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33. Kashin P. 1969. The role of gamma-aminobutyric acid in mosquito-host interactions: a hypothesis. *Ann. Entomol. Soc. Am.* 62:695-702.

34. Burgess, L. 1959. Probing behavior of *Aedes aegypti* (L.) in response to heat and moisture. *Nature* 184: 1968-69.

35. Kellogg, F.E. 1970. Water vapor and carbon dioxide receptors in *Aedes aegypti* (L.). *J. Insect Physiol.* 16:99-108.

36. McIver, S.B. 1981. A model for the mechanism of action of the repellent DEET on *Aedes aegypti* (Diptera:culicidae). *J. Med. Entomol.* 18:357-61.

Mosquitoes as Vectors of Disease in Minnesota

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ABSTRACT — Diseases due to mosquito-borne viruses occur every summer in Minnesota. The incidence of Western encephalitis and LaCrosse encephalitis is usually low, but outbreaks of Western encephalitis have occurred in the past. Evidence of Jamestown Canyon virus activity has been found in Minnesota. This virus may represent a newly-recognized cause of central nervous system disease and encephalitis. The epidemiology of the mosquito-borne encephalitis viruses found in Minnesota and the methods of disease surveillance and control are discussed.

Introduction

Mosquito vector-borne diseases in Minnesota are principally arboviral encephalitis (arthropod-transmitted encephalitis). The public health importance of arboviruses has been recognized since the severe Western encephalitis epidemic during the summer of 1941 when 791 human cases were diagnosed (1).

Arbovirus activity in Minnesota is an annual problem, usually of low reported incidence involving LaCrosse (LAC) virus and Western encephalitis (WE) virus. During periods of favorable meterologic conditions (heavy rainfall), WE virus activity may become greatly amplified and result in outbreaks of human and equine disease (2). In addition, Jamestown Canyon (JC) virus is present in Minnesota and other midwestern states and may represent a newly-recognized cause of encephalitis (3).

Over the past seven years, the Minnesota Department of Health and the Metropolitan Mosquito Control District have used the Minnesota Arboviral Surveillance Committee (MASC) to maintain a coordinated approach to the problems of arbovirus surveillance and control (2).

LaCrosse (LAC) Encephalitis

California encephalitis virus was first isolated in 1943 in Kern County, California (4) and was believed to be a rare cause of disease. In 1964, the LaCrosse strain was isolated from brain tissue of a young child who had died of encephalitis in 1960 (5). Since that time LAC virus has been determined to be the cause of widespread endemic encephalitis during the summer and fall.

LAC virus activity is found in the hardwood forest areas of east central and southeastern Minnesota where the vector *Aedes triseriatus* develops in basal tree holes, old tires, and other artifical containers (6) (Figure 1).

The natural hosts for LAC virus are small woodland animals such as squirrels and chipmunks (7). Humans are incidental, dead-end hosts, becoming infected when they intrude upon areas where the LAC virus is endemic (6).

LAC virus is transmitted transovarially (vertically) from the female to her eggs (8) and venereally during mating from transovarially-infected males to females (9). LAC virus is maintained and amplified through the mosquito/small mammal life cycle (Figure 2).

An average of ten cases of LAC are reported annually in Minnesota (Figure 3). Disease manifests itself in a broad range of signs and symptoms, from inapparent infection or a mild febrile headache to severe central nervous system disease with sequelae and, rarely, death. The most frequently reported symptoms are fever, lethargy, vomiting, and headache (10).

The highest attack rate for disease occurs in children under ten years old. In a series of 75 cases reported in Minnesota and Wisconsin during 1978, the age ranged from 15 days to 32 years (median 6 years); 80% of the victims were less than 10 years old, 94% were less than 15, and only 6% were more than 15 years old.

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Figure 1. Geographic distribution in Minnesota of the viruses that cause Western encephalitis and LaCrosse encephalitis.

The period of greatest incidence of LAC is late summer and early fall (specifically, the last two weeks in August and the first two weeks in September) although cases are reported as early as June and as late as the first hard frost in the fall.

Because LAC occurs in localized foci and may be maintained through several seasons, control efforts must be aimed at elimination of breeding sites in areas where human cases have occurred (11).

Western (WE) Encephalitis

WE virus was isolated in 1930 from horses with encephalitis and later from mosquitoes. In Minnesota, WE virus activity occurs in northwestern and west central Minnesota in the alkalai prairies that stretch south into the Twin Cities Metropolitan area (2) (Figure 1).

