A POPULATION STUDY OF THE *CULICOIDES* MIDGES [1] OF THE EDWARDS PLATEAU REGION OF TEXAS

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Early in 1953 it was definitely established that the virus disease of sheep known as bluetongue has been present for some time and is occasionally epizootic in the southwestern United States. In South Africa, where bluetongue has caused important losses to sheep raisers, and where it has been studied intensively for several decades, the only proved vectors are biting midges of the genus *Culicoides* Latreille (du Toit, 1944). D. A. Price and W. T. Hardy, veterinarians of the Texas Agricultural Experiment Station at Sonora, have produced bluetongue infections in sheep experimentally by inoculations of an emulsion of *Culicoides variipennis* (Coquillett) (fig. 1) made from specimens caught in a light trap on the station where an outbreak of the disease was in course (Price and Hardy, 1954). One of the first steps in planning an investigation on the habits and control of these biting midges was to determine which species were present in the outbreak area as well as their relative abundance and seasonal history.

GEOGRAPHY. The bluetongue outbreak area of western Texas is centered on the extensive sheep-raising region of the Edwards Plateau. The dissected edge of this limestone plateau forms the eastern border of the region at the Balcones Escarpment. The eastern portion of the plateau is hilly, with a subhumid climate. A scrubby forest of Mexican cedar, Texas oak, and stunted live oak forms the dominant vegetation. To the west, the plateau levels

[1] Diptera, Heleidae.

[2] Retired.

[3] We are greatly indebted to the personnel of the Agricultural Research Service laboratory at Kerrville and to D. A. Price and W. T. Hardy, veterinarians of the Texas Agricultural Experiment Station at Sonora, Texas, for assistance in this study.

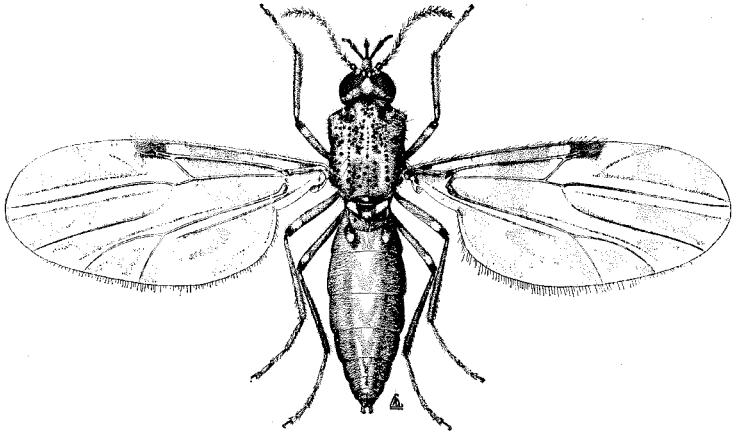


FIG. 1. *Culicoides variipennis,* female (drawn by Arthur D. Cushman, Entomology Research Branch).

out towards and across the Pecos River, the climate becomes semi-arid, and the vegetation becomes a live oak-mesquite savannah (Blair, 1950). The location of the U. S. Department of Agriculture Experiment Station near Kerrville is typical of the hilly eastern section, while the Texas State Experiment Station near Sonora is in the level, more arid savannah country.

METHODS. Earlier published works of James (1943), du Toit (1944), Fox and Kohler (1950), Wirth (1951), Beck (1952), Khalaf (1952), and Fox (1953) indicated that New Jersey light traps would attract large numbers of *Culicoides,* including a wide variety of species. During a preliminary survey by the senior author at the Kerrville station in June 1953, three light traps were operated at locations where they would sample different types of possible breeding places of *Culicoides.* A fourth trap was left with Dr. Price at the Sonora station to sample the population at a location where an outbreak of bluetongue was in progress.

The traps were standard New Jersey mosquito traps modified only by the substitution of a 14-by-18 mesh wire screen for the hardware-cloth screen at the top of the cylinder below the light, to keep out the larger beetles and moths which would injure the midges or otherwise hinder their identification.

