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THE STATUS OF *AEDES SOLLICITANS* AS AN EPIDEMIC VECTOR OF EASTERN EQUINE ENCEPHALITIS IN NEW JERSEY[1]

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ABSTRACT. The status of *Aedes sollicitans* (Walker) as an epidemic vector of eastern equine encephalitis in New Jersey is examined from available literature. Data indicate that *Ae. sollicitans* has met the basic criteria necessary to prove vector involvement. Virus has been isolated from specimens during outbreaks of the disease in humans and tests have shown that *Ae. sollicitans* can become infected and transmit the virus under experimental conditions. The blood-feeding habits of the mosquito and geographic distribution of human cases clearly reveal that *Ae. sollicitans* is associated with human outbreaks. Data show that *Ae. sollicitans* must be considered as an epidemic vector of EEE in New Jersey and should be controlled for the prevention of this disease during the season when EEE virus is active.

INTRODUCTION. The salt-marsh mosquito, *Aedes sollicitans* (Walker), was incriminated as an epidemic vector of eastern equine encephalitis in New Jersey in 1959 when 32 humans contracted the disease in coastal areas of the southern portion of the State (Hayes et al. 1962). Kandle (1960) was the first to state that *Ae. sollicitans* must be considered as one of the vectors responsible for transmission, and epidemiological data collected during the outbreak led Hayes et al. (1962) to hypothesize that *Ae. sollicitans* served as the primary epidemic vector in the coastal area where most of the human cases occurred. Considerable epidemiological evidence has been gathered since that

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time (Kandle 1962, 1963 and 1964, Goldfield et al. 1965 and 1966 and Altman et al. 1967), but these data have never been completely summarized.

Since 1959, eastern equine encephalitis virus has been transmitted to New Jersey residents in 4 different years, and equine cases have regularly resulted in official alerts. Mosquito control agencies in the state have responded by reducing *Ae. sollicitans* populations to reduce the risk of transmission to humans. In recent years, environmentally oriented groups have questioned mosquito control and have asked mosquito control commissions to justify their actions with documentation regarding the true vector status of *Ae. sollicitans*. Since emergency treatment involves the spending of public monies, documentation is certainly justified.

This paper will examine the status of *Ae. sollicitans* as a vector of EEE from available literature.

BASIC CRITERIA FOR PROVING A VECTOR. Transmission of a dangerous pathogen cannot be proven with human subjects. As a result, arbovirus epidemiologists usually use basic criteria to show that an arthropod is an efficient vector for a given virus (Sudia et al. 1969, 1975). The basic criteria include:

1. Isolation of the disease-producing agent from the suspect arthropod during an epidemic or an epizootic.
2. Demonstration of the suspect arthropod's ability to become experimentally infected by feeding upon a viremic host.
3. Demonstration of the suspect arthropod's ability to transmit the virus by bite.
4. Field evidence confirming association of the suspect arthropod with a vertebrate population in which the infection is occurring.

Each step is a logical progression which is used to separate speculation from fact. Satisfaction of any one criterion is only considered as evidence of possible vector involvement. Satisfaction of all the criteria establishes the arthropod as a vector on epidemiological grounds. These criteria were used to establish *Culex tarsalis* as a vector of western equine encephalitis in California (Reeves et al. 1962) and again to establish *Culex nigripalpus* as a vector of St. Louis encephalitis in Florida (Chamberlain et al. 1964, Sudia and Chamberlain 1964). Each of these critera will be examined separately for *Ae. sollicitans* and EEE virus in New Jersey.

