CULICOIDES CONTROL IN THE CANAL ZONE BY WATER MANAGEMENT [1]

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INTRODUCTION. Biting midges of the genus *Culicoides* and genus *Leptoconops* are some of the most annoying and numerous insect pests in the Canal Zone. These midges are referred to locally as "sand flies" or "sand fleas" and are the cause of many complaints concerning biting insects. They were described as notorious pests as early as 1850 during the building of the railroad across the Panama Isthmus. Their control at that time was not considered an immediate need as the chief concern then was the control of the mosquito vectors of yellow fever and malaria. It was not until the late 1950's that a review of possible methods for *Culicoides* control was made. Breeland (1958, 1960) established that the major breeding grounds for these pests were the tidal mangrove swamps on both the Caribbean and Pacific sides of the Isthmus. Breeland achieved good control of breeding in these areas through the use of granular dieldrin but resistance developed to this chemical within a comparatively short time. Breeland also found that great numbers of adults were carried into populated areas by prevailing winds from untreated areas. Rogers (1962) reported on the use of impounding water over the tidal breeding grounds of *Culicoides* to achieve successful control. The authors, with the assistance of Dr. Andrew Rogers, Director of the West Florida Arthropod Research Laboratory, initiated a water management experiment near the townsite of Coco Solo in the Canal Zone.

MATERIALS AND METHODS. An area of approximately 25 acres of tidal mangrove swamp near Coco Solo on the Caribbean side of the Isthmus was chosen for the study site, due to the presence of a pipeline dike and an access road separating the area from the rest of the 300-acre tidal drainage region. The entire 300 acres produced high populations of *Culicoides furens* which were continuously infesting the nearby townsite. The predominant vegetation for this region is a mixed association of mangrove species, black mangrove (*Avicennia nitida*), white mangrove (*Lacuncularia racemosa*), red mangrove (*Rhizophora mangle*), and button mangrove (*Conocarpus erectus*).

The area was part of an extensive project undertaken during the period from 1919 to 1930 to provide canal drainage of the sea level mangrove swamps near the military reservations on the Caribbean coast. The United States Army Sanitary Corps accomplished good drainage of these swamps by making ditches every 250 to 500 feet with large collection canals at intervals to provide sufficient distributional flow during heavy rains. Although this drainage system is still in use today, it does not help in the control of *Culicoides*. The entire 300 acres are flooded twice daily by incoming tides which keep the mud soil saline and optimally suited for breeding *Culicoides furens*.

The study plot selected approximates a rectangle 700 x 1300 feet. The plot is bordered by a highway to the west, a military road to the south, a pipeline dike to the north and another military access road to the east. Earthen dikes were necessary on the west and south sides to

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prevent interference with drainage from the surrounding region. As a result, 1600 feet of 2.5 foot earthen dikes surfaced with crushed coral were constructed to form the impoundment limits. The plot contained two parallel drainage ditches 500 feet apart, running in a north-south direction. Tide gates (Fig. 1) were made from 28″ disks of cast iron mounted on a hinged structure made from angle iron. These structures were mounted in concrete foundations and were set so as to swing against a rubber collar at one end of a 24″ diameter dredge pipe. The six-foot sections of dredge pipe were also set in concrete foundations. The action of the incoming tide was ample to open the counter-weighted gate, thus allowing the plot to become inundated by the high tide. The pressure created by the outgoing tide causes the gate to close securely against the rubber collar. Four of these tide gates were installed in the south dike and two were installed on the north dike. A 10-foot wide main spillway was installed on the west dike (Fig. 2) and a 42″ auxiliary spillway was placed at the northeast corner of the plot. Both were provided with 6-inch flash boards to provide for higher levels of water if needed. The spillways have operated effectively since installation and have kept the maximum water level to an elevation of 1.42 feet above sea level. This water level was chosen as it was enough to inundate the entire plot at high tide but not so high as to kill the mangrove trees.

