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THE ARBOVIRUS SURVEILLANCE AND CONTROL PROGRAM IN OHIO, 1975 – 76

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In 1975 Ohio experienced the largest epidemic of mosquito-borne encephalitis in its history. Four hundred and sixty-eight human cases (416 St. Louis [SLE] and 52 California [CE] occurred with 30 fatalities; one death was due to CE. The entire United States was hard hit (Illinois, 475; Indiana, 297; Mississippi, 210; Michigan, 20; Tennessee, 91; 30 others, 550) with 1816 SLE, 160 CE, 133, Western, and 3 Eastern encephalitis cases causing 150 fatalities.

The cycle of mosquito-borne encephalitis in nature progresses as follows: A mosquito infected with virus feeds on a non-infected animal, such as a bird in the case of St. Louis encephalitis. In approximately 24 hours the bird begins circulating the virus in its blood stream. This situation is called viremia. The bird circulates virus in sufficient quantity to infect other non-infected mosquitoes for a period of approximately four days. The virus then leaves the blood stream, and the bird is no longer able to infect a mosquito. After a period of approximately 10 days the virus has in turn invaded all tissues in the mosquito including the salivary glands. From that time on this mosquito can, by biting, infect any non-immune vertebrate.

California Encephalitis

The Communicable Disease Division of the Ohio Department of Health has had an ongoing surveillance program for CE since 1965, and Ohio continues to rank first in the nation in numbers of human cases of this disease, with 395 cases reported to date from 68 of 88 counties (Figure 1 and 2). California encephalitis affects principally children 15 years of age or under and produces little or no sequellae. The fatality rate is less than 1% with four fatalities due to this virus reported for Ohio. Woodland mosquitoes of the genus *Aedes*[1] transmit the disease with small mammals of the squirrel family, especially chipmunks, as the normal wild hosts. The virus of CE overwinters in eggs of the treehole mosquito, *Aedes triseriatus,* producing already infected adult mosquitoes in June of the following year. Controlling this disease is extremely difficult due to the variety of breeding habitats exhibited by the vectors, ranging from rot cavities in trees containing water to tires, tin cans, bottles, woodland pools, and brackish water marshes and pools. A thorough, sound mosquito control program for this disease must include education in the proper disposal of water-holding containers such as tin cans, bottles, and tires; elimination of water contamination by brackish materials; and permanent filling of rot cavities in trees to prevent mosquito breeding.

St. Louis Encephalitis

Since the inception of mosquito-borne encephalitis surveillance in Ohio, SLE was reported only twice prior to the epidemic of 1975. One case was confirmed in 1964 & 1965, one each in Hamilton and Cuyahoga counties, with one fatality. This type of encephalitis differs from CE in several respects. St. Louis encephalitis is most severe in the elderly, although it affects all age groups. The fatality rate varies from 2-10%, although outbreaks in retirement communities have exhibited fatality rates as high as 22%. Mosquitoes of the genus *culex*[1] transmit SLE virus to man. Birds of a variety of species serve as the natural hosts (Table 1).

The overwintering cycle of this disease is still unknown. Unlike mosquitoes of the genus *Aedes* which overwinter as eggs, *culex* mosquitoes overwinter as unfed adult females hibernating in protected places. In the late spring these female *culex* emerge from their hiding places, take a blood meal, and lay eggs to begin the next generation. The principal species of *culex* responsible for transmitting SLE prefer to breed in water polluted by organic material, particularly sewage. *Culex* frequently breed in catch basins; roadside ditches and streams polluted by the effluent from septic tanks; improperly maintained sewage treatment plants; as well as water-holding containers such as tires, tin cans, bottles, and improperly maintained childrens' wading pools and bird baths. Unlike CE, which is principally a disease of rural and suburban areas occurring as single scattered cases, SLE occurs frequently as an epidemic, particularly in urban areas, although cases also occur in rural and suburban areas.