Through the cooperation of the personnel of the Kerrville station, and of doctors at the Sonora station, each trap was operated all night two nights a week for the remainder of the 1953 season, and into the 1954 season. During the winter the traps were operated only during warm weather, which usually occurred about every two or three weeks. Dr. Price also used the trap at the Sonora station a few alternate nights to collect live *Culicoides* for transmission studies.

The junior author was responsible for the regular operation of the Kerrville traps and for shipping the specimens to Washington, where the senior author sorted out and counted the *Culicoides.* To save time, an attempt was made to divide the larger catches by making aliquot samples. Each aliquot contained about 0.1 pint of insects, which yielded 200 to 300 *Culicoides* to be sorted. The total catches were computed from the sample. This division was usually necessary only for the Luglan trap, which frequently caught more than a pint of insects, even with a screen.

In 1955, the senior author spent about six weeks in March and April at the Kerrville station searching for breeding places

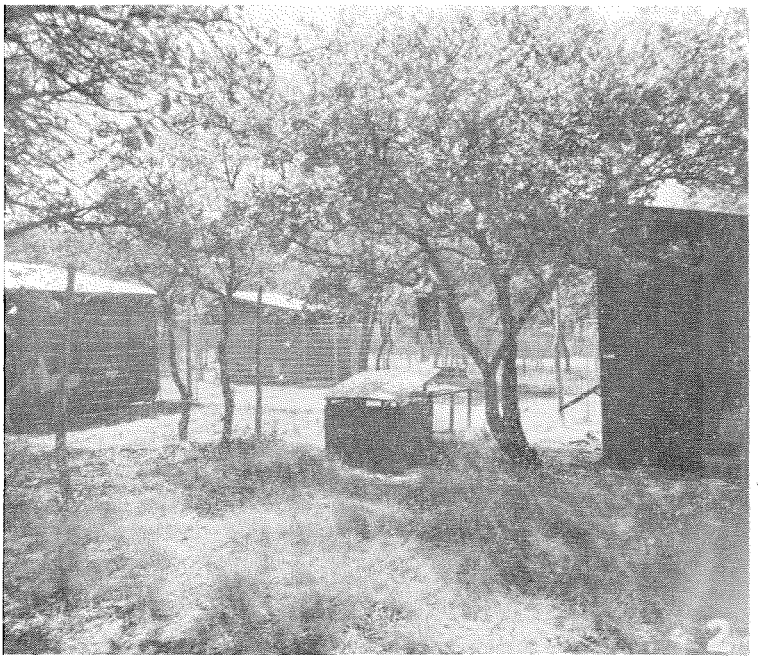


FIG. 2. Location of light trap at poultry yard, Kerrville station, showing characteristic scrubby oak-juniper forest (photograph by Rowland Richards, Entomology Research Branch).

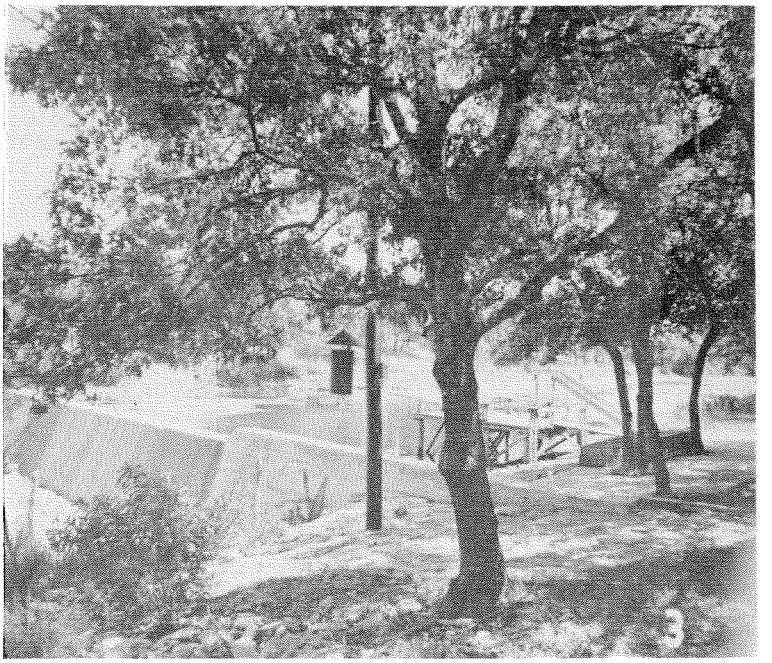


FIG. 3. Location of light trap at impounded creek, Luglan Ranch (photograph by Rowland Richards).