FIG. 1.—A view showing a dual tide gate installation at the end of one of the drainage ditches at the southern limit of the experimental plot. The near gate is in the "locked" position while the far gate is being held open to show the hinge action of the installation. Plot is on the left.

In construction of both the tide gate installations and the spillways, 2″ x 6″ wooden piles were driven to depths of 7 to 10½ feet to provide a leak-proof base for the structures. The piles were set in two parallel rows 3 feet apart and the resultant space between them was filled with earth, rock, and coral. Concrete walls 3″ thick were poured against the outer walls of the piles to seal and support the structures.

The 25 acres were flooded to a depth of 6 inches at the margins and to over 2 feet throughout the entire plot. It was decided that the shade-producing mangrove canopy should be maintained as a cover

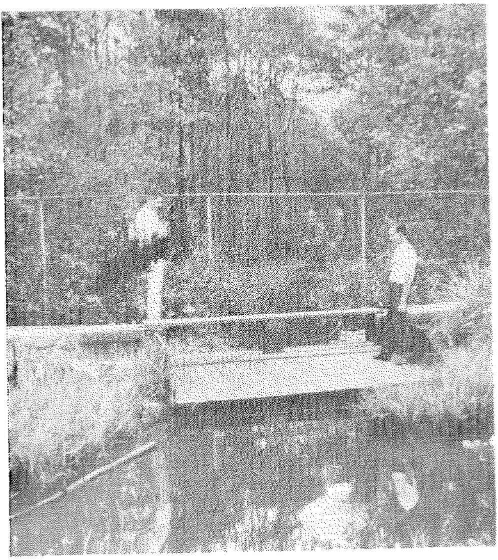

FIG. 2.—The 10-foot wide spillway, located on the west border of the plot, provided for runoff of excess water during heavy rains. A 6-inch flash board was available to raise the water level if necessary. The plot is in the foreground.

to keep sun-loving brackish water mosquito breeders to a minimum.

The tide gates have worked very well in maintaining effective control inundation of the plot for 9 months of the year. When the dry season begins in January with its corresponding lack of heavy rainfall and high tides it has been necessary to reverse the above process to maintain control in the plot. The tide gates are locked shut at low tide thus allowing the plot, with the exception of the main drainage ditches, to dry out. The plot was usually kept in this "locked" condition from the last part of January to the first part of May when the normal mode of operation was re-established.

Throughout the study, the entomologist and his staff made *Culicoides* larval surveys and emergence trap collections to provide comparative data on the experimental plot and the surrounding mangrove swamp. Data on the comparative tidal fluctuations and salinity within the plot and the surrounding area were also collected regularly.

RESULTS. Within the first 2 months of continuous inundation with sea water the plot showed a drastic decrease in both the larval densities and adult *Culicoides* emergence. In the last months of the 9-month inundation both soil samples and emergence cage collections showed counts of *Culicoides* near the zero level. However, the soil samples and emergence collections from areas in the surrounding mangrove swamp continued to show high population indices for *Culicoides* larvae and emerging adults (Figs. 3 & 4). During the reversed process throughout the months of February, March, and April, most of the plot dried out. *Culicoides* breeding was limited to the moist banks of the two drainage ditches within the plot. The breeding in the plot usually showed a peak during this drying-out period (Figs. 5 & 6) and another during the onset of the water impoundment in May.

During the drying-out period breeding is mainly limited to less than one third of the plot. There is enough residual moisture in this area for the *Culicoides* to breed through one or more generations.

