TEN YEARS OF SURVEILLANCE FOR WESTERN EQUINE ENCEPHALITIS IN UTAH[1]

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In March of 1964 we reported at the American Mosquito Control Association meeting in Chicago on the results of five years of surveillance for western equine encephalitis in Utah. This paper covers the 10-year period that this program has been in operation.

During 1958, Northern Utah experienced a serious outbreak of western equine encephalitis in man and horses (Jenkins and Donath, 1959), which caught health authorities and mosquito abatement districts by surprise. As a result of this experience, a strong need was felt for a surveillance program that would predict, or at least determine at an early date, possible future outbreaks of the disease. California experienced a similar outbreak of WEE in 1952 (Longshore, 1953) and subsequently developed a surveillance program under the auspices of the Bureau of Vector Control of the State Department of Health, working in cooperation with mosquito abatement districts (Anonymous, 1956; Loomis, 1959).

A superficial appraisal of the surveillance program in California quickly convinced concerned people in Utah that a similar program was not possible in Utah because funds and personnel were not available in the health department or any other branch of state government to coordinate a statewide program. The Salt Lake City and South Salt Lake County Mosquito Abatement Districts assumed the responsibility of developing and maintaining a coordinated surveillance program for northern Utah since no other agencies appeared to be willing or able to do so. The Utah State Department of Health maintains records of human cases reported to them by physicians and has a laboratory for confirmation of suspected cases. The State Veterinarian, working under the Department of Agriculture, keeps records of the number of cases in horses reported by veterinarians. These reports are probably incomplete. Both agencies have been helpful and cooperative with the mosquito abatement districts in every possible way. The Arboviral Disease Section, Ecological Investigations Program, CDC, U. S. Public Health Service in Fort Collins, Colorado, maintains sentinel flocks of chickens in Salt Lake County to obtain information on transmission rates of WEE and St. Louis encephalitis and reports this information to the mosquito abatement districts.

These procedures of the United States Public Health Service, the Utah State Department of Health, and the Utah State Department of Agriculture record what has happened in regard to transmission rates and human and horse cases. The mosquito abatement districts have been primarily concerned with the development of techniques to predict transmission and approximate numbers of human and horse cases of WEE well in advance of their actual occurrence. These techniques are based on the assumption that a direct relationship exists between changes in populations of the vector, *Culex tarsalis* Coquillett, and changes in the transmission rates of WEE. We are not of the opinion that the relationship is this simple but this is the best operating assumption that can be made at the present level of knowledge of this mosquito-borne disease. Both Hess and Hayes (1967) and Reeves (1968) have demonstrated a direct relationship between

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vector populations and disease transmission.

The first step in developing a surveillance program was to determine the factors responsible for the outbreak in Utah in 1958. Several analyses have been made of the unusual weather factors which may have contributed (Graham and Anderson, 1958; Rees and Collett, 1959; Rees *et al.*, 1959; Graham *et al.*, 1960). There is still no certain answer to the question of what weather factors create conditions favorable to transmission of WEE, but at present the best information indicates that above normal precipitation early in the year either as snow pack in the mountains or above normal precipitation in May or June followed by a long, hot, dry period of 40 to 50 days in late June, July and August are contributing factors. Loomis (1953) indicated a relationship between the 1952 outbreak of encephalitis in California and the snowpack in the Sierras.

Hess and Hayes (*op. cit.*) predicted an outbreak of WEE in Colorado in 1965 using weather factors, *C. tarsalis* populations, infection in *C. tarsalis* and infection in chicken sentinel flocks. Surveillance in Utah does not include all of these factors because we do not have the facilities to use all of these techniques but we do recognize their importance and are trying to build them into our program. Weather factors for the Colorado outbreak in 1965 differed from those in Utah in 1958 in that wet, cool weather persisted in Colorado into July while in Utah the weather became hot and dry beginning early in May. This hot dry period appears to be essential in Utah.

