DRAINAGE OF A DESERT SPRING CREEK FOR CONTROL OF *LEPTOCONOPS KERTESZI* (DIPTERA: CERATOPOGONIDAE) [1, 2]

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INTRODUCTION. *Leptoconops kerteszi* Kieffer is an important anthropophilic ceratopogonid in California and elsewhere in the western United States. Markos and Doty (1965) have reported on its occurrence on the Monterey peninsula, and Smith and Lowe (1948) studied the biology of the species at Bodega Bay, on the Pacific Coast north of San Francisco. The author and M. S. Mulla were unable to collect adults at this site in April, 1965. Lowe (1965) reported that breeding grounds no longer exist in the area after an inspection was made in August. The species was named the Bodega black gnat by Smith and Lowe, but "desert black gnat" is suggested as a more appropriate name due to the widespread occurrence of *L. kerteszi* in desert areas of southern California, and its increasing importance as a public health pest in this region. The gnat also occurs on the Colorado Plateau, and Rees (1958) described methods of control at a breeding ground near Salt Lake City, Utah. He stated that reduction of breeding grounds moisture to 25 percent saturation or less in the early spring prevented emergence of adults.

Since 1957, this small, vicious biter has caused an increasing number of complaints from tourists and visitors to the Salton Sea Recreation Area (State Park). The period of greatest attack coincides with the period of maximum use of the park by tourists and visitors, i.e., from mid-January through May. Gnats are active during the day, and they preferentially attack man's head, biting at the hairline, on the scalp, and pinna of the ear. Some people experience a severe reaction to the bites, but the gnat is not a known vector of human disease.

Riding horses stabled near breeding grounds are bitten not only by *L. kerteszi*, but also by *Culicoides variipennis* (Coq.) a larger, picture-winged ceratopogonid. This midge is crepuscular. It will bite man, but prefers livestock.

BREEDING GROUNDS IN SOUTHERN CALIFORNIA. In Riverside County, newly-discovered *L. kerteszi* breeding grounds include moist, saline, sandy areas in the Santa Ana River valley near Norco, in Thousand Palms canyon, in seeps below the All-American Canal, and in the Salt Creek drainage basin. Additional breeding grounds in the county include a wasteland along the north shore of the Salton Sea east of Whitewater Cove, and within the State Park. Gnats breed at Hot Mineral and near Brawley, both in Imperial County, and in Borrego Springs canyon in San Diego County. More than 3000 acres of gnat-breeding grounds are presently known in southern California.

OBJECTIVES. A drainage experiment was conducted along a small creek to study the effect of soil moisture reduction on larval and pupal populations of *L. kerteszi*. If source reduction was found to be practical and long-lasting, cultural control might be employed in larger breeding grounds at the State Park. Here, the immature gnat stages are present in the sandy margins of a creek ½ mile long,

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and in a 20-acre marsh formed by the creek as it nears the Salton Sea.

DESCRIPTION OF THE STUDY AREA. The general area of these studies is shown in Figure 1. The shaded portions of the enlarged section of the map are hummocks 10 to 50 feet high. The common reed, *Phragmites communis,* grows here, and desert fan palms, *Washingtonia filifera,* are located on the northernmost hummock. The hummocks are aligned northwest-southeast on an accessory fissure of the San Andreas fault. A small stream, called Outback Creek in this study, originates from a spring on the palm-covered hummock, and flows southwest down across the desert. The stream once flowed southeast into the main Salt Creek basin, but in July, 1964, the landowner changed the course of the stream.

Soil types of the area are Superstition coarse gravelly sand, and desert. Fine sand has been blown onto the surface of the breeding ground along the creek by prevailing northwesterly winds which weather a low escarpment of sandstone. A heavy, fine-textured adobe clay pan is present 4 to 6 inches beneath the sand surface. Sparse vegetation along the creek includes tamarix, desert holly, *Atriplex hymenelytra;* and pickleweed, *Allenrolfea occidentalis.* The creek is approximately 2 feet wide and 4 inches deep. During the test, pH of the creek was 6.8 ± 2, and contained more than 25,000 p.p.m. free chlorine. Five to 8 yards of desert floor on either side of the creek was moist, and covered by a thin crust of salts. This was the gnat breeding ground, as shown in Figure 2. The UCR Agricultural Extension Laboratory analyzed saturation extracts of soil samples. The results were: pH, 8.6; EC, 41.6 millimhos/cm (electrical conductivity $\times 10^3$:25° C.); Ca+Mg, 123 meq./l; Na, 500 meq./l; K, 3.3 meq./l; SO_4, 298 meq./l; B, 28 p.p.m.; and .22 percent organic matter.