The principal *culex* vector in Ohio, *culex pipiens* (Northern House mosquito), and peridomestic bird species, such as house sparrows and pigeons, combined with organically polluted water and the littering habits of man, perpetuate SLE transmission right in our own backyards. Here again, public education as to the need for properly maintained septic tanks and sewage treatment plants, modernized sewage disposal systems, proper disposal of all water-holding containers, and proper maintenance of bird baths, childrens' wading pools, roof gutters and drains, must be a part of any well organized mosquito control program.

SLE Epidemic – 1975

Paralleling a national epidemic of SLE in 1975, Ohio ranked second, with 416 human cases of this disease which produced 29 fatalities (7%), principally in the elderly (Figure 3). Fifty-four counties were involved, with the highest number of cases occurring in Franklin (142) and Cuyahoga (83). The highest attack rates per 100, 000 population (10.0 - 24.9) occurred in Franklin, Pickaway, Paulding, Van Wert, and Allen counties. The first human case occurred the week of July 2nd, with the peak of the epidemic occurring in mid-September.

Five-thousand one-hundred and twenty-one *culex* mosquitoes identified and tested from 11 counties during the epidemic yielded 27 SLE virus isolates (Figure 4). An intensive study of *culex* populations in Franklin County demonstrated several significant points. A minimum field infection ratio (MFIR) of one positive *culex* out of 200 collected (1: 200) is considered indicative of an epidemic. The MFIR in Franklin County was 1: 108. By different collection techniques the MFIR's for *culex* were as follows: from catch basins-1: 40; from pigeon coops-1: 81; from other natural shelters, such as dog houses, garages, culverts, under bridges-1: 108, and from light traps-l: 134. Sixty-seven percent of the catch basins sampled in Columbus were breeding *culex,* while 47% harbored resting adult *culex*. Septic tanks leaching into a small stream in a suburban area of the county accounted for high numbers of *culex.* In this area, 50% of the birds showed signs of infection, and 1 out of every 58 *culex* were positive.

Six-hundred and sixty-three bird sera collected from 18 species in five counties produced 255 (38.3*%)* seropositives by the haemagglutination-inhibition test (Franklin, 49.4%; Montgomery, 34.0%; Cuyahoga, 30.1%; Summit, 6.8%; Warren, 0%) (Figure 5). A 5% positive avian population indicates epidemic spread of virus.

SLE Surveillance - 1976

The possibility of recurring epidemics of SLE in Ohio, coupled with the need to know of virus activity in the bird or mosquito populations in time to instigate increased mosquito control activities, prompted the ODH to institute a Statewide surveillance and control program in 1976. The surveillance program utilized a network of preselected collection sites to be sampled biweekly. Specimens obtained were identified and tested immediately. This required the cooperation, training, and assistance of some 35 local agencies and individuals (Figure 6).

Mosquitoes were collected by light traps baited with dry ice, from shelters such as storm drains, under bridges during the day, and in bird coops at night. Thirty-one agencies or individuals made four light trap and five shelter collections every two weeks from June through September. With the additional help of field personnel from the Vector-borne Disease Unit (VBDU) 87, 965 mosquitoes (44, 721 *culex* spp., 12, 850 *Aedes* spp.) were submitted from 37 counties (Fig. 7). Thirteen isolates of SLE virus from *culex* spp. and 9 CEV isolates from *Aedes* spp. were made from 9 counties (Franklin, 4; Summit, 4; Pickaway, 3; Hamilton, 2; Lorain, 2; Lake, 2; Scioto, 1; Montgomery, 1; Allen, 1). The highest MFIR occurred in Pickaway County where one of every 147 *Aedes* were positive for CE, and Lorain County where one of every 515 *culex* were positive for SLE.

Nine cooperators and field personnel of the VBDU collected sera from 2, 525 juvenile birds, principally house sparrows (1, 653), pigeons (268), and chickens (320), from 29 counties (Figure 8). Twenty seropositives (< 1%) were obtained from house sparrows (16), pigeons (3), and ducks (1) in 7 counties: Franklin, 5 (2%); Pickaway, 8 (3%); Putnam, 2 (1%); Hamilton, 2 (1%); Scioto, 1 (1%); Wayne, 1 (1%); Tuscarawas, 1 (1%). The earliest indication of SLE virus activity in nature was detected July 6th.