Reeves (*op. cit.*) correlated *C. tarsalis* populations with the threat of both WEE

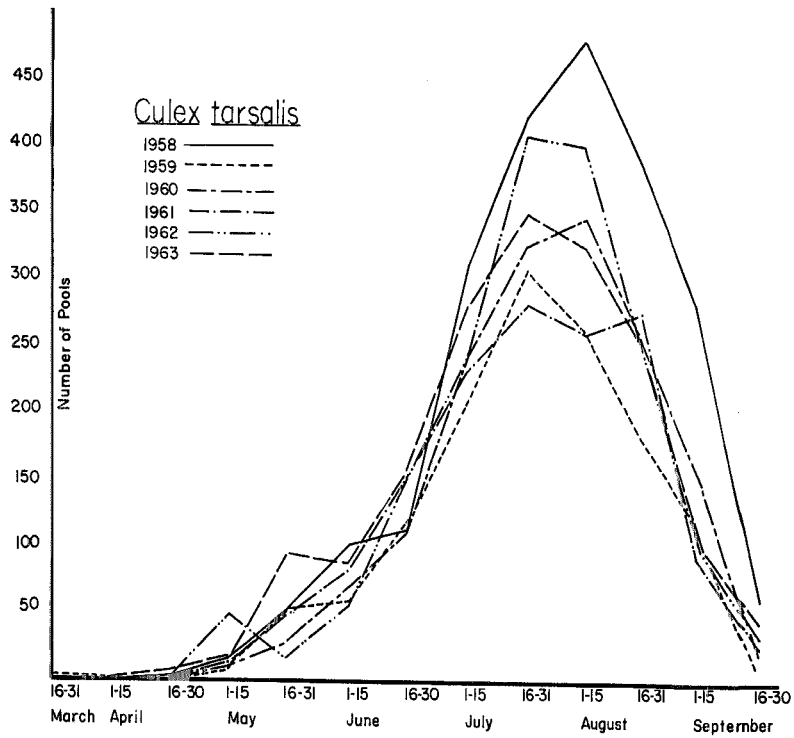

FIG. 1.—A comparison of the total number of pools with *Culex tarsalis* larvae in South Salt Lake County Mosquito Abatement District in 1958 and the following five years.

and St. Louis encephalitis in California. Since changes in populations of the vector, *C. tarsalis,* probably have a direct influence on changes in the incidence of the disease, population levels of *C. tarsalis* are used in the Utah surveillance program. The outbreak of WEE in Utah was accompanied by a large increase in *C. tarsalis* populations (Rees *et al., op. cit.*). A direct relationship between population levels of the vector and the transmission of the WEE virus is difficult to demonstrate in Utah since vector populations were probably higher in the years before control operations began, including many years without significant numbers of cases of the disease, than in 1958 in areas included in mosquito abatement districts. Loomis (*op. cit.*) reported above-normal populations of *C. tarsalis* associated with the 1952 outbreak of encephalitis in California.

Larval survey data, biting counts, and light trap collections are presently used to obtain information on mosquito populations in Utah. Larval survey data should give earlier indications of unusual mosquito populations than biting counts or light trap collections, not only because larvae appear before adults, but also because control operations apparently delay increases in adult populations.

The larval survey techniques used in Utah have been described elsewhere (Graham, 1959), but mention should be made here that all pools with larvae are recorded in the survey and the number of pools is used as an index. Several years of experience, careful study, and the application of statistical techniques were necessary to develop adequately standardized procedures. Both larval survey procedures and light trap collections were in effect before, during, and since the 1958 outbreak.

The number of pools with larvae of *C. tarsalis* in 1958 was greater than in other years in the South Salt Lake County Mosquito Abatement District. Graham and