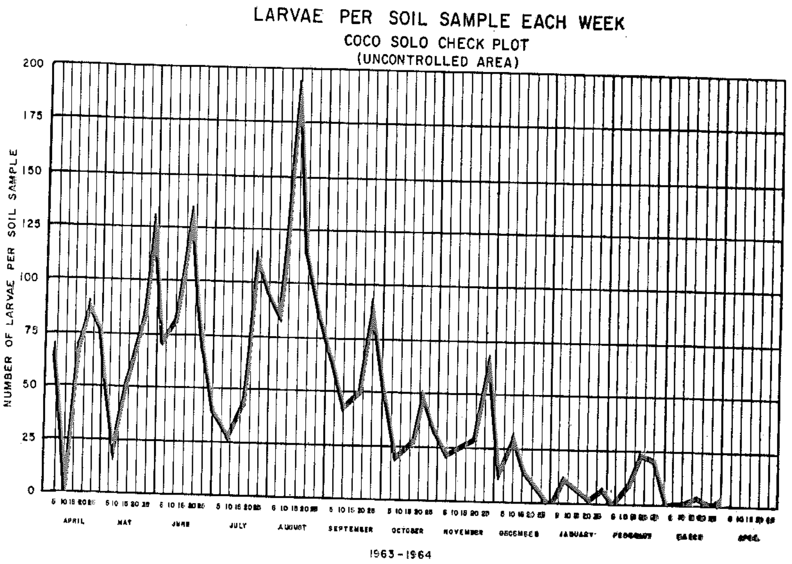

Fig. 3.—The results of soil sample collections for *Culicoides* larvae in the tidal mangrove swamp region surrounding the experimental plot during 1963–1964.

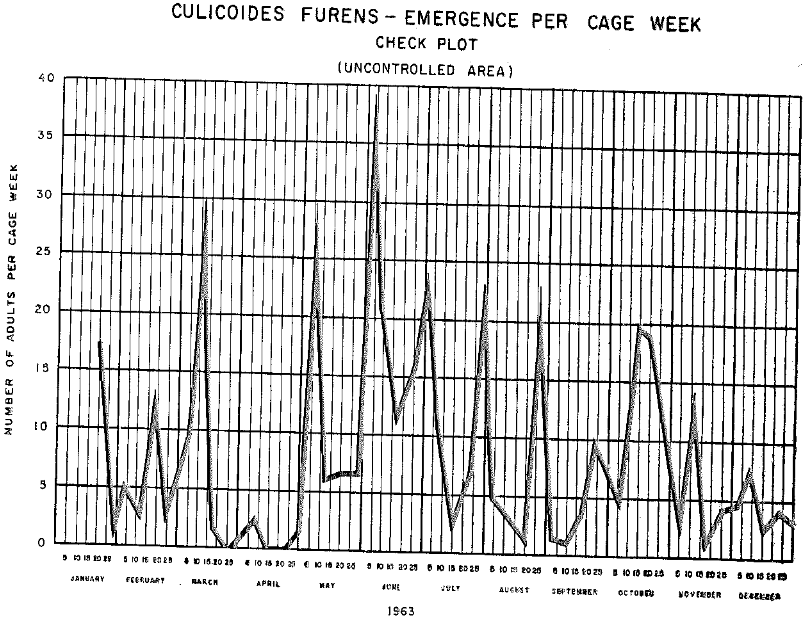

Fig. 4.—The results of emergence trap collections for *Culicoides* adults in the region surrounding the experimental plot during 1963.

