RELATIONSHIP OF *CULEX TARSALIS* DENSITY TO TRANSMISSION RATES OF WE AND SLE VIRUSES [1]

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INTRODUCTION. The possible relationship of population levels of *Culex tarsalis* (Coq.) to activity rates of western (WE) and St. Louis (SLE) encephalitis viruses has been of considerable interest to investigators for some years. A definite, positive correlation between vector populations and incidence of human disease seems apparent, particularly during epidemic years. During the epidemic in Yakima Valley, Washington, in 1942, vector mosquitoes were abundant as reported by Hammon *et al.* (1945). Observations by Stead and Peters (1953) and Halverson *et al.* (1953) during the 1952 outbreak of encephalitis in California showed that *C. tarsalis* populations were exceedingly high. Ranzenhofer *et al.* (1957) found a dense population of *Culex pipiens* (Linn.) associated with the SLE epidemic in Calvert City, Kentucky, in 1955. Preceding the 1954 SLE outbreak in Hidalgo County, Texas, as stated by Beadle *et al.* (1957), conditions were favorable for high mosquito production prior to occurrence of human cases. From 1950 to 1952, a low incidence of human disease paralleled a low *Culex tarsalis* population in the northern plains (Eklund, 1954). Rempel (1953) noted, however, that the 1937 outbreak of WE in Saskatchewan occurred during severe drought conditions whereas the disease was absent in 1942 when *C. tarsalis* and *Aedes* mosquitoes were unusually abundant.

The purpose of this study was to determine if there is a correlation between *C. tarsalis* population levels and virus transmission rates in enzootic environments.

METHODS AND MATERIALS. The study was performed in Weld County, Colorado, during the summer months of 1956 through 1959 in two established study areas (Pierce and St. Vrain). The Pierce study site is situated in a typical Upper Sonoran short prairie grass environment, with an intermittent stream bed coursing through the center of the area. Light trap mosquito indices in the area have been relatively low for the years that the area has been studied, with very few *C. tarsalis* breeding areas occurring within a mile or more of the sentinel sites. The St. Vrain study area is situated in bottom lands adjacent to the St. Vrain River where there are many seeps and oxbow sloughs suitable for high *C. tarsalis* production. Waste irrigation water from areas of intensive agriculture along the river valley adds considerably to the mosquito breeding potential. During each year since observations were begun in 1954, the St. Vrain station has had a high mosquito index as measured by light traps.

Two to four avian sentinel flocks, composed of forty to fifty birds each, were maintained in standard sheds in each area as a means of measuring transmission rates of WE and SLE viruses. The birds were bled in the fall of each test year and their sera were tested for hemagglutination-inhibition (HAI) antibodies against WE and SLE antigens. Routine virus isolation and neutralizing antibody tests with mosquito pools and bird and mammal sera collected from the study areas gave no evidence that any Group A or Group B viruses other than WE and SLE were present. The HAI test is, therefore, believed to reflect the presence or absence of specific antibodies against these two viruses. During 1956 the virus trans-

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mission rates were obtained from sentinel flocks of adult pigeons *(Columba liva)* and for the following years of the study adult chickens were employed. Results from the two study sites when compared with those from various other sentinels operated in the same general area, adequately reflected year-to-year changes in transmission rates. Differences in excess of 15 percent appeared to be significant at the 5 percent probability level.

Population indices of *C. tarsalis* reported in this paper were obtained from mosquito catches collected in New Jersey type light traps operated in the same site each year. All light traps were operated from four to seven nights per week throughout the virus transmission seasons (May through September). The figures given are the average number of *C. tarsalis* collected per trap night for the entire season. Although light trap collections from different sites generally cannot be compared directly on a quantitative basis, year-to-year comparisons can be made at the same trap site. Observations of mosquito populations by various other means, (dipping, resting stations, bait traps, etc.) indicated that the light traps at Pierce and St. Vrain did usually reflect the major annual changes in mosquito populations at these two stations.

Results: Western Encephalitis. Populations of *C. tarsalis* were consistently

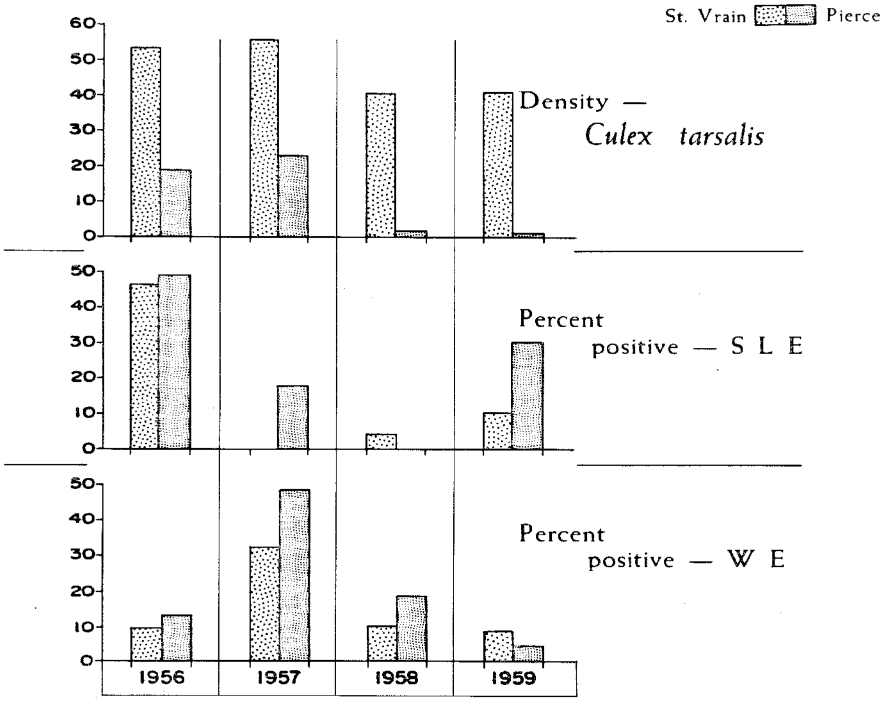

Fig. 1—*Culex tarsalis* population densities (average per light trap night), and SLE and western encephalitis virus transmission rates (percent with hemagglutination-inhibition antibodies) in avian sentinels at Pierce and St. Vrain study areas, Greeley, Colorado, 1956–59.

