

700 males were released during an 11-week period (average of 9,500 males per week) at two stations about $\frac{1}{8}$ mile apart within an extensive breeding area in a tree-covered swamp flooded by rain water and spring-fed streams, located at the south end of Lake Panasoffkee, Sumter County, Fla. To determine if these sterile males caused any reduction of, or sterility in, the natural populations, the number of adult *quadrimaculatus* in resting stations and the viability of eggs from females collected from these resting stations were followed in the release and check areas.

In the Lake Okeechobee experiment the release of sterile males may have influenced the abundance of *quadrimaculatus* during the first half of the experiment when the natural population was in a sea-

sonal decline, but it had no effect when the natural population increased during the second half of the test. Release of sterile males in the Lake Panasoffkee area did not conclusively demonstrate any induced sterility in wild females.

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NULLIPARITY IN SUMMER AND FALL POPULATIONS OF *CULEX TARSALIS* COQ.¹

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INTRODUCTION. A practical technique for the separation of nulliparous and parous female mosquitoes was originated by Detinova (1945, 1949). Its basis is the simple fact that the ovarian tracheoles retain an original coiled state until stretched, irreversibly, by the development of eggs. The method of Detinova was first applied to the study of *Culex tarsalis* Coquillett by Kardos and Bellamy (1961). It has been used further to analyze the special collections of *C. tarsalis* which are discussed in the present paper.

All of these special collections were

made in the summer and fall of 1960 in Weld and Boulder Counties, Colorado. The ovaries were dissected from all females that were neither engorged nor gravid. Females with ovaries retaining only a few mature eggs were called parous. The tracheoles of the mounted ovaries were not always readable and though, in separate collections, the state of the ovaries in as many as one-fourth of the deplete females could not be determined, the occurrence of these unknowns is believed not to compromise any statement made in this paper.

PROPORTION OF NULLIPAROUS FEMALES AS AN INDICATOR OF POPULATION AGE. In a study of western and St. Louis encephalitis under enzootic conditions in Weld County, Colorado (Blackmore *et al.*, 1962), it was found that the transmission rates in two different areas were not related to the corresponding prevalence data

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for *C. tarsalis*. One of the two areas (Pierce), located in a district of extensive dry-farming, had very little water suitable for mosquito breeding. In the other area (St. Vrain), where the surrounding land was mostly irrigated, water, occurring as seeps and oxbow sloughs, was relatively abundant. The populations of *C. tarsalis* at Pierce, in contrast to those at St. Vrain, might therefore be supposed to contain more females of greater age because more had developed at some distance from the study area. Since an older female of *C. tarsalis* is more likely to have become infected with encephalitis and more likely to be ready to transmit the virus, the populations at Pierce, if actually older, might have contained enough more individuals that were infective to account for the difference in transmission rates. To find out if the female *C. tarsalis* at Pierce contained more parous, and therefore older, specimens than at St. Vrain, collections were made in both areas by means of CO₂ bait traps that were operated high in the

foliage of trees. Examination of the ovarian tracheoles of specimens taken in July and August 1960 showed that the percentage of parous females was usually higher at Pierce than at St. Vrain (Figure 1). Even in the period ending August 4, however, as disclosed by a chi-square test, the difference in the numbers of parous and nulliparous females in the two areas was not significant at the five percent level. Whether the slight difference found in this study would prove consistent and meaningful could be established only by further observations.

NULLIPARITY IN RELATION TO DIAPAUSE. Observations made by G. A. Mail in Cache Valley, Utah, and reported here with his permission, showed that collections of female *C. tarsalis* taken in various daytime shelters in the late summer of 1956 contained engorged specimens in a steadily decreasing percentage that approached zero long before the females disappeared (Table 1).

Similar observations on the decrease of

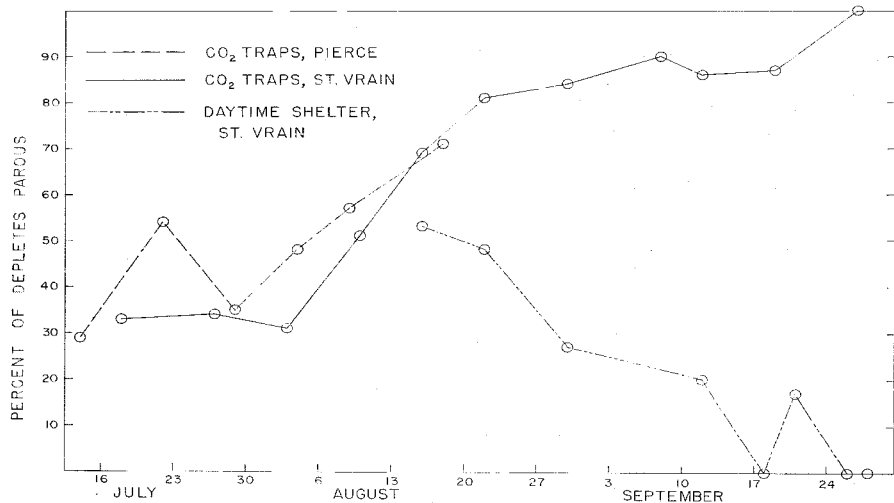


FIG. 1.—Oviparity in three populations of *Culex tarsalis*, Weld County, Colorado, 1960. All equivocal specimens were omitted from the total of depletes used to calculate the percent parous.

