursday night exclusive of holidays. Occasionally one of the boards would fall down and that count would be lost but the collection would be dropped so that the average would not be affected.

Although there was considerable variation from trap to trap, the monthly average gave a very definite trend. The graph, Fig. 1, presents the monthly averages of the catches from August 1950 through December, 1953.

The monthly average of *Culicoides* per trap varied from 2 in April and May, 1953 to 684 during December 1950. In a total of 10,829 collections, 1,212,877 specimens were captured, for an overall average of 112 for the period under study.

The adult count began to go up in August 1953 despite the continuation of control measures which had been successful in previous years. The writers have not been able to explain this sudden uptrend since no comparable increase in larval breeding could be found. Larval surveys revealed an increase in the number of positive samples in November, 1953, but most samples had only a very few larvae. It was thought that perhaps the adults had blown in from other areas but this did not seem plausible after larval

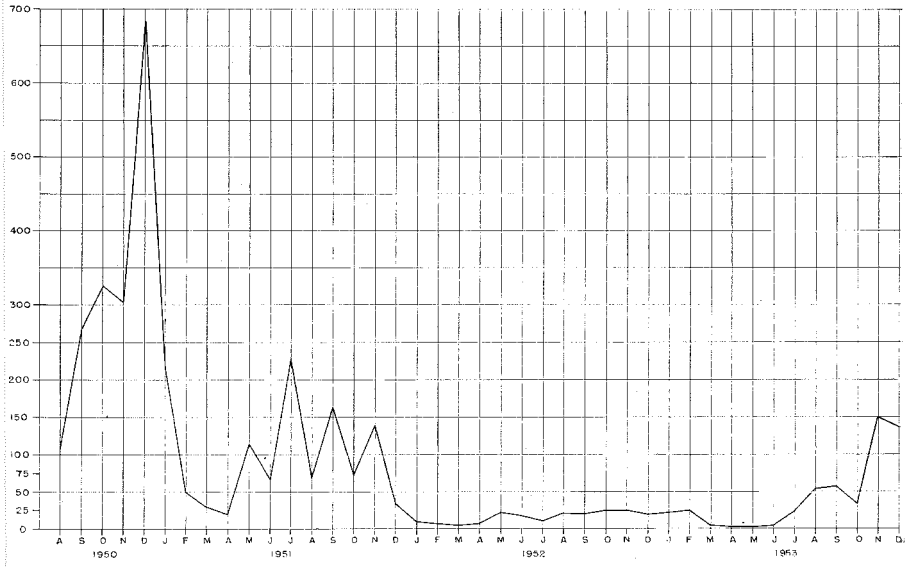

FIGURE 1.

surveys in other nearby areas showed only a few larvae per sample. Then, too, observations on adult landing rates in the Farfan swamp area exceeded that of other areas. The writers think that the adults were coming from the ditch banks and along the Farfan river system.

Control. Several control measures were undertaken for the specific purpose of reducing the number of adult *Culicoides* in the residential section of Fort Kobbe to a tolerable level. Other control measures were undertaken for other reasons, but may have had some effect on the activities of the adults.

Fog and mist sprays were used at Fort Kobbe at approximately the same frequency as other Army posts in the Canal Zone. These spray operations were designed to kill adult *Anopheles* mosquitoes, but the residents of Fort Kobbe firmly believe that fogging alleviates the *Culicoides* biting nuisance. The writers' observations are that neither operation has a substantial effect on either the number or the activities of the adult *Culicoides* at this location.

Reference has already been made to the installation of tidegates at the mouth of the Farfan River and the resultant elimination of salt water and lowering of the water level in the swamps. These gates were installed in August 1950, but, as expected, they did not have an immediate effect. September, October and November are the months of peak rainfall in the Canal Zone and it was not until February 1951 that the water level in the swamp was substantially lowered. After that time drying was rapid and the swamp was soon covered with vegetation. Concurrent with these ecological changes there was a substantial decrease in the numbers of larvae and adults. It will be noted that there was a definite downward population trend prior to the time that any large scale application of insecticide was made.

Small scale tests made in April 1951 indicated that lindane and dieldrin at the rate of one pound per acre and chlordane at two pounds per acre were each effective in killing the larvae of *Culicoides*. A larger test was conducted in October 1951 when approximately 1,000 acres were sprayed with an L-5 airplane. Half of this area was sprayed with two pounds of chlordane per acre and the other half with one pound of lindane per acre. The other 1,200 acres were sprayed with dieldrin using hand methods of application. In this area mosquito control workers walked along the drainage ditches and sprayed ditch banks and other likely breeding places with dieldrin at the rate of one pound per acre.

