At the present time, no practical keys are available for the separation of all the species in this complex. Biological and behavioral data are needed to support and confirm the specific status and the various populations that we have in California. Laboratory colonization methods and genetic studies will be needed to advance our knowledge regarding the species identity of the many biotypes of *Leptoconops* species in California.

REFERENCES CITED

Carter, H. F. 1921. A revision of the genus *Leptoconops*. Skuse. Bull. Ent. Res. 12: 1-28.

Clastrier, J. and W. W. Wirth. 1978. The *Leptoconops kerteszi* complex in North America (Diptera: Ceratopogonidae). U. S. Dept. Agr. Tec. Bull. 1573: 58 pp.

Wirth, W. W. 1952. The Heleidae of California. University of California Publications in Entomology. Vol. 9(2): 95-266.

Wirth, W. W. and W. R. Atchley. 1973. A review of North American *Leptoconops* (Diptera: Ceratopogonidae). Graduate Studies Texas Tech. University 5: 57 pp.

ASSESSMENT OF BITING MIDGES (DIPTERA: CERATOPOGONIDAE) IN THE SALTON SEA BASIN

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The Coachella Valley of southern California (Riverside County) has a rapidly rising human population, and in the southern and eastern regions, an extensive population of domestic animals. Both are subject to various species of biting midges in the family Ceratopogonidae throughout most of the year. Following heavy rainfall in late spring, summer, and early autumn, large broods of *Leptoconops torrens* are produced near the densely populated cove cities. During the cooler months of the year, large numbers of *L. foulki* and *Culicoides variipennis occidentalis* emerge on the shores of the Salton Sea, along drainage ditches, and along seeps and springs of Riverside and Imperial Counties where the soil is permanently damp.

My objectives during the winter season have been to characterize larval development sites at the Salton Sea with the hope of developing a model for delineating larval habitats and predicting larval densities. Secondly, the host-seeking behavior and gonotrophic cycle of *L. foulki* were studied to gain an understanding of reproductive potential, flight range, and vector potential.

The area chosen for study was on the shores of the Salton Sea at North Shore where Foulk (1969) reported large numbers of adults in a bimodal frequency-distribution with populations peaking in mid-morning and again in mid-afternoon. The distribution of immatures was determined by extracting life stages from cores of soil (5.5 cm. dia x 5 cm. deep) using saturated sodium chloride solution (Horsfall 1956). This technique routinely recovers 85% of the immatures present in the core. Eleven samples were taken every 5.5 m along each of 3 parallel transects extending inland from the Salton Sea shoreline. The elevation of each sample was measured with a Craftsman transit to the nearest mm in relation to the water level of the Salton Sea and the level of free soil water; the latter being determined by digging numerous holes at strategic locations. Following a preliminary survey for larvae, replicated soil samples from each zone were collected for soil chemistry analysis, performed by the UCR Cooperative Extension laboratory.

This study identified 4 ecological zones. The first, a relatively narrow band at the ecotone of the Sea and shoreline, contained immatures of *C. variipennis occidentalis*. A second zone was characterized by saturated soils. In such areas, larvae of *Dasyhelea* spp., a non-hematophagous ceratopogonid were collected in large numbers. When such sites were adjacent to the shoreline, some overlap with *C. variipennis occidentalis* was noted. *L. foulki* larvae were found in soils above the level of free soil water. The inland margin of this zone was not easily delineated by visual inspections; however, the communities of vegetation generally described the distribution of *Leptoconops*. As Iodine bush (*Allenrolfea occidentalis*) became sparse and arrowweed (*Pluchea sericea*) began to dominate, the density of larvae dropped rapidly. The 4th zone was characterized by nearly pure stands of arrowweed, and no larval ceratopogonids were found in soil samples.

Soil chemistry analysis revealed some trends that vaguely correlated with distribution of larval ceratopogonids. Readings of pH varied without an obvious pattern, however, values of free chlorides and electrical conductivity increased with increasing distance inland. Other parameters found not to be significantly different between zones were percent organic matter and the soil particle size.

Having delineated the macrohabitat of *L. foulki*, the microhabitat was next studied by taking 15 contiguous samples (each replicated three times) well within the *L. foulki* zone. This transect extended from a depression to the top of a small hummock. As previously described, the elevation of each sample was measured and additional samples were collected for soil chemistry analysis.