ISOLATION OF EEE FROM WILD-CAUGHT *Ae. sollicitans*. EEE virus has been isolated from *Ae. sollicitans* during human outbreaks of the disease in New Jersey. The initial isolation made during the 1959 outbreak was speculative since virus was detected in a pool of *Aedes* mosquitoes which were "mostly" *Ae. sollicitans* (Kandle 1960, Goldfield et al. 1966). When EEE next appeared in 1965, however, Goldfield et al. (1966) reported 2 isolations from *Ae. sollicitans* from collections taken less than 5 miles from the residence of the single human case. In 1967, 7 isolations were obtained from *Ae. sollicitans* when 1 human case and 32 equine cases were reported (Goldfield et al. 1968). Twelve human cases and 126 equine cases of EEE were detected in New Jersey during 1968 (Goldfield et al. 1969), and virus was again isolated from *Ae. sollicitans* (Goldfield and Sussman 1970).

In a 10-year summary of continuous EEE investigations, Goldfield and Sussman (1970) reported that EEE virus was isolated from *Ae. sollicitans* in the 4 years when human cases were recognized in New Jersey and in none of the other years during the decade. These efforts by the New Jersey State Department of Health clearly show that EEE virus does occur in natural populations of *Ae. sollicitans*.

EXPERIMENTAL INFECTION OF *Ae. sollicitans* WITH EEE VIRUS. The susceptibility of *Ae. sollicitans* to EEE virus was established before human cases of EEE were recognized in New Jersey. Studies by Chamberlain et al. (1954) showed that *Ae. sollicitans* had a 100% infection rate when fed upon viremic chicks in the laboratory and was listed as the most susceptible mosquito in the test series. Attempts to establish the level of virus necessary to infect the mosquitoes revealed that less than 4.6 logs of virus resulted in the infection of 80% of the specimens which were fed upon a viremic pigeon. The results of these studies led Schaeffer and Arnold (1954) to rank *Ae. sollicitans* as the most susceptible mosquito vector known for EEE with an estimated infection threshold of 2.0–3.0 logs of virus.

Successful laboratory infection of *Ae. sollicitans* has not been restricted to avian studies. Sudia et al. (1956) were able to infect from 14 to 41% of the *Ae. sollicitans* which they fed on an experimentally infected horse. Since horses are normally considered to be dead-end hosts for this virus, these data provide further evidence of the high potential of *Ae. sollicitans* as a vector of EEE.

EXPERIMENTAL TRANSMISSION OF EEE VIRUS BY *Ae. sollicitans*. EEE virus has also been transmitted to susceptible animals by the bite of *Ae. sollicitans*. Chamberlain et al. (1954) showed that 75% of the *Ae. sollicitans* tested were able to transmit EEE to susceptible chicks, and they rated this species as "excellent" in vector potential for EEE.

The most significant transmission studies with *Ae. sollicitans* were conducted by Sudia et al. (1956). They successfully transmitted EEE from horse to horse as well as from horse to chick and showed evidence of virus multiplication in the mosquito after the transmission attempts.

ASSOCIATION OF *Ae. sollicitans* WITH HUMANS WHO HAVE CONTRACTED EEE. *Ae. sollicitans* is well known to feed upon humans, for the nuisance inflicted by the salt marsh mosquito is legendary. The coastal areas of southern New Jersey were once thought to be uninhabitable because of *Ae. sollicitans* (Smith 1904) and the persistence of this troublesome biter is well documented by Headlee (1945). Serological determinations of blood-meals from wild-caught specimens in southern New Jersey confirmed that the species feeds primarily on mammals including man but results also showed that nearly 10% of the specimens had fed upon birds, the epizootic reservoirs of EEE (Crans 1964, 1965).

The geographic distribution of human cases of EEE in New Jersey has occurred well within the flight range of *Ae. sollicitans*. In 1959, the 32 human cases occurred in a zone sharply limited to the coastline (Kandle 1960, Hayes et al. 1962, Goldfield and Sussman 1968). All the persons involved had either resided in or visited the southern counties of the State prior to the onset of disease (Goldfield and Sussman 1968). Data presented by Hayes et al. (1962) revealed that *Ae. sollicitans* was the predominant mosquito in the area during the outbreak.