FIG. 4. Location of light trap at Bottimer residence, showing characteristic post oak woodland (photograph by Rowland Richards).

FIG. 5. Location of *Culicoides varipennis* breeding area in sewage effluent seepage area at the Sonora Experiment Station (photograph by Rowland Richards).

of *Culicoides*, and made a few rearings from the vicinities of the light traps. These rearings are reported herein.

LOCATIONS OF LIGHT TRAPS AND RELATIVE ABUNDANCE OF DIFFERENT SPECIES. Trap I (figure 2) was placed in a poultry yard at the Kerrville station, which is about six and a half miles northeast of the city of Kerrville. The terrain was, in general, rather high and well drained. The nearest permanent stream was a creek which arose from springs about half a mile from the poultry yard and flowed past the Luglan Ranch (location of trap II). Smaller springs within several hundred yards of the poultry yard were temporary and had dried up several months before the trap was operated. Breeding places on the station near the trap were restricted to overflow and leaks from stock-watering tanks and troughs, manure piles and drains from livestock pens, damp leafmold and, judging from the large numbers of *arboricola* and *ousairani* caught, a considerable number of tree holes in the scrubby woods covering the entire area.

At the poultry yard (table 1) the commonest species was *haematopotus* (66.5 per night), followed by *arboricola* (55.2), *ousairani* (40.5), and *multipunctatus* (7.8).

Trap II (figure 3) was located at the Luglan Ranch about two miles north of the Kerrville station. A dam had been built across a small, cool permanent creek, forming a pond about 50–75 feet in width and a quarter of a mile in length in front of the house and gardens. The pond was heavily fertilized to support a high fish population for recreational purposes, and in consequence developed a high population of aquatic insects. The trap was set up on the shore at the lower end of the pond. A few hundred yards away the heavily watered lawn and garden and the ranch pens for a few sheep and horses afforded suitable breeding areas for less aquatic species.

At the Luglan Ranch *haematopotus* was by far the commonest species (135.9 per night), followed by *multipunctatus* (64.2) and *bottimeri* (53.5).

TABLE 1. Average Number of *Culicoides* Taken per Night in Texas Light Traps, June 1953 to June 1954, inclusive

Species	Poultry Yard	Luglan Ranch	Bottimer Residence	Sonora Station
arboricola	55.2	1.4	1.0	0.1
borinqueni	0.5	0.1	0.1	...
bottimeri	1.1	53.5	4.0	0.2
crepuscularis	4.2	27.5	0.7	5.3
haematopotus	66.5	135.9	22.9	0.3
hieroglyphicus	0.1	0.2	0.1	0.5
jamaicensis	0.2	0.1	0.6	1.8
multipunctatus	7.8	64.2	54.8	1.2
neopulicaris	1.8	2.9	0.3	...
ousairani	40.5	3.0	5.7	11.8
salihi	4.5	20.9	6.7	...
spinosus and *nanus*	3.3	20.9	0.7	0.1
stellifer	0.3	27.5	0.8	...
variipennis	1.2	4.2	0.8	210.2
weesei	...	...	...	...
n. sp. near *haematopotus*	...	0.5	0.2	...
Totals:	13,107	21,405	7,745	10,183
Number of nights operated	70	59	78	44
Average per night	187.2	362.9	99.3	231.4

Trap III (figure 4) was located at the Bottimer residence on the western edge of the city of Kerrville. A small portion of the lawn was heavily watered, and the most likely remaining breeding places consisted of several very large compost piles at the back of the lot and rot holes in several large oak trees. There was usually some direct competition from lights in the house, not present at the other localities.