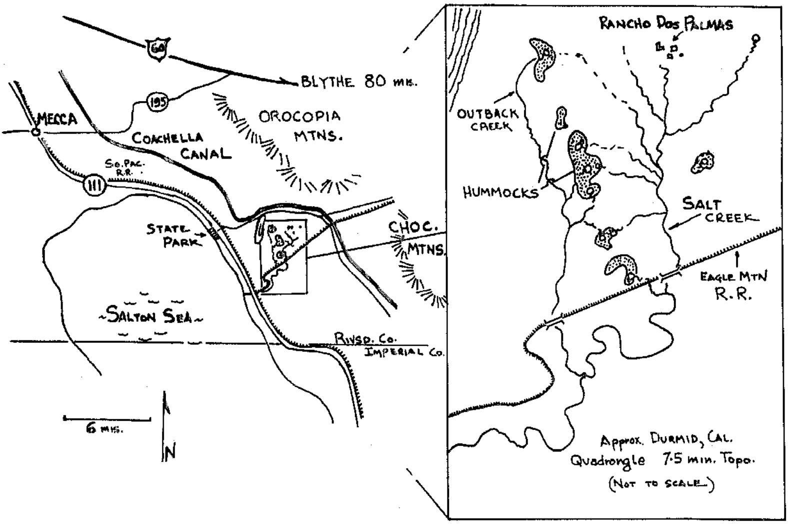

FIG. 1.—Region northeast of Salton Sea. Enlarged area is Salt Creek drainage basin.

MATERIALS AND METHODS: ALTERATION OF THE CREEK. On March 17, 1965, two semi-circular ditches were dug with a grader to divert the water in the stream bed from two areas, 85 yards long. The ditches were 18 inches deep, and extended into the clay pan. In the center of each

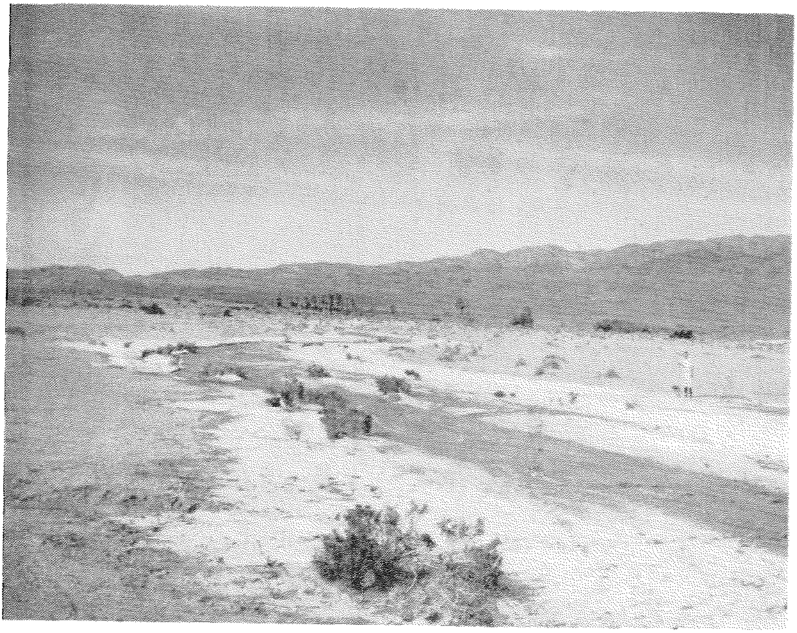

FIG. 2.—Breeding ground along Outback Creek. March, 1965.

area a 17-yard length of the original stream bed was selected for soil sampling. The next day, two 17-yard sections of 6-inch transite pipe were laid in two other portions of the main channel to dry the sand along the sides of the stream bed. A dam of sand and clay covered with plastic sheeting directed the stream into the head of each pipeline. Unaltered areas, or checks, were left above, between, and below the drained areas. Each of these was 17 yards long.

SOIL SAMPLING. Fifty soil cores, 2 inches in diameter and 2.5 inches deep, were collected at random from each area every week. More than 90 percent of *L. kerteszi* immatures at this site were found in the top 2 inches of sand. Ten cores were composited into each of 5 one-quart plastic containers. Each composite sample was washed through .35 and .71 mm. sieves. The clean sand retained by the smaller sieve was placed in a waxed paper cup, flooded with 100 ml. of 40 percent aqueous sucrose (Karo syrup), stirred, and allowed to stand for 1 minute. Larvae and pupae floated to the surface. Live specimens were removed, counted, and preserved in 70 percent ethanol. Eggs and first instar larvae were not retained by the .35 mm. sieve. Sampling began on March 11, and continued weekly until June 4th. In the unaltered areas, sampling was continued bimonthly during the remainder of the year. The results of this seasonal abundance study are not included in this paper.