Once again, trends in soil chemistry were evident but unsatisfactory in describing larval density. However, larval numbers correlated with elevation above the free water line (r=–.90). This is an indirect measurement of soil moisture. It now seems likely that this measurement, combined with patterns of vegetation, will enable us to quickly identify and evaluate development sites of larval *L. foulki*.

The reproductive bionomics of adults was also studied at this location. The vertical and horizontal distribution of host-seeking midges was determined using paired dry ice baited CDC traps placed at ground and vegetation canopy levels (2 m). Pairs of traps were placed 5, 50, and 120 m inland and operated during morning hours and again during the afternoon. Midges were counted and 5-10 *L. foulki* were randomly selected from each of the 6 traps and were dissected to determine the physiological age of the population by time collected. This was done by examining the ovaries for follicular relics (Detinova 1962), the presence of which indicate that oviposition has occurred and that the female is therefore parous. The spermathecae were crushed to determine if mating had occurred and the stage of ovariole development was recorded (Christophers 1911). The remainder of the midge was crushed in cold anthrone reagent (Van Handel 1972). If nectar was present in the crop, the reagent changed color from yellow to deep blue within 20 minutes. These procedures were initiated in March 1981 and are being continued at monthly intervals.

Several strong trends have persisted to date. Only 2 species of biting midges have been present in large numbers during the day. Both *L. foulki* and *C. variipennis occidentalis* were more abundant in ground level traps regardless of weather conditions or distance from the Salton Sea. More females have also been captured 120 m inland than 5 m inland.

Because of Foulk's studies, and because the summer pests are also of this genus, only females of *L. foulki* were dissected. A distinct difference was seen in the "age" of the AM versus PM populations. In March and April parous flies were rare in the morning (<10%) but abundant in the afternoon (>35%). These differences were statistically significant on each of the 3 sampling dates. Furthermore, virtually all females were mated, and no nullipars exhibited ovarioles beyond the resting stage, indicating an obligate anautogenous reproductive strategy (Magnarelli and Cupp 1977). No significant difference was noted in the prevalence of nectar-positive females between AM and PM populations; at least 35% of the population had imbibed nector relatively recently.

In May, the age structure shifted. Parous midges constituted over 70% of both AM and PM populations, indicating that the number emerging had diminished greatly. In addition, the proportion of nectar-positive females had increased to greater than 60%.

What is the significance of these findings? First, a distinct pattern in the behavior of *L. foulki* is clear; a pattern that warns of vector potential. It is now apparent that this species seeks nectar and is fairly successful in obtaining it. With these nectars, *L. foulki* can disperse beyond the larval site in search of blood, and can survive beyond the first gonotrophic cycle. In fact, examination of the ovaries has shown that parous flies are not only common, but concentrated during the afternoon hours and late in the season. Consequently, if this species is a vector of pathogenic agents, suscepts are more likely to become hosts in the afternoon rather than morning. Information taken from the literature reveals that this species readily attacks man, as well as domestic and wild animals. Therefore, although no study has rigorously examined the role of *Leptoconops* in transmitting pathogens, based on these findings, one cannot discount the possibility that it may be involved in the cycle of animal or zoonotic diseases. With the human population of Coachella Valley increasing, and the presence of domestic livestock in large numbers, further rigorous studies are warranted.

Finally, it may be possible to quickly identify larval sites and to predict population levels by a combination of vegetation communities and elevation above free soil water. If so, larval control may be practical.

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REFERENCES CITED

Christophers, S. R. 1911. The development of the egg follicle in anophelines. Poludism 2: 73-89.

Detinova, T. S. 1962. Age-grouping methods in Diptera of medical importance. Wld. Hlth Organ., Geneva. 216 pp.

Foulk, J. D. 1969. Attack activity of two species of gnats in southern California. Annals. Ent. Soc. Amer. 62: 112-116.

Horsfall, W. R. 1956. A method for making a survey of floodwater mosquitoes. Mosq. News. 16: 66-71.

Magnarelli, L. A. and E. W. Cupp. 1977. Physiological age of *Simulium tuberosum* and *Simulium venustrum* (Diptera: Simuliidae) in New York State, U. S. A. J. Med. Ent., 13: 621-624.

Van Handel, E. 1972. The detection of nectar in mosquitoes. Mosquito News. 32(3): 458.