At the Bottimer residence the commonest species was *multipunctatus* (54.8 per night), followed by *haematopotus* (22.9), *salihi* (6.7) and *ousairani* (5.7).

Trap IV was located at the laboratory building of the Sonora Experiment Station between Rocksprings and Sonora. In addition to tree holes and the usual occasional overflow from livestock-watering tanks and the watering of residential lawns and gardens, the largest and most productive source of breeding (actually determined by recovery of *variipennis* lar-

vae) was a heavily polluted seepage area of about half an acre fed by the sewer system for the station and opening about 300 yards from the trap (figure 5).

At the Sonora station there was an enormous population of *variipennis* (210.2 per night), with relatively few *ousairani* (11.8), *crepuscularis* (5.3) and other species.

SEASONAL ABUNDANCE. The average nightly catch of each common species of *Culicoides,* and the average total catch per night for all species by monthly intervals for a thirteen-month period from June 1953 through June 1954, are shown in figures 6 to 9.

Populations at the poultry yard and Luglan locations where *haematopotus* was dominant reached their maximum in August, and those at the *variipennis* locality at the Sonora station crested in September. The population at the Bottimer residence, where *multipunctatus* was most numerous, reached a much earlier peak, in April of 1954 and in June or before in 1953. An April, 1954 peak at the Luglan trap was higher than the August, 1953 peak primarily because of proportionally greater numbers of *bottimeri, spinosus,* and *stellifer,* which are also evidently more common in early spring. Populations of the common tree-hole species *arboricola* and *ousairani* apparently built up steadily and reached their peak in the hot summer months. Populations of *Culicoides* generally diminished rapidly in October, and adults practically disappeared by November first. In February a few specimens were taken in two of the traps, and by March full-scale emergence was in progress during warmer weather. Observations at the Kerrville station during 22 nights of trapping in March and April of 1955 indicated that there was very little adult activity on cool nights when the minimum temperature dropped below 55° F.

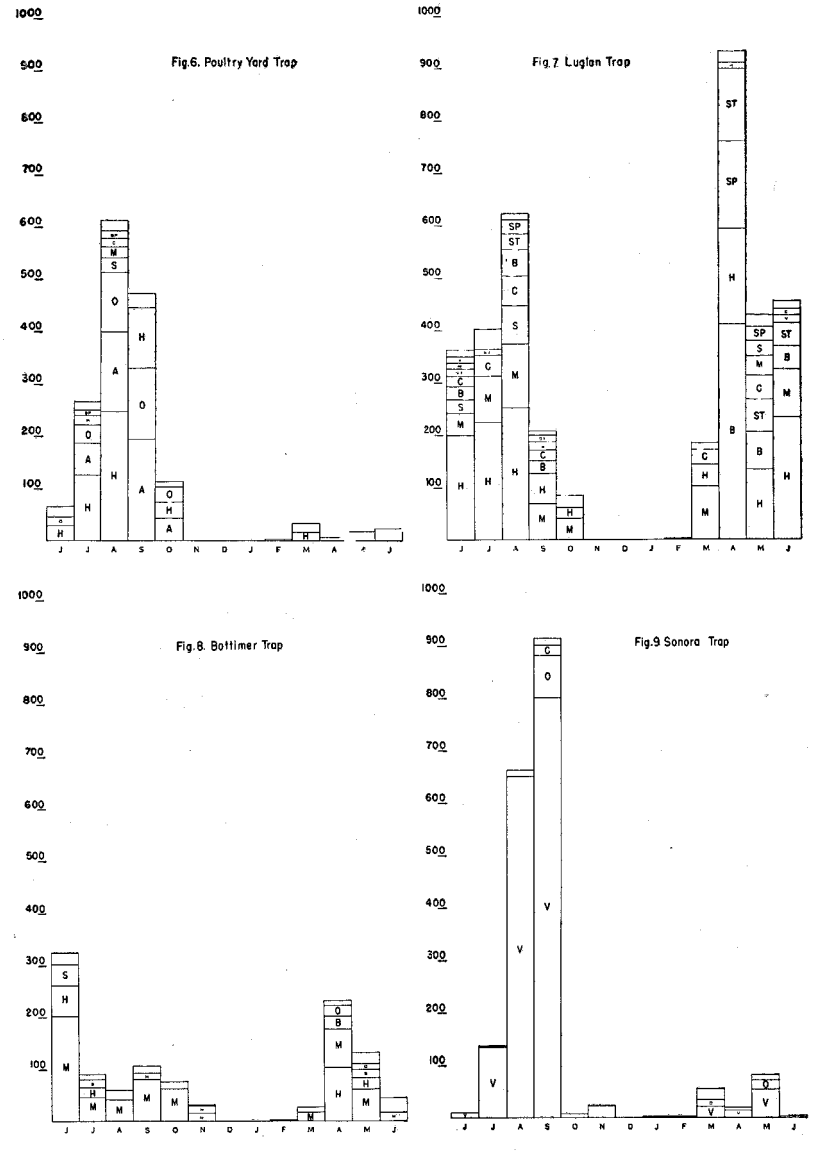
For unexplained reasons the populations in the poultry yard and Sonora traps were much lower in June of 1954 than in June of 1953. It is possible that the constant trapping seriously depleted the population of females before they oviposited. Weather or human activities may also have had some effect. We cannot say from our data whether the same depletion actually occurred at the Bottimer location or whether there was a shift in time of greatest emergence due to weather conditions or other factors. At the optimum aquatic Luglan location it is apparent that the population remained high the second season.