Twenty-eight human cases of mosquito-borne encephalitis (10 SLE, 18 CE) were recorded during 1976 from 20 counties (Figure 9). Hardest hit were Allen (3 CE, 1 SLE), Cuyahoga (3 CE), Franklin (2 SLE), Pickaway (2 SLE), and Ross (2 CE) counties. Overall virus activity within Ohio and throughout the nation was low during 1976.

Vector Control

During the epidemic of 1975, it became very obvious that Ohio did not have the mosquito control capabilities to abate an epidemic. To correct this situation, two programs were instituted in 1976.

Initially, with the assistance of the Bureau of Environmental Health, a comprehensive survey was made of every community in the State to determine the amount, quantity, and quality of equipment and insecticides on hand for use in mosquito control. Secondly, because a large number of communities either had no control capability whatsoever, or insufficient capability to abate an epidemic, the ODH asked for monies to purchase mosquito control equipment and insecticide to loan to local departments. This was done on a contract basis, which required each participating department to accomplish as complete a mosquito control program as possible, including public education, surveys to determine mosquito populations and breeding sites, breeding source reduction, and larval and adult mosquito control. Thirty-five mosquito control units were provided to 30 local agencies in 26 counties (based on population and prior number of encephalitis cases) to institute, or increase, existing mosquito

control programs (Figure 10). Only by increasing mosquito control programs, formulated to be the most environmentally safe and scientifically sound, throughout Ohio, can we expect to avert another epidemic. In so doing we will also reduce the pest mosquito problem significantly in many areas. Once an epidemic is started it is too late to initiate programs. The skill, training, and materials must already be available.

1977 - ?

Plans are already in progress for the 1977 season. Continued arbovirus surveillance of mosquito and bird populations will be carried out over as large a network of collection sites as possible, beginning in May and continuing through September. Once again, this will require the energies of many local and state agencies and individuals. We hope to Include vector species of *Aedes* and *culex* collected by those control programs not already included in the surveillance program. Plans to expand the existing control program to make it more efficient and provide coverage to areas unprotected at this time are underway.

No one can predict an epidemic of mosquito-borne encephalitis, but with the cooperation of many disciplines we will be able to reduce the chance of being caught unaware in the future, and be prepared to reduce the impact of virus activity within the State.

(This program was partially supported by NIH Grant No. AI12047-02.)

[1]Reference to *Aedes* and *Culex* includes only those species which serve as vectors in Ohio: *Aedes canadensis,* Ae. *sollicitans, Ae. triseriatus*, Ae. *trivittatus; Culex pipiens, Cx. restuans, Cx. salinarius.*

DISCUSSION

Good: What is the effect of St. Louis encephalitis on the bird? or the mosquito? Do they suffer anything from that?

Parsons: There is no effect on the mosquito. Where the birds are concerned, the answer is really not know. In nature dead nestlings have been found in the same nest with infected birds.

Question: Do I understand correctly that after a bird has been infected by a mosquito, that only for a period of 1-5 days can it carry this infection on to another mosquito? After that 5-day period, can it be re-infected by another mosquito?

Parsons: No. This holds true for the human population, too. Once you have had St. Louis Encephalitis, you are immune to SLE virus. However, if you go for a stroll in the woods and get bitten by an *Aedes* mosquito carrying California encephalitis virus, you can get California encephalitis.

Question: What are the effects on the human survivors of encephalitis?

Parsons: It ranges from complete recovery to paralysis and death and all levels in between. The most frequent sequellae are headaches and some loss of motor ability or vision or hearing acuity.

Question: If you're bitten by an infected mosquito, what are the chances that you will become infected?

Parsons: The answer is, "I don't know." It is generally accepted that probably 20% or less of the people bitten by infected mosquitoes come down with clinical symptoms of encephalitis. We see just the tip of the iceberg. It's known that with both California and St. Louis encephalitis you get a great many sub-clincial or inapparent cases. These are cases where symptoms are no more severe than low fever and headache. In serological surveys of adult populations for California encephalitis, it has been that 30-40% of the adult population sampled demostrated titers indicative of past infection with this virus; and yet the individual is unaware of being ill with a disease of this nature.