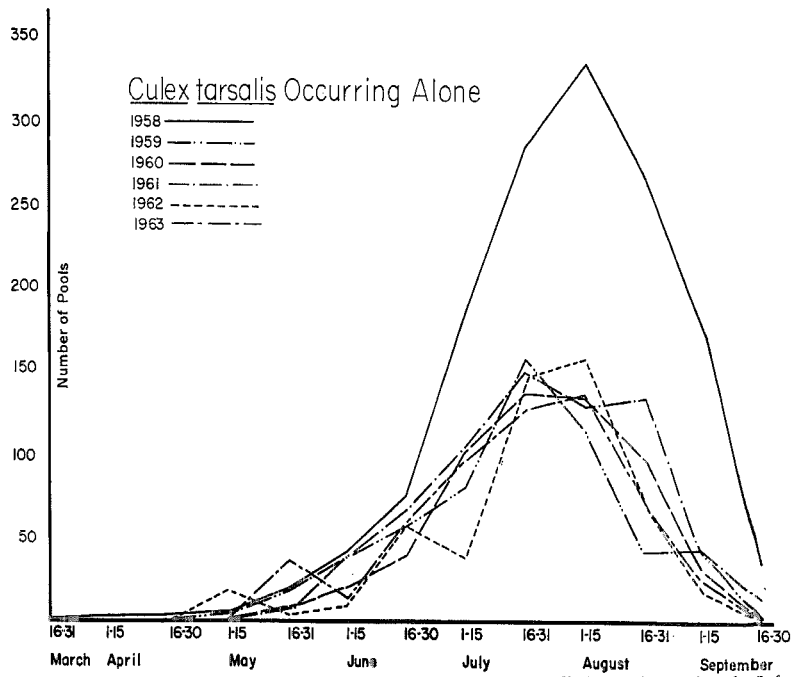

FIG. 2.—A comparison of the number of pools with only *Culex tarsalis* larvae in South Salt Lake County Mosquito Abatement District in 1958 and the following five years.

Bradley (1962) reported on the importance of larvae of mosquito species being able to occupy larval habitats without other mosquito species being present. When the pools with only *C. tarsalis* larvae are compared for several years, the increase in 1958 is more pronounced. Fig. 1 compares total number of pools with *C. tarsalis* larvae from 1958 through 1963. Fig. 2 compares pools with only *C. tarsalis* larvae for the same period. Fig. 3 compares pools with only *C. tarsalis* larvae for 1958 and for the years 1964 through 1968.

New Jersey light trap locations have been stabilized for many years in the Salt Lake City Mosquito Abatement District and data from these traps are used for the surveillance program. Light trap locations in the South Salt Lake County Mosquito Abatement District were not stabilized in time to obtain long term comparative data. The number of *C. tarsalis* females taken in light traps is compared each year with 1958. Fig. 4 compares light trap collections of female *C. tarsalis* for 1958 with the 10-year average since then.

There are some indications that increases in mosquito populations in Utah may occur over a period of two or more years. This is not definitely demonstrated, but is considered in the surveillance program as a possible factor.

This program has been in operation since 1959 and so far has indicated accurately each year that outbreaks of WEE would not occur. More testing and improvement is desirable and probably necessary but the surveillance program, while not yet adequately tested, represents the best techniques that can be applied at this time in Utah. The prediction of an outbreak of WEE would more definitely demonstrate the value of the surveillance program but no outbreak has occured while the program has been in operation.

Plans have been made to act on the

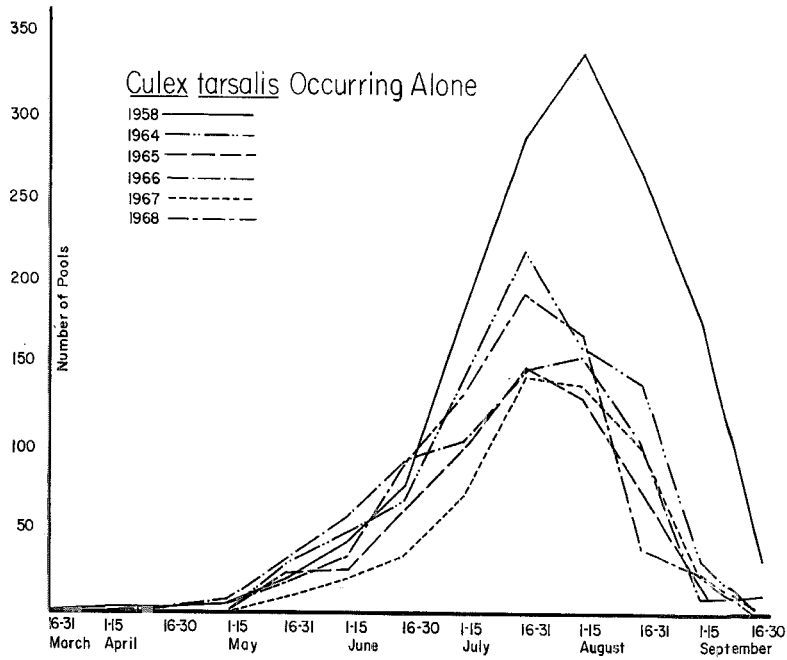

FIG. 3.—A comparison of the number of pools with only *Culex tarsalis* larvae in South Salt Lake County Mosquito Abatement District in 1958 and the five year period from 1964 through 1968 inclusive.