NOTES ON SPECIES OF *Culicoides* COLLECTED. 1. *C. arboricola* Root and Hoffman is a common tree-hole species in the Southeastern States, occurring from Maryland to Oklahoma and Texas. It ranked fourth in our Texas light traps, being most abundant at the poultry yard where there were many oak-tree rot holes. We reared it twice: from wet wood debris in a hollow stump at the Kerrville station in company with *ousairani,* and from a tree hole at the Bottimer residence in company with *nanus* and *borinqueni.* Earliest record, March 9; latest, November 4.

2. *C. baueri* Hoffman was not identified from light traps, but we reared it once, on April 4, from the muddy margin of the Henke pond about a mile from the Kerrville station, where it was associated with *haematopotus, stellifer,* and *crepuscularis.* This species occurs from coast to coast in the United States.

3. *C. borinqueni* Fox and Hoffman was described from tree-hole rearings in Puerto Rico, and it has also been reared frequently from tree holes in Virginia and Tennessee. It has been taken frequently while biting man. It was taken occasionally in the three Kerrville traps in the more heavily wooded section of the plateau. We reared it once from an oak-tree hole at the Bottimer residence, where it was associated with *arboricola* and *nanus.* Earliest record, May 6; latest, October 20.

4. *C. bottimeri* Wirth was described (Wirth, 1955) from specimens taken in the present study and is not known to occur outside the Kerrville area. It is common at Kerrville, ranking sixth in the total trap collections and third in the Luglan trap at the pond margin where we suspect it breeds. It has not yet been reared. Earliest record Mar. 30; latest, October 2.



FIGS. 6–9. Seasonal distribution of *Culicoides* species, showing average nightly catch per month in four Texas light traps, June 1953 to June 1954.

A—*arboricola*
B—*bottimeri*
C—*crepuscularis*
H—*haematopotus*
M—*multipunctatus*
N—*neopulicaris*
O—*ousairani*
S—*salihi*
SP—*spinosus* (+ *nanus*)
ST—*stellifer*
V—*variipennis*
Unlettered—other species

5. *C. crepuscularis* Malloch is a common Nearctic species, reaching its greatest abundance in open, unwooded country. It ranked only seventh in our trappings, but we reared it from twelve samples in 1955: from mud at pond margins, sand at pond margins, puddles at water tank overflows and septic tank effluents, where it occurred with *haematopotus, multipunctatus, baueri, stellifer, spinosus,* and *variipennis.* Earliest record, February 26; latest, October 31.