lower at Pierce. The average catch per trap night ranged from about 35 percent to less than 1 percent of the catch at St. Vrain (Figure 1). In three out of the four years, however, the transmission rates of WE were higher at Pierce by 25 to almost 50 percent. In 1957, *C. tarsalis* populations at both stations were about the same as in 1956, but WE transmission rates were 3 to 4 times higher than in the previous year. In 1958, transmission rates and the numbers of *C. tarsalis* decreased at both stations. In 1959, however, the transmission rate of WE decreased by three-fourths at Pierce as compared with 1958, even though the *C. tarsalis* population remained about the same.

ST. LOUIS ENCEPHALITIS. As with WE, transmission rates of SLE at Pierce ranged from nearly equal to many times higher than at St. Vrain in 3 of the 4 years even though the populations of *C. tarsalis* at Pierce were much lower (Figure 1). In 1957, transmission rates of SLE dropped by 63 and 100 percent as compared with 1956 even though the *C. tarsalis* populations remained about the same at both stations. In 1958, decreased *C. tarsalis* populations were accompanied by a lower transmission rate of SLE at Pierce, but a higher rate at St. Vrain. In 1959, there was a marked increase in SLE transmission at both stations even though mosquito populations were almost identical to those of the previous year.

DISCUSSION. The results show clearly that there was no direct relationship between mosquito populations and encephalitis transmission rates. These findings are in agreement with that of Longshore *et al.* (1960) in California where they were unable to show a direct relationship between mosquito infection rates and population indices of *Culex tarsalis* during non-epidemic years.

Light trap catches did not always vary directly with mosquito blood feeding activity. During the summer of 1956 it was noted that during certain periods in July and August there was a greater abundance of blood seeking mosquitoes at Pierce than at St. Vrain (Blackmore and Dow, 1958). The following years, however, low light trap catches coincided with low biting rates at Pierce.

The few available breeding sites in the intermittent stream at Pierce dried up completely early in the season of 1958 and remained dry from then through the study period of 1959. The few mosquitoes that were in the area during these two years must have moved in from other breeding areas several miles away.

One possible explanation for the lack of correlation between mosquito populations and virus transmission rates is that there are wide variations in the infection rates and infectivity of *C. tarsalis* populations from year to year and place to place. Thus the mosquitoes migrating into the Pierce area during 1958 and 1959 may have been older and have taken more blood meals than those at St. Vrain. Consequently, they would have had more opportunity to become infective. This hypothesis is supported by the fact that 3 out of 31 pools of 10 *C. tarsalis* each collected at Pierce during 1959 were found to contain virus, whereas all of 49 pools of 50 mosquitoes each collected at St. Vrain were negative.

SUMMARY. From 1956 through 1959 observations were made on population densities of mosquitoes and on transmission rates of SLE and WE viruses at two study sites near Greeley, Colorado, which were ecologically different. There was no direct relationship between populations of *Culex tarsalis* mosquitoes and transmission rates of western and St. Louis encephalitis viruses in avian sentinel flocks.

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TOXICITY OF GRANULAR MALATHION TO WALLEYED PIKE FINGERLINGS [1]

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Introduction. Darsie and Corriden (1959) indicated a wide variation in the susceptibility of different fish species to malathion poisoning. The effect of malathion on the walleyed pike, *Stizostedion vitreum* (Mitchill), an important game fish in Wisconsin, has not been previously reported. A laboratory study of malathion toxicity to this species was initiated because of the possible use of malathion for the control of aquatic midges (Diptera; Tendipedidae).

Materials and Methods. Batteries of five slate-bottomed aquaria, 10 x 20 x 16 inches, were placed in large water baths at 14.5° C. A 2½-inch layer of mud from Lake Winnebago, Wisconsin, was placed in the bottom of each aquarium, and Madison city water was circulated through the aquaria until 12 inches of clear water remained above the mud. The water was oxygenated by bubbling compressed air through a porous stone just above the surface of the mud.

Two tests were undertaken, each employing a completely random design, with five different treatments and four replicates of each treatment. Commercially prepared 10 percent, 30/60 mesh, AA-RVM malathion granules were used in both tests. In the first test, treatments with granular malathion at 50.0, 20.0, 10.0, and 5.0 pounds actual per acre were compared with a control. Twenty-five walleyed pike fingerlings, 4 to 6 inches long, were placed in each aquarium after the introduction of the insecticide. The number of healthy fish surviving after 24 hours was tabulated. In the second test, application rates of 2.0, 1.0, 0.5, and 0.2 pounds per acre were compared with a control. The procedure used was the same as in the first test, except 16 fish were used in each replicate.

Results and Discussion. The results are recorded as percentages, and an angular transformation (arc sin $(\%)^{1/2}$) of the data was made prior to statistical analysis

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