THE ROLE OF BIRDS IN THE EPIZOOTIOLOGY OF EASTERN ENCEPHALITIS

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EASTERN encephalitis is a disease of horses, man, birds, and reptiles caused by a virus that in some hosts results in an inflammation of the brain. The causative virus belongs to a group classified as mosquito-borne encephalitides. This disease, more commonly called eastern equine encephalitis in the past, occurs from Wisconsin and Texas to the Atlantic coast and is particularly prevalent on our eastern seaboard.

Two other related forms of the disease are presently known from North America: St. Louis encephalitis and western equine encephalitis. Also classified in this group are Japanese B encephalitis, Murray Valley Fever of Australia, Nile Valley encephalitis, Venezuela encephalitis, and perhaps others. All of these affect man, and all apparently also occur in birds.

Encephalitis was first described from horses in the United States in 1912 (Udall, 1913), and the eastern type was differentiated in 1933 (Ten Broeck and Merrill, 1933). Giltner and Shahan (1933) suggested that pigeons played a role in the epidemiology of encephalitis, and Fothergill and Dingle (1938) isolated the causative agent from a wild pigeon in Massachusetts. Ten Broeck (1939) postulated that "birds act as reservoir hosts for the virus." Tyzzer *et al.* (1938) found the virus in wild pheasants from Connecticut at a time when severe losses were occurring among horses. Since that date the infection has been reported frequently among pheasants, particularly at breeding farms, from New England to the Southern states. In some parts of New Jersey it is considered impractical to attempt to raise pheasants without prophylactic vaccination.

During the past two decades many species of wild birds have been reported to carry antibodies to eastern encephalitis or have been demonstrated to carry virus in their blood. Stamm (1958) has recently reviewed the literature on incidence in birds, and Dougherty and Price (1960) have reported losses in domestic ducks on Long Island.

The list of naturally or experimentally infected birds now includes at least 48 species, including eight species of Ciconiiformes (Common Egret, *Casmerodius albus*; Snowy Egret, *Leucophoyx thula*; Black-crowned Night Heron, *Nycticorax nycticorax*; Green Heron, *Butorides virescens*; Little Blue Heron, *Florida caerulea*; Louisiana Heron, *Hydranassa tricolor*; Yellow-crowned Night Heron, *Nyctanassa violacea*; White Ibis, *Eudocimus albus*), one of Anseriformes (White Pekin Duck, *Anas platyrhynchos* [domestic]), six of Galliformes (Bobwhite, *Colinus virginianus*; Chicken, *Gallus domesticus*; Chukar, *Alectoris graeca*; Guinea Fowl, *Numida galeata*; Ring-necked Pheasant, *Phasianus colchicus*; Turkey, *Meleagris gallopavo*), one of Charadriiformes (Lesser Yellowlegs, *Totanus flavipes*), two of Columbiformes (Mourning Dove, *Zenaidura macroura*; Pigeon, *Columba livia*), one of Strigiformes (Screech Owl,

Otus asio), and 29 species of Passeriformes (Red-winged Blackbird, *Agelaius phoeniceus*; Blue Jay, *Cyanocitta cristata*; Cardinal, *Richmondena cardinalis*; Catbird, *Dumetella carolinensis*; Carolina Chickadee, *Parus carolinensis*; Brown-headed Cowbird, *Molothrus ater*; Common Grackle, *Quiscalus quiscula*; Eastern Kingbird, *Tyrannus tyrannus*; Ruby-crowned Kinglet, *Regulus calendula*; Eastern Meadowlark, *Sturnella magna*; Mockingbird, *Mimus polyglottos*; Robin, *Turdus migratorius*; House Sparrow, *Passer domesticus*; Song Sparrow, *Melospiza melodia*; Swamp Sparrow, *Melospiza georgiana*; White-throated Sparrow, *Zonotrichia albicollis*; Scarlet Tanager, *Piranga olivacea*; Brown Thrasher, *Toxostoma rufum*; Hermit Thrush, *Hylocichla guttata*; Wood Thrush, *Hylocichla mustelina*; Tufted Titmouse, *Parus bicolor*; Rufous-sided Towhee, *Pipilo erythrophthalmus*; Red-eyed Vireo, *Vireo olivaceus*; White-eyed Vireo, *Vireo griseus*; Yellow-throated Vireo, *Vireo flavifrons*; Kentucky Warbler, *Oporornis formosus*; Myrtle Warbler, *Dendroica coronata*; Northern Waterthrush, *Seiurus noveboracensis*; Carolina Wren, *Thryothorus ludovicianus*).

During the summer of 1960 our staff at the Patuxent Wildlife Research Center, in collaboration with the Walter Reed Army Institute of Research, added five new species of Passeriformes to the list (Russell and Clark, 1961). We can anticipate that many more bird hosts will be added to the list.