Since 1959, human cases of EEE have also occurred in areas where *Ae. sollicitans* is the dominant species. The single human case of EEE in 1965 occurred in a resident of coastal Cape May County (Goldfield et al. 1966) and the single case in 1967 occurred within 1–2 miles of an *Ae. sollicitans* collection station (Goldfield et al. 1968). The 12 human cases of EEE in 1968 were distributed in the 6 southern counties of New Jersey, and Goldfield et al. (1969) reported that all but one had been exposed within 10 mi. of the salt marsh-fresh water swamp boundary considered to be the major focus of infection (Chamberlain 1958, Altman et al. 1967, Goldfield and Sussman 1968).

CONCLUSIONS. Examination of available literature shows that *Ae. sollicitans* has fulfilled each of the basic criteria necessary to prove vector status for EEE in New Jersey. Virus has been isolated from *Ae. sollicitans* during human outbreaks, and tests have shown that the species can become infected and transmit the virus under experimental conditions. The blood-feeding habits of the mosquito and geographic distribution of human cases clearly reveal association with humans during outbreaks.

In view of these findings by a series of separate scientists over nearly 2 decades, sufficient data have been accumulated to show that *Ae. sollicitans* is an epidemic vector of EEE in New Jersey and should be controlled for the prevention of this disease during the season when EEE virus is active. Other mosquito vectors are undoubtedly involved in the cycle, but *Ae. sollicitans* remains a major factor in the transmission to humans.

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BOOK REVIEW

HANDBOOK OF GENETICS, VOLUME 3, INVERTEBRATES OF GENETIC INTEREST. Editor: Robert C. King. Published: Plenum Press, New York, 1975, 826 pp.

This book is part of the five-volume "Handbook of Genetics" edited by Robert C. King. It is composed of thirty-two chapters, and except for Chapter 1 which is a review of Mollusca, this volume is a collection of brief, concise discussions that describe the reproductive biology and genetics of insect species that are commonly favorites of geneticists.

One-half of the chapters deal with the genetics of *Drosophila* sp., which is expected in view of the vast body of information available from studies of *Drosophila melanogaster* and other *Drosophila* sp. The other fifteen chapters cover a variety of insects including a hemimetabolous insect (*Blattela germanica*), two Lepidopterans (*Bombyx mori* and *Ephestia kuhniella*), two Coleopterans (*Tribolium castaneum* and *T. confusum*), Hymenopterans (*Apis mellifera*, *Habrobracon* sp. and *Mormoniella* sp.) and several Dipteran species. Of the Dipterans many (*Rhynchosciara*, *Sciara*, *Chironomus*, and *Glyptotendipes*) are of interest because of the excellent quality and quantity of work that has been accomplished with their polytene chromosomes. The remainder of the Dipteran species, which include mosquitoes, house flies, and sheep blow flies, are of medical and veterinary importance; indeed, most of the genetics work with these species has been oriented toward the solution of insect control problems.

Except for the chapters on *Drosophila* sp., each chapter begins with a description of the subject species, its taxonomic classification, reproductive biology, and culturing procedures in the laboratory. This is very helpful to the reader by eliminating problems with terminology that so often are confusing to readers who work with diverse organisms.

The reviews are brief, but this does not detract from the usefulness of the contents. Longer and more elaborate discussions of the subject matter would add more bulk to the book but would not add substantially to the purpose of the review. In those areas where I am knowledgeable the references cited are nearly complete; therefore, for a reference work this book is an excellent source of information.

For those whose primary interest is mosquito research, there are three chapters (numbers 12–14) on this subject. These chapters are excellent in the presentation of genetic and cytogenetic information on anophelines, *Aedes*, and *Culex* mosquitoes.

For anyone involved in biological research or teaching, this book is recommended as a valuable reference work for published papers that appeared prior to 1975.—Jack A. Seawright, Agricultural Research Service, USDA, Insects Affecting Man Research Laboratory, P. O. Box 14565, Gainesville, Florida 32604