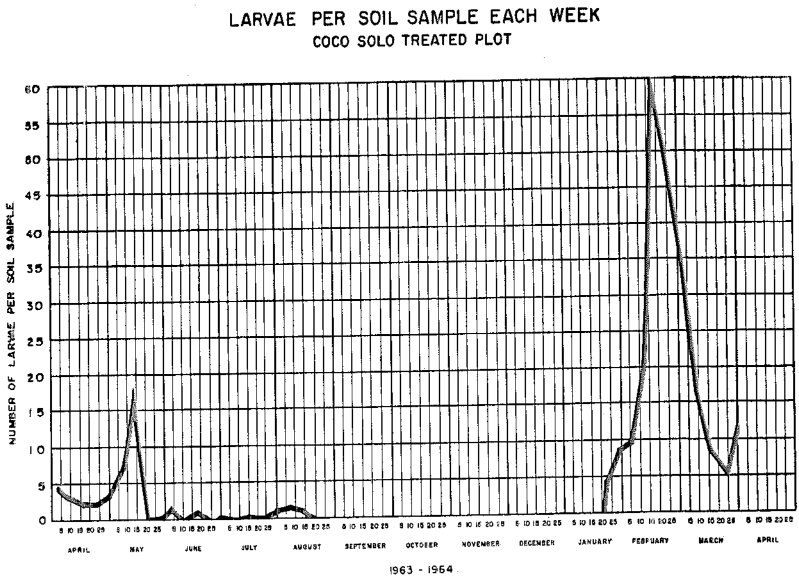

FIG. 5.—The results of soil sample collections for *Culicoides* larvae in the experimental plot during 1963–1964.

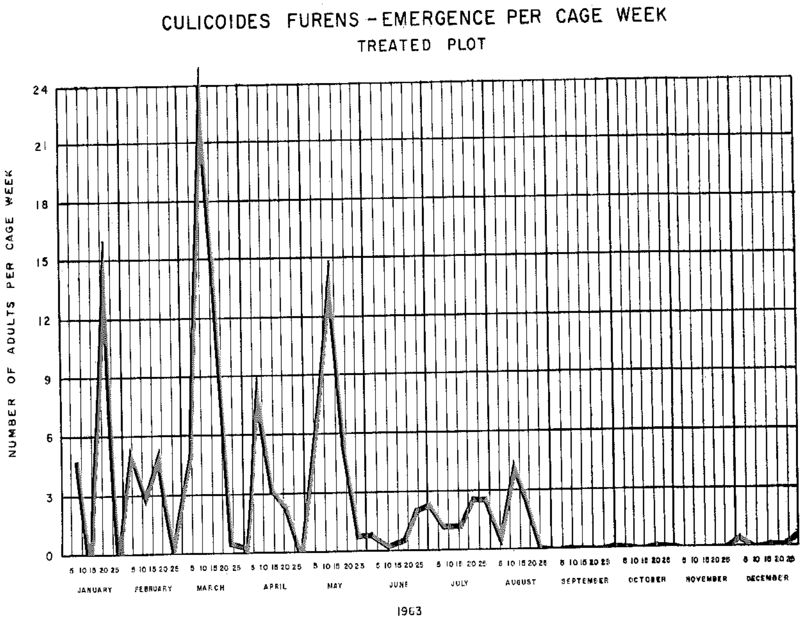

FIG. 6.—The results of emergence trap collections for *Culicoides* adults in the experimental plot during 1963.

The re-established inundation is apparently enough to hatch the accumulation of eggs laid during the dry season and allows another generation to emerge in May. It appears that the covering of water merely eliminates the favorable oviposition substrate, thus controlling breeding in the plot during the next 8 months.

Throughout the study, observations were made on the effects of the impoundment on mosquito breeding. During the rainy season, monthly rainfall varies from 2 to nearly 23 inches on the Caribbean side of the Isthmus. At times this heavy rainfall diluted the seawater environment of the plot to a brackish or almost fresh water condition. *Anopheles albimanus, Anopheles aquasalis, Aedes taeniorhynchus,* and *Culex elevator* were collected along with some *Deinocerites* and *Uranotaenia* species in larval collections from the plot. However, population levels for any of these species never reached a point that was considered significant. The highly abundant surface-feeding minnows within the plot continuously decimated the larval mosquito populations.

On one occasion, a few burlap bags of sawdust soaked with a 5 percent malathion oil solution were placed in the southeast corner of the plot as a precautionary measure against the possible breeding of *Anopheles albimanus.* A small population of *Culex elevator* had already established itself in this area. This method of control was shown to have good residual effectiveness. The water impoundment in the plot gave good control of *Aedes taeniorhynchus* as it kept their normal oviposition sites continuously covered. Also an important feature of water management control was the lowering and raising of the water level within the plot whenever mosquito breeding was noted. The operation was completed several times during the rainy season by opening the tide gates and releasing the impounded waters. The gates were closed again whenever a high tide had returned a satisfactory water level over the area.