Additional soil cores were collected bimonthly for gravimetric soil moisture determination. Forty cores, 1 inch in diameter and 2.5 inches deep, were taken at random from each area and composited in air-tight tin sample boxes, two per box. Moisture content by weight was calculated using the standard gravimetric procedure described by the U.S.D.A. (1954).

RESULTS AND OBSERVATIONS. Changes in soil moistures in the check, pipelined, and ditched areas, are shown in Figure 3.

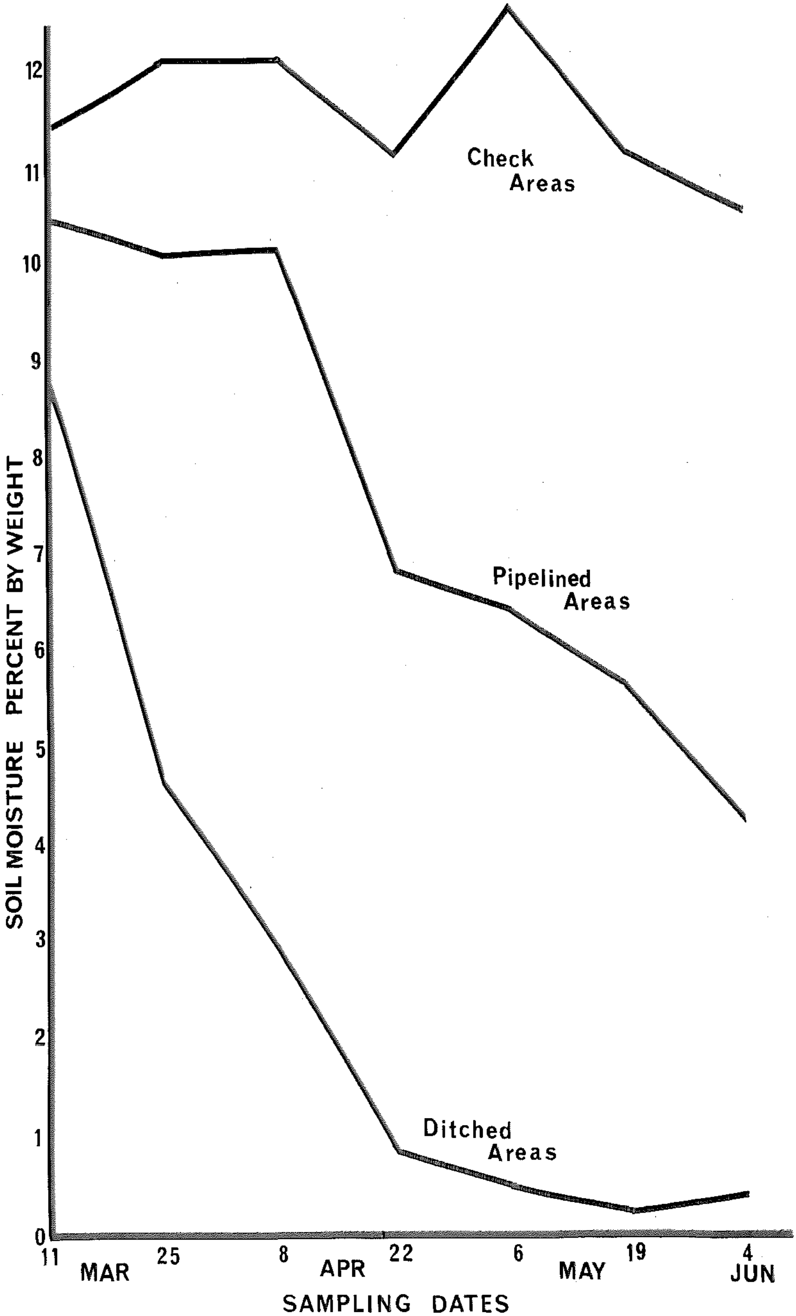

FIG. 3.—Changes in soil moisture in the drained and unaltered areas.

The ditched area dried rapidly during the first 3 weeks, and cores taken from mid-April to the conclusion of the experiment contained less than 1 percent moisture. The pipelined areas dried less rapidly and completely than the ditches due to subsurface leaks beneath the plastic-covered dams and the slow rate of drying at the efferent ends of the pipelines. The soil adjacent to the center of each pipeline dried to less than 5 percent. Cores were taken at random, however, and the moisture curve includes readings for those portions that never dried, as well as those that did. In the check areas, moisture varied from 10.5 to 13 percent. Drying was not significant in these areas.