Question: What is the average life-span of a mosquito and how often do they require blood?

Parsons: Most female mosquitoes require a blood meal to lay eggs. They feed on plant juices the rest of the time. The life span of a mosquito varies with the species. Some species overwinter as adults or larvae and therefore may live 9-10 months. Those overwintering as eggs usually live somewhere between 1 to 3 months as adults. The life cycle is over a year and a half. However, the adult female mosquitoes which overwinter apparently have never had a blood meal. The reason is that blood-fed mosquitoes have an inability to develop fat bodies to protect themselves against cold winter temperatures. Therefore, females are not infected with virus.

Question: Prior to 1975 did the Ohio Department of Health sample birds and do you intend to continue this program?

Parsons: Yes, we did sample birds for at least three years in the late 1960s. We had, I believe, only two serological positives. We were working with pest birds - Redwings, Grackles, Starlings, etc. We had to stop because money became scarce, and it was necessary to decide which disease we should work on. Since we've always had California encephalitis in Ohio it was decided to study this disease; consequently we have done most of our surveillance with mammals. We do intend to continue this program.

Question: Where does the virus overwinter?

Parsons: I assume you're referring to St. Louis encephalitis. This is unknown. Currently investigations are underway on a theory that overwintering bird bugs, related to bed bugs, found in swallows' nests were found positive in January and February for Western virus. Although the swallows migrate, many of the bugs do not. These bugs overwinter in nests and are capable of maintaining a virus infection---the same principle as the mosquito remaining infected for life. When the birds return to the same nest the next year, the infection spreads to the young. This is the only current lead we have. We are sampling birds' nests and planning to test the parasites received from them.

Question: Do you feel fairly confident that your control program is responsible for the reduced number of cases of encephalitis?

Parsons: Any reduction in the mosquito population reduces the transmission of disease agents. By gradually building up this control program and making more and more people aware that you must correct the situations that cause epidemics, it is possible to prevent large scale epidemics. I did not mention another part of the control program this year. The Bureau of Environmental Health of the Ohio Department of Health surveyed every community in the State of Ohio to find out exactly what equipment is available, what condition it is in, and what insecticides are being used. Now we have a much better picture of the control capability in Ohio.

TABLE 1. Comparison of SLE serological results in avians in epidemic and non-epidemic years in Ohio, 1975 vs 1976.

Avian Species	1975 ALL AGES Number Tested	1975 ALL AGES Number Positive	1975 ALL AGES Percent	1976 JUVENILES ONLY* Number Tested	1976 JUVENILES ONLY* Number Positive	1976 JUVENILES ONLY* Percent
Wild Species:						
Blackbird, Red-winged	---	---	---	1	0	---
Bluejay	---	---	---	2	0	---
Bunting, Indigo	2	0	---	1	0	---
Cardinal	4	1	25.0	---	---	---
Catbird	1	0	---	3	0	---
Chickadee, Black-capped	5	0	---	---	---	---
Cowbird	---	---	---	2	0	---
Dove, Mourning	192	73	38.0	---	---	---
Goldfinch, American	---	---	---	2	0	---
Grackle, Common	---	---	---	19	0	---
Oriole, Baltimore	---	---	---	2	0	---
Robin	9	4	44.4	3	0	---
Sparrow, House	34	12	35.2	1605	16	0.96%
Sparrow, Song	2	0	---	3	0	---
Starling	---	---	---	40	0	---
Swallow, Barn	---	---	---	24	0	---
Thrasher, Brown	1	0	---	---	---	---
Thrush	1	0	---	3	0	---
Woodpecker, Hairy	---	---	---	1	0	---
Wren, Carolina	3	0	---	---	---	---
Unknown spp.	---	---	---	4	0	---
Domestic Species:						
Chickens	65	39	57.3	320	0	---
Ducks	11	0	---	12	1	8.3%
Geese	---	---	---	16	0	---
Guinea Fowl	---	---	---	2	0	---
Pheasant	---	---	---	71	0	---
Pigeons	326	127	38.9	268	3	1.1%
Quail	---	---	---	3	0	---
Swan	---	---	---	3	0	---
Turkey	---	---	---	65	0	---
Turkin	1	1	100.0	---	---	---
TOTAL	660	257	38.9	2525	20	0.79%

* 3 adult house sparrows, 1 adult robin, and 3 adult pigeons were also positive.