Conclusions. Close observations on the operations of the 25-acre experimental *Culicoides* control plot have revealed that the tide gate structures operated exactly as designed and kept the area continuously inundated for about 9 months out of the year. The remaining 3 months the procedure was reversed and the gates were placed in a "locked" position to keep the plot as dry as possible during Panama's dry season. The operation of the appropriately designed water management on breeding areas proved to be an effective method of reducing sand fly breeding. The invasions, if any, of mosquito breeding was controlled easily by the changing of water levels. The utilization of portable low head, high volume pumps was considered a possibility where feasible to maintain inundation during the dry season as this would eliminate the peaks of breeding noted during this period.

Continuous inundation of normally tidal mangrove areas with water management structure shows great promise in controlling *Culicoides* on the Atlantic side of the Canal Zone. Larval breeding was nearly eliminated in the experimental area within only a few months. It can be presumed that it would have remained so if the inundation was continued. The biggest drawback is the existence of approximately 3000 acres of breeding to be controlled within the Canal Zone and many more within flight range in the Republic of Panama. With the *Culicoides* flies not considered to be of vector importance in this region it is not financially feasible to utilize this control method at present. Coordination will be required among property owners to inaugurate economical tide control structures for the above control method to remove *Culicoides* as a biting pest in this large area in the Canal Zone.

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HYDROGEN ION CONCENTRATION (pH) AS RELATED TO THE OCCURRENCE AND ABUNDANCE OF TREE-HOLE DWELLING *CULICOIDES* SPP., (DIPTERA: CERATOPOGONIDAE) IN NORTHERN FLORIDA [1]

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INTRODUCTION. The species of *Culicoides* which complete their immature stages in tree-holes or stump-holes constitute an important part of the pestiferous insect fauna in wooded areas where rainfall supplies sufficient moisture. Although most species presumably feed on birds by choice, *C. paraensis* (Goeldi) and *C. hinmani* Khalaf (*borenqueni* of authors) avidly bite man during daylight hours in Tennessee forests (Snow, 1955) and *C. guttipennis* (Coquillett) also feeds on man during the crepuscular hours. We have been bitten diurnally by specimens of *C. arboricola* Root and Hoffman which escaped in the laboratory. Wirth and Hubert's report of *C. snowi* Wirth and Jones biting man is the only host record known by the authors for this species. *C. debilipalpis* Lutz, *C. ousairani* Khalaf and *C. villosipennis* Root and Hoffman recorded from northern Florida are believed to be feeders on birds primarily as blood-engorged specimens were trapped in chicken houses (Messersmith, 1965).

The biting habits of *C. nanus* Root and Hoffman, probably the most abundant tree-hole species in northern Florida, are unknown. This species was rarely captured in light traps and chicken houses, and no blood-engorged specimens were encountered. Antennal sensory pits on segments 3 through 14 (Varnell, 1967) indicate it may feed on birds, based on Jamnback's suggestion (1965) that species with pits on most antennal segments prefer to feed on birds rather than on large mammals. One specimen of *C. pusillus* Lutz was taken from a tree-hole sample in this study. Its biting habits are unknown and it may not be a true tree-hole species. *C. ousairani* was also reared from two samples obtained after this study had been concluded.

No species has been incriminated as a disease vector, but the tendencies of certain species to bite both birds and humans indicate the possible transmission of commonly shared viral diseases by some tree-hole *Culicoides*.

METHODS AND MATERIALS. Collections of tree-hole and stump-hole debris and water samples were made in Alachua County, Florida from September, 1964 through September, 1966, examinations of samples continuing until January, 1967.

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