6. *C. haematopotus* Malloch was the most abundant species in our trap collections and rearings. It was the only species taken while biting man in the spring 1955 study, when it was caught twice while feeding. It was reared from 17 samples: from mud at pond margins, sand at pond margins and stream margins, but never when pollution was extensive. Associated species were *baueri, crepuscularis, spinosus, stellifer,* and *variipennis.* Earliest record, February 26; latest, November 6.

7. *C. hieroglyphicus* Malloch is a common species in the western states, as far east as the Great Plains, but is replaced in Texas and the Midwest largely by its close relative, *multipunctatus.* We took it only in light traps, a few specimens in early spring. Earliest record, March 1; latest, June 2.

8. *C. jamaicensis* Edwards is a Central American species ranging south to Jamaica and Panama. It belongs to the *copiosus* group of species which have been reared from rotting stems of cacti. It was fairly common at Sonora but scarcer in the more heavily wooded Kerrville area. Earliest record, February 18; latest, October 20.

9. *C. multipunctatus* Malloch is a midwestern species occurring from Illinois to Texas. It seems to be more abundant in the southern part of its known range, ranking third in our light-trap collections. We reared it in 1955 from four samples from mud at pond margins, where it occurred with *crepuscularis* and *haematopotus.* Earliest record, February 26, latest, November 4.

10. *C. nanus* Root and Hoffman is a fairly common southeastern tree-hole species. In our earlier determinations this species was confused with *spinosus,* which it closely resembles, but a recheck of pooled samples indicates that it is at least a tenth as common as *spinosus,* and probably more abundant in the wooded areas where tree holes are numerous. We reared *nanus* once in 1955, from an oak tree hole at the Bottimer residence, where it occurred with *arboricola* and *borinqueni.*

11. *C. neopulicaris* Wirth is a Mexican species known to occur from Kerrville to the Balsas Valley of southern Mexico. It was fairly common in the Kerrville traps, but was not taken at Sonora nor was it reared. Earliest record, March 9; latest, October 23.

12. *C. ousairani* Khalaf is a southwestern representative of the *guttipennis* group of tree-hole species. It was common in all our traps, ranking fifth in abundance. We reared it once, from a hollow tree stump where it was associated with *arboricola.* Earliest record, March 9, latest October 23.

13. *C. pecosensis* Wirth was not taken in the Kerrville and Sonora traps, but is included in the Edwards Plateau list of species because it occurs in the Trans Pecos section known as the Stockton Plateau. It is known only from light-trap collections made at Sanderson, Texas, in April and August by personnel of the Kerrville station. It belongs to the *guttipennis* group of tree-hole breeding species.

14. *C. salihi* Khalaf is known only from the Wichita Mountains of Oklahoma and the Edwards Plateau of Texas. It was fairly common at Kerrville, ranking eighth in total frequency, but was not taken in the Sonora trap. It has not been reared. Earliest record, April 27; latest, October 23, a relatively late-season species.

15. *C. spinosus* Root and Hoffman is a common species east of the Rockies, breeding in stream and pond margins and similar aquatic habitats. We reared it four times in 1955, from mud at pond margins. Earliest record, March 9, latest October 9.

16. *C. stellifer* (Coquillett) is a common

species over the entire United States. It was taken in large numbers only in the Luglan trap and we reared it twice from mud at pond margins. Earliest record, April 7, latest October 2.

17. *C. variipennis* (Coquillett) is common over the entire United States and southern Canada and ranges into the temperate parts of Mexico. This species is apparently a complex of several closely related subspecies and populations with somewhat different habits and morphological characteristics which may assume importance in future studies on disease transmission and control methods. In the East the species is not common and breeds principally in barnyard drains and sewer effluents. In the West it is a dominant form in saline and alkaline aquatic habitats, and around municipal sewage farms and other polluted water. Muddy margins of stock ponds (figure 10) and streams and puddles in pastures are favored breeding places near livestock. This species was scarce in the Kerrville traps but extremely abundant at the Sonora station where bluetongue outbreaks occur frequently. The larvae could be taken by thousands in each small cup of mud from a sewer effluent on the station. In 1955 we reared *variipennis* from ten samples, in small numbers from mud and sand at pond margins where the water was fresh and in very large numbers from heavily polluted mud. Earliest record January 30; latest, October 27. This species apparently is active sporadically during the winter months when the minimum night temperature does not drop below 60° F.