Small flower pot emergence traps (Foulk, 1965) were damaged or destroyed by vandalism twice during the test, and no quantitative estimate of adult gnats was made. Adult gnats were present in large numbers from mid-January to mid-July. The adult population decreased during the period of mid-July to late November, but females were still collected from man. In December, adults were very scarce, but in early January, 1966, they again became increasingly abundant. Mature pupae were recovered in soil samples from the unaltered areas at every sampling date during the study. No hibernating nor aestivating pupal stage has been reported for *L. kerteszi*. In the laboratory at $90 \pm 5°$ F. and relative humidity greater than 85 percent, the length of the pupal stage is 2 to 3 days.

Weather instruments could not be left unprotected at this site, so records of soil surface temperatures were not obtained. After May 19, surface temperatures in both wet and dry areas exceeded 100° F. during midday. Two heavy thunderstorms occurred at Outback Creek during the first week of April, but the amount of rainfall was not measured.

A staphylinid beetle, and oribatid and trombidiid mites were frequently noted in the soil samples. Two other ceratopogonids also shared the breeding niche, namely, *Culicoides mohave* Wirth, and *Dasyhelea festiva* Wirth. The larvae of

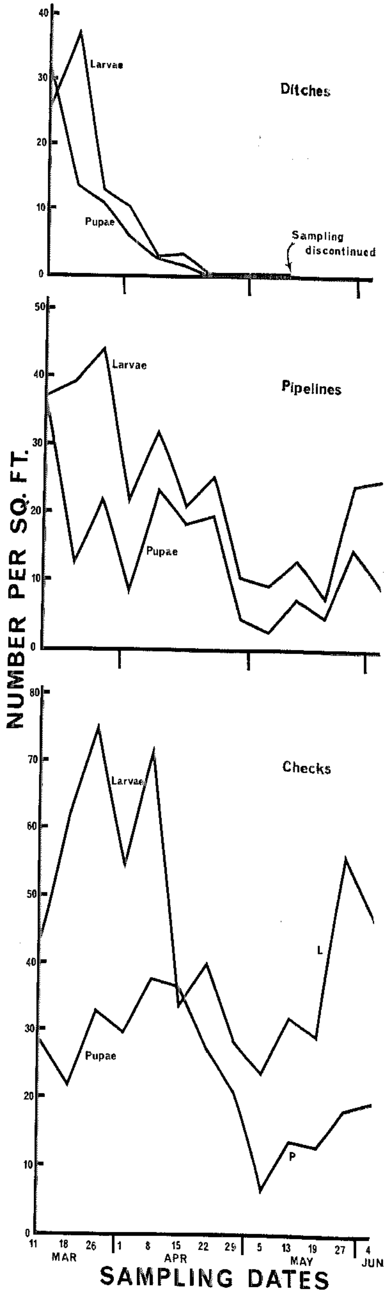

FIG. 4—Changes in larval and pupal populations for each area.

both of these midges had well-defined head capsules, and were white. *L. kerteszi* lacks a chitinized head capsule, and mature larvae are yellow or orange. Adults were reared from pupae for taxonomic determination. No chironomids were collected along Outback Creek, but simuliid larvae and pupae were attached to small stones in riffles of the stream.

The changes in *L. kerteszi* larval and pupal populations for each of the areas are illustrated in Figure 4. The gnat population was approximately equal in each area at the start of the test. The larval numbers in the ditched areas increased 1 week after the stream had been altered, but steadily decreased, thereafter, until no larvae were found in the April 22 collection. Sampling was discontinued after 3 weeks of negative collection. No breeding occurred along the clay-lined sides of the drainage ditches.

Unexplained fluctuations marked the gradual decrease of the immature stages in the pipeline areas. Fewer than 10 larvae and pupae per sq. foot were estimated from samples taken in these areas on May 19. Subsequent samples indicated a higher population, however, so gnats were never completely eliminated here.

CONCLUSIONS. The experiment indicated that the desert strain of *L. kerteszi* occurs in sandy soils of 10 to 13 percent moisture content. Ditching was the most effective means of source reduction, but the presence of a relatively impermeable clay layer was an important factor. Gnat larvae and pupae were able to survive in the drying stream bed containing only 3 percent moisture, but were completely eliminated when moisture dropped to 1 percent. Pipelines may be used in sandy soils lacking a clay layer, but they must be leak-proof to be effective. A recent drop in the Salton Sea level has increased the drainage slope in the breeding grounds at the State Park, and a pipeline drainage system would be an effective, permanent method of gnat control.

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