Like other arboviral diseases, WE affects the central nervous system. Among infants, high fever and convulsions are the most common symptoms; in older children and adults, acute onset of headache, fever, vomiting, and drowsiness are early symptoms. Deterioration of mental status within three to four days occurs among many patients. Sequelae consist of seizures, paralysis, mental retardation, and behavior problems. The case-fatality rate is approximately 3%. The most severe symptoms are noted among infants and the elderly (10).

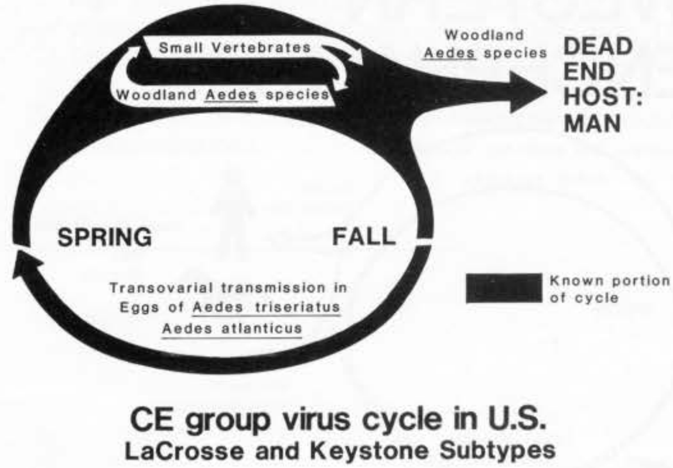

Figure 2. California encephalitis virus life cycle (LaCrosse and Keystone subtypes).

Culex tarsalis is the principal vector of WE. WE is maintained and amplified in a bird/mosquito life cycle (Figure 4) with humans and horses being dead-end hosts. Wild birds (principally house sparrows, *Passer domesticus*) develop sufficient viremia in high enough titers to infect the mosquitoes which feed on them, thus amplifying WE infection in the life cycle (12).

WE has a complex and, in several areas, incompletely-described natural history involving enzootic transmission cycles in nature and endemic and epidemic cycles of transmission to humans and horses. The most perplexing aspect of the natural history of WE is the mechanism by which WE overwinters. Careful studies of all types of arthropod vectors and wild vertebrate hosts have failed to demonstrate more than hypothetical mechanisms to account for the virus' overwintering ability (13).

During years of normal to little rainfall, *C. tarsalis* represent less than 1% of all mosquitoes, and disease in humans and horses tends to occur only in endemic foci. During years of heavy rainfalls, the normally *Aedes*-producing depressions

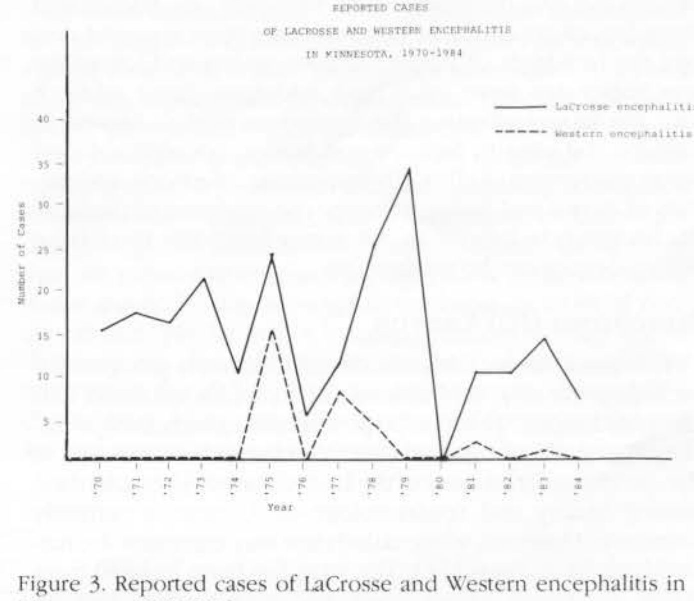

Figure 3. Reported cases of LaCrosse and Western encephalitis in Minnesota, 1970-1984.