Although in man and horses this virus causes a severe, and usually fatal, disease, clinical symptoms are not recognized in most of the species of birds that have been studied to date. The main exceptions to this are the Pheasant, Chukar, Pekin Duck, and House Sparrow, all exotic species. A few species of our native birds have been experimentally infected without evidence of illness or death. Usually the viremia (demonstrable presence of virus in the blood) is short lived, a day or two, or at most a week. It is only during viremia that a blood-sucking vector can pick up the virus. Most diagnoses of evidence of infection in wild birds are based on finding antibodies. In the course of infection an animal produces antibodies to the specific infective agent. These antibodies circulate in the blood, and their presence can be recognized by proper laboratory tests on blood serum. Antibodies, at demonstrable level, may persist in the blood of a bird for several months.

In addition to man and horses, a number of other mammals have been shown to be susceptible to eastern virus. Natural infections have been reported from several species of rodents.

Thomas *et al.* (1958) experimentally demonstrated the susceptibility of garter snakes to western virus, and Karstad (1961) has reported infection with eastern virus in reptiles from Georgia and Florida. In at least one case a viremia lasting 28 days was recorded.

Reeves (1951) stated that "the evidence now indicates that the epidemiology of the encephalitides is the most complicated of any of the known arthropod-borne diseases." With the extensive advancement of our knowledge in the past decade, Reeves' statement is even truer today.

Encephalitides are recognized as arthropod-borne diseases, although in pheasants it has been demonstrated that infection can be transmitted by a susceptible bird pecking an infected one. Many arthropods, including mites, ticks, triatomids, and others, have been implicated to a degree. The list of species infected in the laboratory is, as would be expected, more extensive than the one for natural infections. However, it is almost universally accepted today that the chief, if not the only, natural vector is the mosquito. Currently we know that many species of mosquitoes are infected in nature, and, from laboratory tests, we know that many others can become infected. It is believed that *Culex tarsalis* is the chief vector of western virus, although others may be involved. In the transmission of eastern virus there is still much controversy as to which mosquito is the most important vector. While a fresh-water marsh mosquito, *Culiseta melaneura*, is perhaps an important vector, there is still insufficient evidence to define its specific role. Perhaps one species is of more importance for infecting horses or man, another for birds, and still another for reptiles.

Early in our knowledge of this virus disease most investigators believed that infection was not transmissible from horse to horse or man, or from man to horse or man, because of the short duration and low titer of the attendant viremia. When birds were subsequently found to harbor the virus, they were immediately implicated as the source of infection in both horse and man. The much longer duration of viremia in the reptiles, however, suggests that this group of animals is a much more logical primary source of the infection.

Infections in birds, as well as in mammals, occur seasonally. Although they have been reported rarely as early as March or April, the majority of cases observed are in late summer. Reeves *et al.* (1958) reported that chronic latent infection of one to 10 months' duration occasionally occurs in wild birds experimentally infected with western virus, and suggested that this may account for maintenance of virus during winter months. Kissling *et al.* (1957) did not isolate western virus from blood of 764 birds wintering in southern United States or from 739 birds entering the same area on their spring migration. The relative paucity of evidence that birds served as a winter reservoir of virus or reintroduced it into northern areas each year suggested to Thomas *et al.* (1958) a consideration of hibernating animals and led to their studies on the garter snake. They pointed out that evidence is mounting that mosquitoes are relatively unimportant as a winter reservoir of infection.

Although circumstances and current knowledge of this infection have implicated birds as the source of infection in horse or man, there are no specific data to confirm this hypothesis. At best, a knowledge of the inci-

dence or activity of this disease in birds may only be an indicator of activity of the virus in nature.

Many investigators have emphasized that the migration phenomenon of birds is a potential for spreading the virus. Available information, however, does not support this hypothesis. Data obtained from studies on endemic centers are strongly suggestive that this problem is a local one, although geographically widespread.

In a review of the encephalitis problem in the United States, presented before a meeting of the American Public Health Association, Reeves (1951) summarized his presentation by pointing out that while present information indicates these infections to be widespread in North America he nevertheless considered them only a relatively minor public health problem. However, various factors have led to the belief that these diseases may have an epidemic potential. The natural history of these viral agents indicates a complicated infection chain characterized by a completely inapparent infection in nature, involving birds as hosts and mosquitoes as vectors, with some unknown factor serving as a long-term reservoir. Such inapparent infection may become a public health problem when man becomes infected.

Reeves emphasized that local health departments must determine the extent and nature of the problem in their areas. He recommended a control program based on individual personal protection from mosquito vectors and, if practical, specific vector abatement. He urged that public health departments "keep abreast of new developments in this field," as current comprehensive investigations by federal, state, and university research workers will undoubtedly clarify the many unanswered questions.

Reeves concluded his review of the subject with the statement: "At the present time there would appear to be no possibility of controlling encephalitis by an attack on the widespread avian hosts." The above-reported pronouncements are just as true today as 10 years ago. Bird banders and ornithologists too should "keep abreast of new developments in this field," and at every opportunity we should strive to cooperate or collaborate with research teams investigating local outbreaks. Let us do our part to make the data as complete as possible so that the gaps in our knowledge will not work to our detriment.

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