TABLE 1.—Seasonal decline in percentage of engorged female *C. tarsalis*

Dates	Total days of collecting	Percentage of females engorged
Aug. 10	1	29
Aug. 13-18	6	25
Aug. 20-25	6	19
Aug. 27-31	5	13
Sept. 7	1	8
Sept. 14	1	1
Sept. 17-20	4	1
Sept. 24-28	5	0
Oct. 1-4	3	0

blood feeding were made by Bennington *et al.* (1958) in Weld County, Colorado. In their study, the percentage of engorged and gravid females decreased rapidly from about 30 percent on August 1 to zero on October 10. Although the authors did not study successive broods of reared adults, they found evidence that the late summer and fall broods "enter a diapause with respect to blood feeding."

In 1960, the CO₂ trap collections of *C. tarsalis* at the St. Vrain area in Weld County were continued through the month of September to obtain specimens for the study of nulliparity in late-season adults. Shelter collections were made during the same period in a small shed which had been built at St. Vrain to serve as a mosquito resting place. In the CO₂ traps, which are known to capture mostly females in search of blood, the total numbers of females decreased rapidly, and at the same time, the proportion of parous individuals, which had started to increase before mid-August, rose to 100 percent before the end of September (Figure 1). It is believed that the drop in total numbers indicates the progressive mortality in the blood-feeding population, and that the increasing proportion of parous females reflects a decrease in the number of newly emerged females which developed an appetite for blood. There was no abrupt drop in the actual number of nulliparous females, however, and consequently no indication that the onset of diapause was sudden.

The collections of *C. tarsalis* made in

the daytime shelter contained decreasing numbers of both parous and nulliparous females, but the parous individuals decreased more rapidly and finally reached 0 percent (Figure 1). Though the drop in parous specimens probably reflects the mortality of the blood-feeding population, it is possible that most of the decrease in nulliparous specimens was due to the movement of this population into those spots, mostly inaccessible or unknown, that are chosen for hibernation.

SCARCITY OF PAROUS FEMALES IN AN OVERWINTERING POPULATION. In the late fall, the tunnels of abandoned gold mines in the canyon east of Jamestown, in Boulder County, Colorado, normally contain numerous female *C. tarsalis* with enlarged fat-bodies. One pool of 50 *C. tarsalis* taken from these mines on December 30, 1953, produced the only isolation of western encephalitis virus ever reported from winter-collected mosquitoes taken outside the state of California (Blackmore and Winn, 1956). In one mine tunnel, normally wet, which is unusually large and therefore cold in winter, *C. tarsalis* has been shown to survive the period of hibernation. Another tunnel, at an elevation of 6,560 feet, normally dry, is smaller and therefore warmer in winter and much easier to examine for mosquitoes. This mine, in which *C. tarsalis* appears not to hibernate successfully, was inspected periodically from August 11 to December 2, 1960. No mosquitoes were observed on August 11, 16, or 25. Two females of *C. tarsalis* were collected in the mine on August 29, 14 on August 31, and a total of less than 100 on three dates in the first three weeks of September. In the period from September 26 to November 29, during which no mosquitoes were removed from the mine, the count rose from 67 to a maximum of 602 on November 21. The last fourth of this increase occurred after the middle of October. On December 2, over 600 females were collected in this mine. Earlier a total of 156 specimens from this and two other mines had all been found to be nulliparous, but in this collection of December 2, 597 specimens

were nulliparous and 2 parous. Since gonotrophic dissociation is not known to occur in the genus *Culex*, it is reasonable to assume that only the 2 parous specimens, unless perhaps autogenous, had taken a normal meal of blood. If no more than 1 in 300 *C. tarsalis* ordinarily feeds on a host before hibernating, it is difficult to understand how this mosquito could serve as the normal winter reservoir of any arthropod-borne encephalitis virus.

SUMMARY. Detinova's technique to determine the proportions of nulliparous and parous females was applied to the study of several different populations of *Culex tarsalis*. Examination of specimens from a dry and a wet area in Weld County, Colorado, gave results in agreement with a hypothesis that in the dry area more of the females were older and therefore more likely to be infected with western and St. Louis encephalitis viruses. In collections of host-seeking *C. tarsalis* taken in CO₂ traps in Weld County at the end of the summer, an increasing proportion of parous females indicated that progressively fewer newly emerged females were developing an appetite for blood. In daytime shelter collections made in the same area during the same period, the proportion of nulliparous females rose

to 100 percent. In fall collections of female *C. tarsalis* from abandoned gold mines in Boulder County, Colorado, 753 specimens were nulliparous and 2 parous. If these parous females fairly represent the proportion that feeds on blood before hibernating, it is unlikely that *C. tarsalis* is the normal winter reservoir of arthropod-borne encephalitis viruses.

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