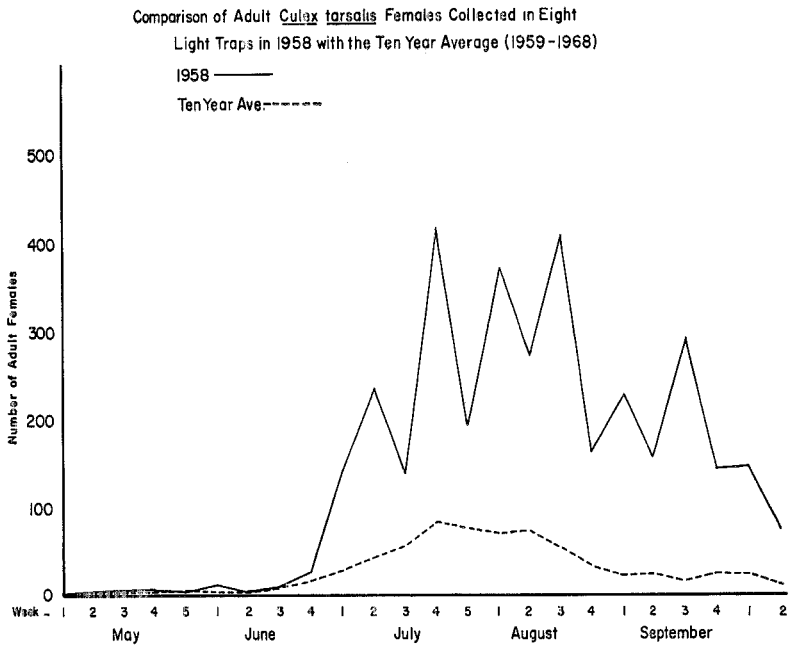

FIG. 4.

basis of the factors mentioned for the surveillance program. When early weather conditions indicate the possibility of an outbreak, health authorities will be notified and mosquito abatement districts alerted. If this is followed by above normal larval population increases in *C. tarsalis,* control operations will be intensified and concentrated on this species. If this is followed by light trap catches and biting counts that further indicate a large increase in population of the vector, control efforts will be further intensified and possibly other mosquito species will be ignored if necessary to bring as much effort as possible against this species.

SUMMARY AND CONCLUSIONS. After the western equine encephalitis outbreak in Utah in 1958, the Salt Lake City and South Salt Lake County Mosquito Abatement Districts developed a coordinated surveillance program for the disease using information from the State Health Department, the State Agriculture Department, United States Public Health Service, the United States Weather Bureau, and their own records of mosquito populations. The factors evaluated to predict outbreaks of WEE are weather conditions and larval and adult populations of *C. tarsalis.* The surveillance program has not yet been completely tested, but is the best possible with present knowledge and conditions. Predictions of outbreaks would support the value of the surveillance program but no outbreak of WEE has occurred in Utah since 1958. Many years of testing will be necessary for complete confidence in the surveillance procedures. To date, the program has indicated accurately for 10 years that outbreaks would not occur. In the event that surveillance indicated the probability of an encephalitis outbreak, control efforts against *C. tarsalis* would be intensified.

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ESTERASE ACTIVITY IN ORGANOPHOSPHORUS-TOLERANT STRAINS OF *AEDES AEGYPTI*

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Larval selection in the laboratory has indicated that strains of *A. aegypti* from Africa, Asia and the Caribbean area do not develop any more than a moderate tolerance to OP compounds such as malathion and parathion. Moreover, strains selected with either of these compounds did not show any increased production of phosphatase or carboxyesterase detoxication products, but only a decreased uptake which was significant in the case of malathion (Matsumura and Brown, 1961; *Ibid.*, 1963). Arylesterase activity had been demonstrated by Plapp *et al.* (1965) in *Aedes aegypti* as in *Culex* and *Anopheles* larvae, particularly on the substrate tributyrin, but the malathion-selected Penang strain showed less paraoxon-insensitive arylesterase activity than the susceptible Orlando strain. Moreover it showed an increased aliesterase activity on phenyl acetate and no less than the normal on methyl butyrate.

Therefore it seemed necessary to assess the aliesterase and arylesterase activities of the malathion- and parathion-selected strains of African, Asian and Caribbean origin in our laboratory. This was performed by means of agar-gel electrophoresis of the esterases, supplemented by an enzyme assay performed on the malathion-selected African strain by the same