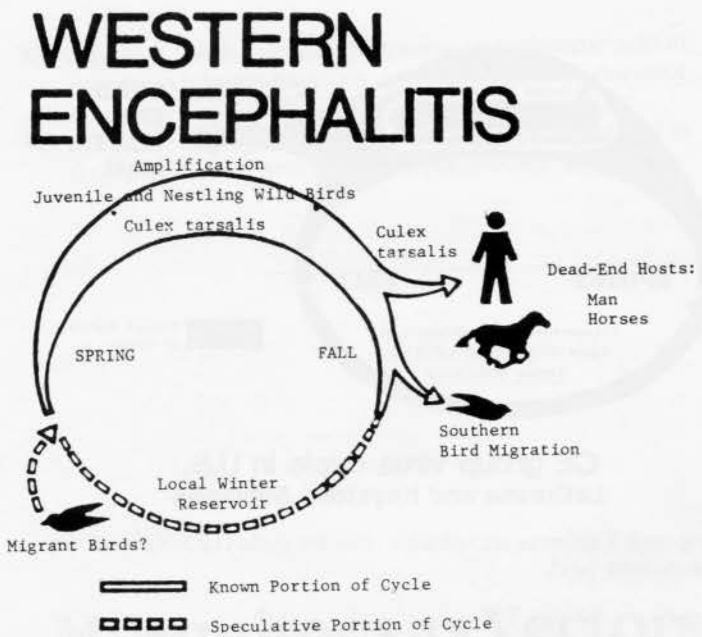

Figure 4. Western encephalitis virus life cycle.

become saturated, retain water, and become a favorable habitat for *C. tarsalis.* During these years, *C. tarsalis* populations can represent up to 10-11 percent of all mosquitoes (2).

The years 1941, 1975, 1977, and 1983 were years of frequent heavy rainstorms. During 1983, as a result of favorable climatic conditions, large populations of *C. tarsalis* developed over a 40-county area in central, west central, and northwestern Minnesota. In addition, evidence of WE transmission was documented among chicken and turkey flocks used as sentinel indicators and the virus was isolated from pools of *C. tarsalis* collected in the region. On the advice of the Centers for Disease Control, other national experts, and the MASC, a large-scale adulticiding program was undertaken to reduce the risk of WE infection among humans.

Several important questions arose following the 1983 program to control WE, but most notable from the public health perspective was the question of why only one human and three laboratory-confirmed equine cases were reported despite the hundreds of suspected case reports and laboratory specimens that were submitted. Additional basic research into the factors affecting the competence of *C. tarsalis* to transmit the virus to humans and horses, population-based serologic surveys of clinically inapparent infections, and studies of strains and factors affecting the virulence of the virus are necessary before any truly accurate predictive models for WE epidemics can be established.

Jamestown (JC) Canyon

There are seven subtypes of the California group virus, including the original California encephalitis virus and LAC discussed earlier. The JC subtype is receiving increasing attention as a newly recognized cause of arboviral encephalitis in the decidious forest areas of the United States (3). Much of the natural history and epidemiology of JC virus is currently unknown. However, white-tailed deer may represent the natural host for JC virus (14). The virus has been isolated from *Aedes triseriatus.* Other hosts and vectors may also be involved. Among humans, there is limited serologic evidence currently available regarding infections with JC virus; however, there is data from recent work in Wisconsin which suggests that JC virus may be responsible for a portion of summer viral infections and encephalitis cases in which no etiologic agent is identified (15).

Minnesota Arbovirus Surveillance Committee (MASC)

In November 1977, the MASC was formed in order to provide a coordinated approach to ongoing arbovirus surveillance and to advise the Minnesota Department of Health and the Metropolitan Mosquito Control District on matters of public health and safety (2). The MASC is composed of representatives from the departments of Entomology and Veterinary Medicine, University of Minnesota; the Livestock Sanitary Board; the Minnesota state departments of Agriculture and Health; and the Metropolitan Mosquito Control District. During potential public health emergencies additional representatives from agencies such as the United States Weather Service, the Minnesota Division of Emergency Services, and the National Guard are added.

In 1983, the MASC performed its most exemplary services in coordinating and advising the WE control program.