From a practical viewpoint all of these spray applications were successful. On 19 and 23 October, one and five days after spraying, a total of 101 mud samples were collected from stations which had been positive for larvae at some time during the previous year. These samples taken at random from all the treated areas, were all negative on these post treatment counts.

Adult counts were sharply reduced for a period of about two weeks after the airplane spray application and then increased slowly in November. However the average for the month of November was less than the average for the same month in 1950. In December 1951, the adult count decreased sharply, averaging only 34, as compared with an average of 684 for December 1950.

During 1952 the monthly averages for adults varied from 4 in March to 25 in October and November. Even the highest counts represented satisfactory control as these numbers were too low to be noticed by anyone on the post. In fact during 1952 many people lived at Fort Kobbe for months without being aware that such a thing as sandflies existed!

In 1953 there was a gradual increase in the number of adult *Culicoides* collected in the horse traps. There was no corresponding increase in the number of larvae collected from the stations in Farfan Swamps. This contradictory situation caused the authors to spend considerable time searching for the larvae in other less likely breeding places on other sides of the post, but up until this time (April

1954) no concentration of larvae has been found which was in proportion to the number of adults collected in November and December, 1953.

As a result of severe corrosion and the action of the waves, the tidegates did not function efficiently toward the latter part of 1953. Enough salt water ran back into the river at high tide to raise the minimum water level in the river and many of the drainage ditches to a higher level than had existed in 1952. Also, the mixed ocean and fresh water was more saline. It appears to the authors that a new ecological balance was established in the swamp to which the local population of *Culicoides furens* adjusted itself. In this new situation large numbers of *C. furens* were produced in the drainage system itself such as along ditch banks and other places that were flooded occasionally but not constantly.

In September 1953, Farfan Swamp was sprayed by airplane with dieldrin but due to malfunctioning of the pumps on the spray rig, the dosage was slightly less than one-half pound per acre. A second application at the same dosage rate was made one week later, but the combined effect did not reduce the numbers of adult *Culicoides* reaching the post.

The painting of window screens with 5 percent DDT in kerosene has been found to reduce the number of adults which enter houses through the screens and later bite. However, under the conditions existing at Fort Kobbe, this technique has not been as successful as it was in the tests reported by Trapido (1947).

Discussion and Summary. The writers feel that the *Culicoides* problem at Fort Kobbe has greatly improved since the installation of tidegates. The plant growth has increased enormously in most areas. This shaded condition has limited the breeding to the banks of ditches and streams. It is felt that improved tidegates will continue to exclude tide water from entering the swamp and so change the ecology that breeding will eventually be a negligible factor in this area.

When a heavy flight of adults is experienced aircraft spraying may be employed and is very effective. This is expensive and should be resorted to only in an emergency. Screens, painted with DDT, will exclude *Culicoides* for a short time.

During the period of this study, 1,432 samples of mud were examined for *Culicoides* larvae. A total of 288 samples were positive and 89 had over 100 larvae per sample. During the latter half of 1953 the larval population began to build up again indicating that the soil was again changing to more optimum condition. Leaking tidegates probably caused this. A total of 10,829 adhesive boards were examined during this study and 1,212,877 *Culicoides* were trapped. The average varied from 2 per board in April and May, 1953 to 684 per board in December 1950. The populations were again building up in the latter part of 1953.

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LABORATORY OBSERVATIONS ON A MOSQUITO, *CULISETA MELANURA* (COQUILLETT)

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Recent isolations of virus from field-caught *Culiseta melanura* (Coquillett) have directed attention to this species as a possible vector of both eastern and western equine encephalitis (Chamberlain *et al.*, 1951, Kissling *et al.*, 1954, Holden, 1954). *C. melanura* is a rarely encountered but widely distributed mosquito which breeds throughout the southern and eastern states in swampy or low areas where small permanent waters occur (Carpenter *et al.*, 1946). As recently pointed out by Wallis (1954), the bionomics of the adult, including its feeding habits, are largely unknown. In view of its potential importance as a vector and the paucity of information regarding its life habits, an attempt was made to establish a colony in the laboratory.

On November 6, 1951, 2nd to 4th stage *C. melanura* larvae, associated with those of *Culex territans* Walker, were collected