18. *C. weesei* Khalaf is found only in the drier parts of Oklahoma and western Texas. We identified four specimens collected in the Luglan trap on March 9, 1954. This species was taken more frequently in traps operated west of the Pecos River by Kerrville station personnel.

FIG. 10. Location of *Culicoides variipennis* breeding area at muddy margin of a stock pond on a ranch in western Kerr County, Texas, where a bluetongue outbreak occurred (photograph by Rowland Richards).

19. *Culicoides* new species near *haematopotus*. Forty-three specimens were taken in the Luglan and Bottimer traps. Earliest record, April 27; latest, July 2.

CONCLUSIONS. A very gratifying feature of this light-trap study was the constancy of the total number of species caught in each location. Ten species were consistently caught in each location. Four additional species (*borinqueni, neopulicaris, salihi,* and *stellifer*) were caught only in three traps in the more moist Kerrville area. The Sonora location was probably unsatisfactory for them. Two additional species were caught less regularly: *weesei* only in the Luglan trap and "new species near *haematopotus*" in the Luglan and Bottimer traps only. We feel that we have recovered all of the important species, although we have undoubtedly missed a few rare ones or a few which are not attracted to light. In this category is *baueri,* which we reared but did not find in light-trap catches. In spite of the marked difference in habitat reflected between the poultry yard, Luglan, and Sonora traps, the average nightly catch for each—187.2, 362.9 and 231.5 respectively—showed good correlation and represented a high population level. For some reason the Bottimer trap (99.4 *Culicoides* per night) was a much poorer location.

Although catches at the three Kerrville traps, especially the Luglan trap, probably reflect the nature of *Culicoides* populations under optimum conditions for the eastern Edwards Plateau, it is believed that the population at the Sonora station trap is more representative of the more arid, sheep-raising country where bluetongue has occurred. This belief is supported by the results of 82 nights of light-trapping by personnel of the Kerrville station at scattered ranch localities from Kerrville to the Pecos River and from Del Rio to San Angelo, which are not reported here. At nearly all of these localities, as well as at Sonora, the population of *variipennis* was comparatively high. This species is known to breed in very high concentrations in polluted puddles of barnyards, in sewage farm irrigation systems, and at the margins of saline and alkaline ponds throughout the western United States. According to our present information, this habitat preference would bring the species into closer contact with sheep and other livestock than happens with other species. For this reason, *variipennis* is the primary suspect in the search for the principal vectors of bluetongue in North America.

SUMMARY. Four light traps were operated at regular intervals in ecologically different areas in and near the Edwards Plateau region of Texas, where the bluetongue disease of sheep was present, in order to compare the prevalence of possible vector species of *Culicoides* in each habitat and to record their relative numbers through a complete annual cycle. A total of 52,440 individuals, representing 17 species of *Culicoides,* were taken in the four traps during 251 trap-nights of operation. Nearly all species appeared in large numbers with warm weather, in early March, and continued at a constant level until late October. In the three wooded and better watered locations in and near Kerrville, Texas, where bluetongue occurred sparingly, the commonest species were, in fairly close order, *haematopotus* Malloch, *multipunctatus* Malloch, *arboricola* Root and Hoffman, *ousairani* Khalaf, *bottimeri* Wirth, and *crepuscularis* Malloch. At the extremely arid Sonora Experiment Station, where bluetongue was prevalent, *variipennis* (Coquillett) outnumbered all the remaining species combined, by nearly thirteen to one. Average numbers of *Culicoides* caught per night were 187, at a poultry yard on the Kerrville station; 363 near a pond on a nearby ranch; 99 at a residence in the city of Kerrville, and 231 at the Sonora station.

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