References

1. Eklund, C.M. 1946. Human encephalitis of the Western Equine type in Minnesota in 1941: clinical and epidemiological study of serologically positive cases. *Am. J. Hyg.* 43: 171-93.
2. Sjogren, R., and Washburn J. 1979. *Arbovirus surveillance and control in Minnesota.* Proceedings and paper of the 47th Annual Conference of the California Mosquito and Vector Control Association, Inc., p. 17.
3. Thompson, W.H. 1984. Studies of *Aedes triseriatus,* the LaCrosse Virus carrier. *Wisconsin Academy Review* 31(1): 64-66.
4. Hammon, W.M., and Reeves, W.C. 1952. California encephalitis virus: a newly-described agent. I. Evidence of natural infection in man and other animals. *Calif. Med.* 77: 303-9.
5. Thompson, W.H., Kalfayan, B., and Anslow, R.O. 1965. Isolation of California group virus from a fatal human illness. *Am. J. Epidem.* 81: 245-53.
6. Balfour, H.H., Edelman C.K., et al. 1976. California arbovirus (LaCrosse) infections. III. Epidemiology of California encephalitis in Minnesota. *J. Infect. Dis.* 133: 293-301.
7. Monath, T.P.C., Nuckolls, J.G., Berall, J., Bauer, H., Chapell, W.A., and Coleman, P.H. 1970. Studies on California encephalitis in Minnesota. *Am. J. Epidem.* 92(1): 40-50.
8. Miller, B.R., DeFoliart, G.R., and Yuill, T.M. 1977. Vertical transmission of LaCrosse virus (California encephalitis group): transovarial and filial infection rates in *Aedes triseriatus. J. Med. Entomol.* 14(4): 437-40.
9. Thompson W.H., and Beatty, B.J. 1978. Venereal transmission of LaCrosse virus from male to female *Aedes triseriatus. Am. J. Trop. Med. Hyg.* 27(1): 187-96.
10. *Harrison's Principles of Internal Medicine.* 1983. Tenth Edition. McGraw-Hill. 1983.
11. Hedberg, C.W., Washburn, J.W., and Sjogren, R. 1985. The association of artificial containers and LaCrosse encephalitis cases in Minnesota. *J. Am. Mosq. Control Assoc.* 1(1):89-90.

12. U.S. Department of Health, Education, and Welfare, Public Health Service. 1976. *Epidemiology and control of vectorborne diseases.* Publication No. (CDC) 76-8245, Atlanta, GA.
13. Hess, A.D., and Hayes, R.O. 1967. Seasonal dynamics of Western encephalitis virus. *Am. J. Med. Sci.* 253(3): 333-48.
14. Issel, C.J., Trainer, D.O., and Thompson, W.H. 1972. Serologic evidence of infections of white-tailed deer in Wisconsin with three California group arboviruses (La Crosse, Trivittatus and Jamestown Canyon). *Am. J. Trop. Med. Hyg.* 21(6): 985-88.
15. Thompson, W.H. University of Wisconsin (personal communication).

Physical, Chemical, and Biological Controls: Modern and Future Approaches to Mosquito Control *

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ABSTRACT — Effective mosquito management depends on a blending of many techniques. The primary technologies available are physical, chemical, and biological; and their continued improved usage is demanded. Chemicals are more contemporary. Modern organic insecticides were first used in 1943 with the advent of DDT usage. The judicious use of pesticides remains imperative in control methodology. However, a program optimizing non-chemical applications offers the best method for long-term success. A systems approach is needed regardless of strategies used. Basing strategies on objectives differs according to objectives of disease, annoyance, or livestock protection. The strategy is predicated on knowledge of the biology of specific species involved; no one set of strategies applies to all species.

Introduction

Perhaps the title of this presentation should be Integrated Pest Management (IPM) of mosquitoes since the three subjects, physical, chemical, and biological control, constitute the primary strategies of IPM in contemporary mosquito control. The concept of IPM came into vogue in the early 1970s. A general definition of IPM might be the combination of all known techniques to manage (not eradicate) insects, or in this instance, mosquito populations. Such blending of techniques previously was referred to as integrated control and was often confused with organic gardening or even biological control *per se.* For more details concerning IPM, Botrell (1), has provided a comprehensive report on the subject. The phrase "integrated pest management" denotes an approach to the reduction of a pest problem in which decisions are based on consideration of what is ecologically and economically in the long-term best interest of the environment and mankind. The objective of integrated pest management is to lower the mean abundance level of a pest population by any method or combination of methods that supplement the natural control agents, to provide long-term alleviation of the problem, and cause the smallest possible disruption of the ecosystem. It is based on the realization that natural pest populations cannot be eliminated. Instead, they must be managed so that they occur at tolerable levels (2). Organized mosquito control has long employed these IPM principles and has indeed served "in cognito" as a template for IPM (3).

Effective mosquito control can be essentially summarized in four categories: 1) Determination of species present within a given area. Only female mosquitoes take blood meals and all species require water for development. Beyond these facts, further generalities become increasingly difficult to make. Some mosquito species deposit eggs on moist soil, some on standing water, and others in artificial containers. Some, such as *Aedes vexans* (Meigen), which is common in Minnesota, deposit eggs on moist soil and have a flight range of more than 40 miles. Others, such as the yellow fever mosquito, *Aedes aegypti* L., deposit eggs in treeholes or artificial containers and may fly only a hundred yards from their site of development. *Aedes vexans* is both a daytime and a nighttime biter while the yellow fever mosquito is almost entirely a diurnal biter. Many *Anopheles* species rest during the day and are almost exclusively nocturnal feeders. Certain species of

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