Figure 1

OHIO DEPARTMENT OF HEALTH
1964 - 1974
CE
HUMAN CASES

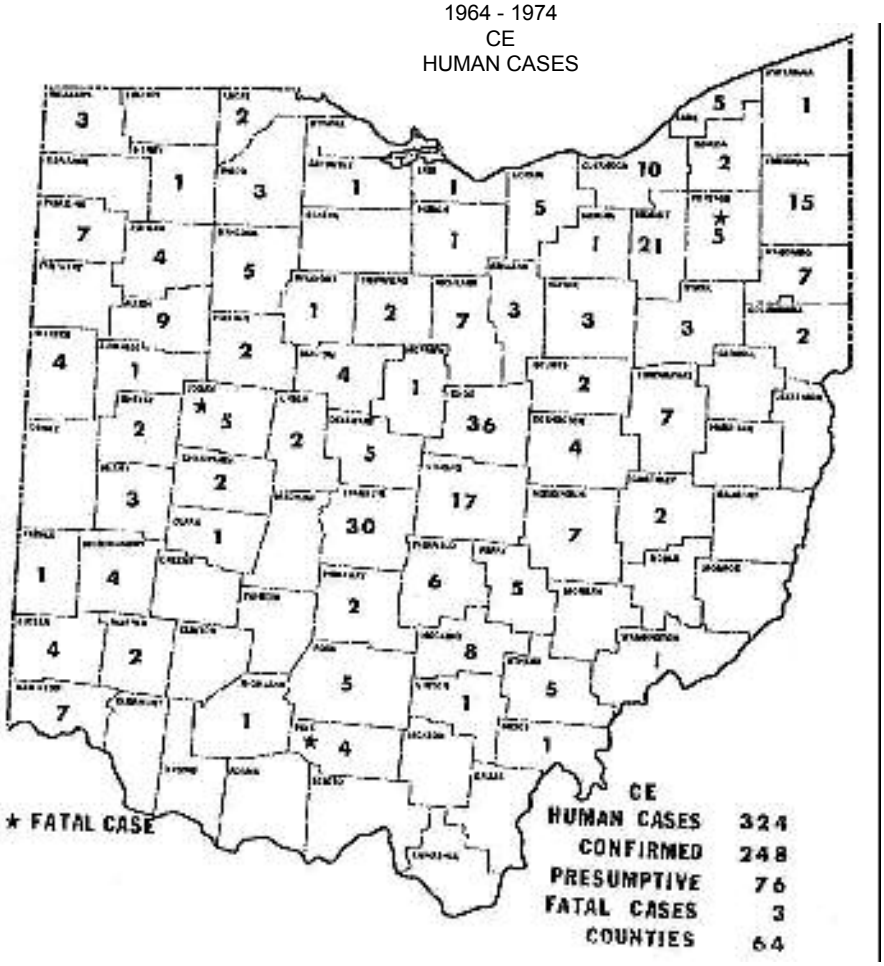

Figure 2

OHIO DEPARTMENT OF HEALTH
1975
CE
HUMAN CASES

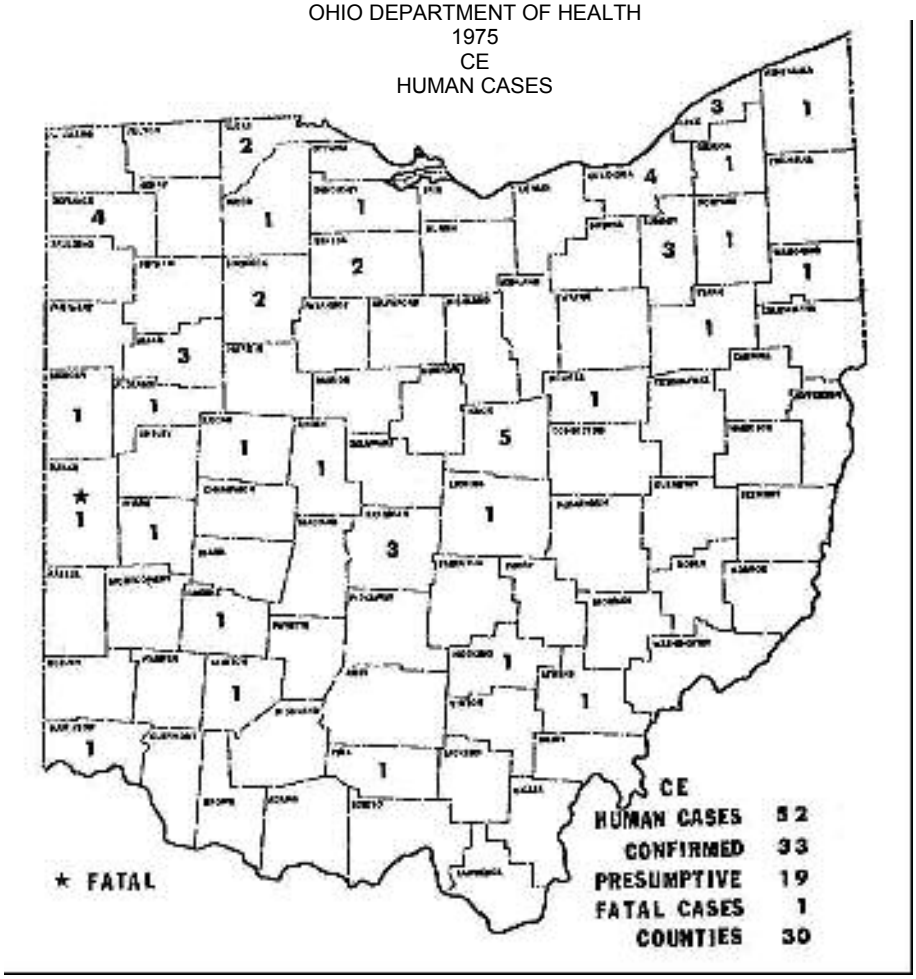

Figure 3

OHIO DEPARTMENT OF HEALTH
1975
SLE
HUMAN CASES

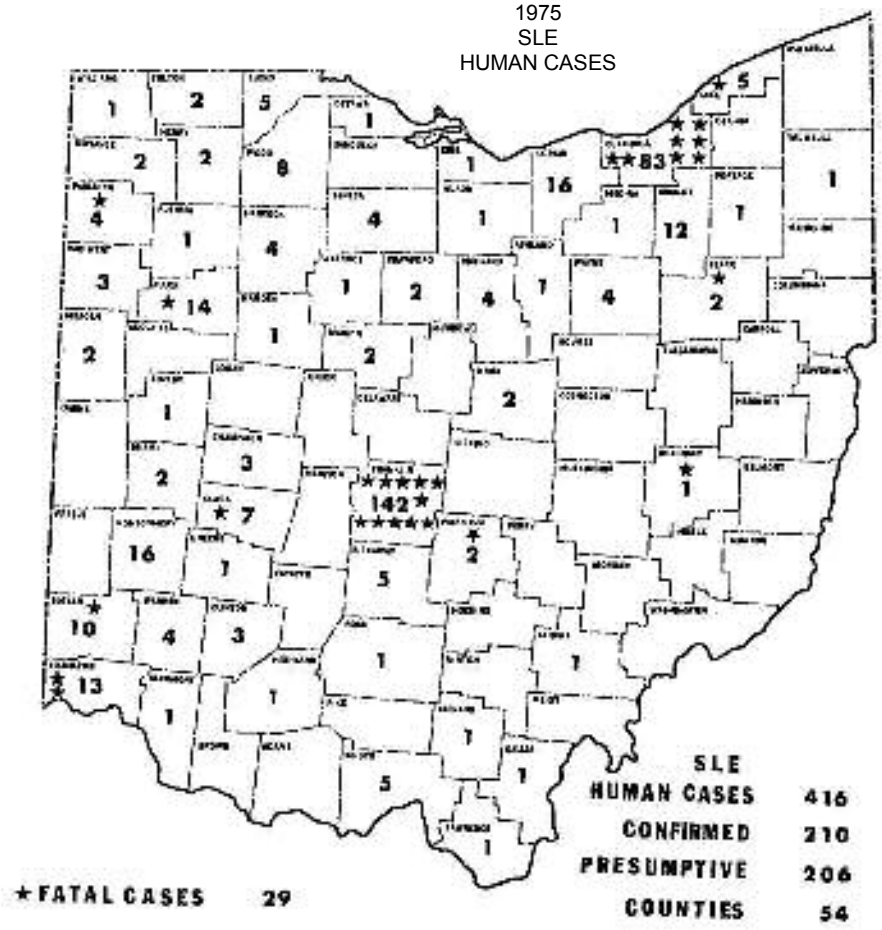

Figure 4

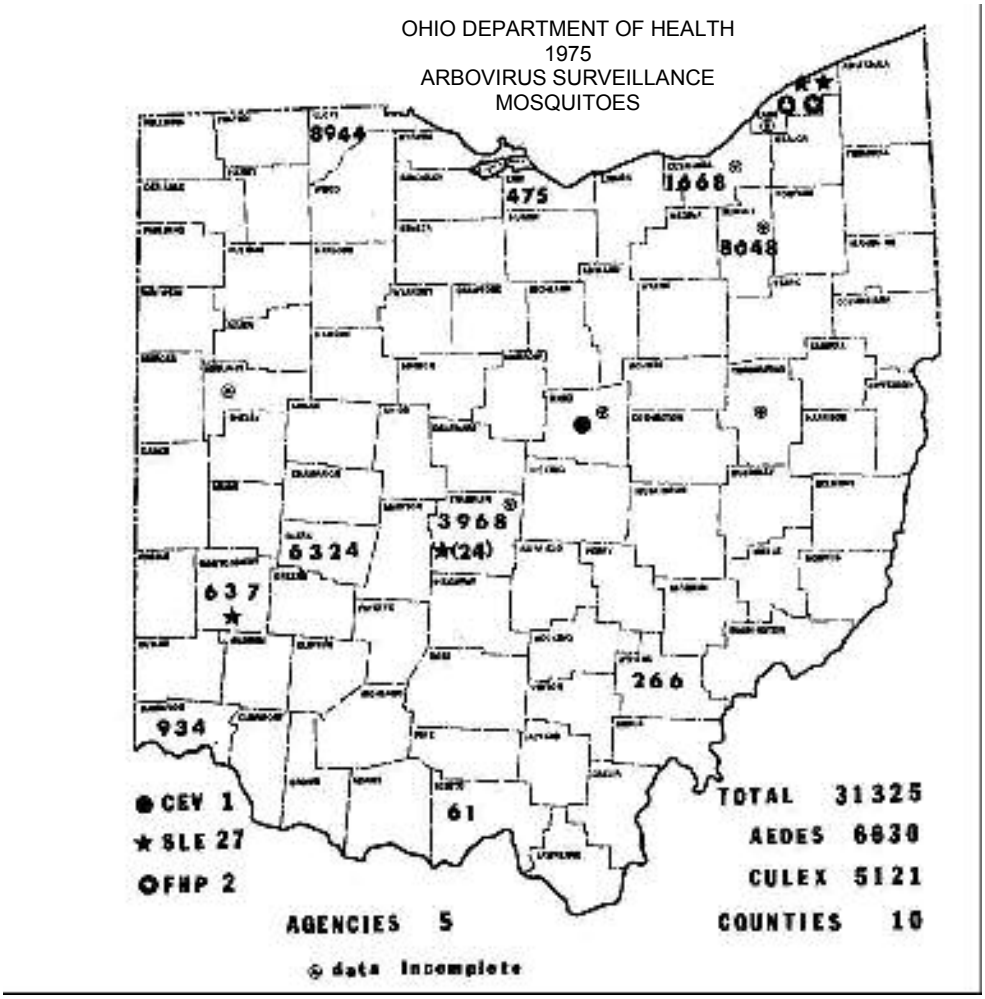
OHIO DEPARTMENT OF HEALTH
1975
ARBOVIRUS SURVEILLANCE
MOSQUITOES
8944
475
1668
8048
3968
(24)
6324
637
266
934
61
CEV 1
SLE 27
FHP 2
AGENCIES 5
TOTAL 31325
AEDES 6830
CULEX 5121
COUNTIES 10
data incomplete

FIGURE 5

OHIO DEPARTMENT OF HEALTH

1975

ARBOVIRUS SURVEILLANCE
AVIANS

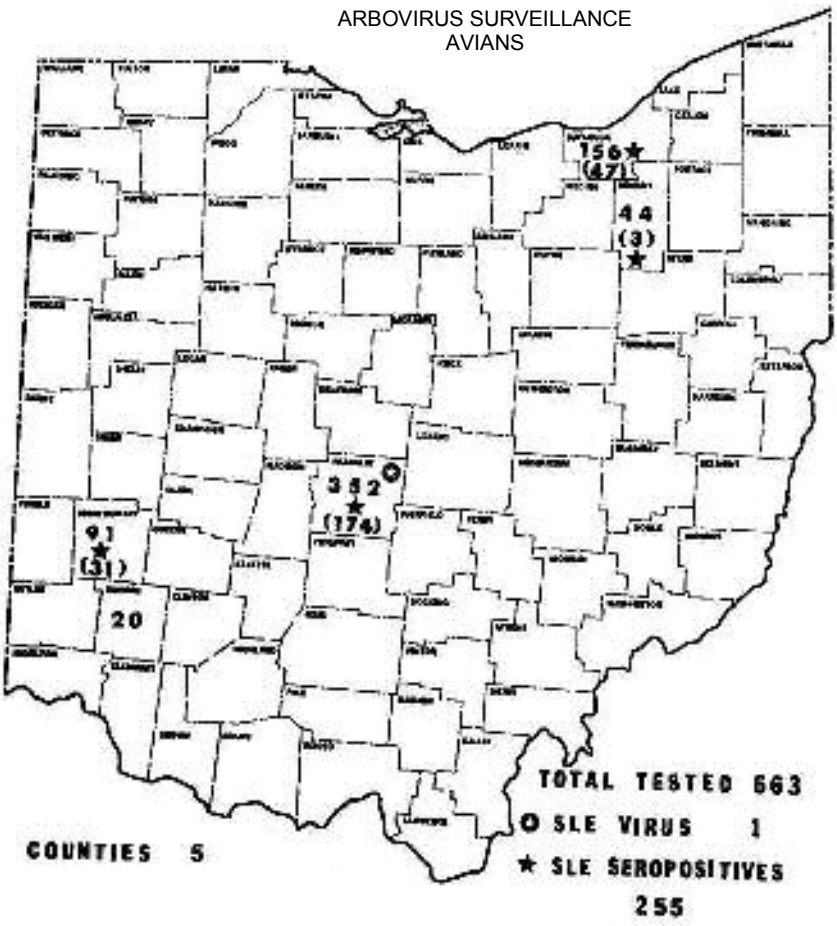

Figure 6


OHIO DEPARTMENT OF HEALTH
1976
ARBOVIRUS SURVEILLANCE
SITES
AVIAN
MOSQUITO
COOPERATING AGENCIES 35

Figure 7

OHIO DEPARTMENT OF HEALTH
1976
ARBOVIRUS SURVEILLANCE
MOSQUITOES

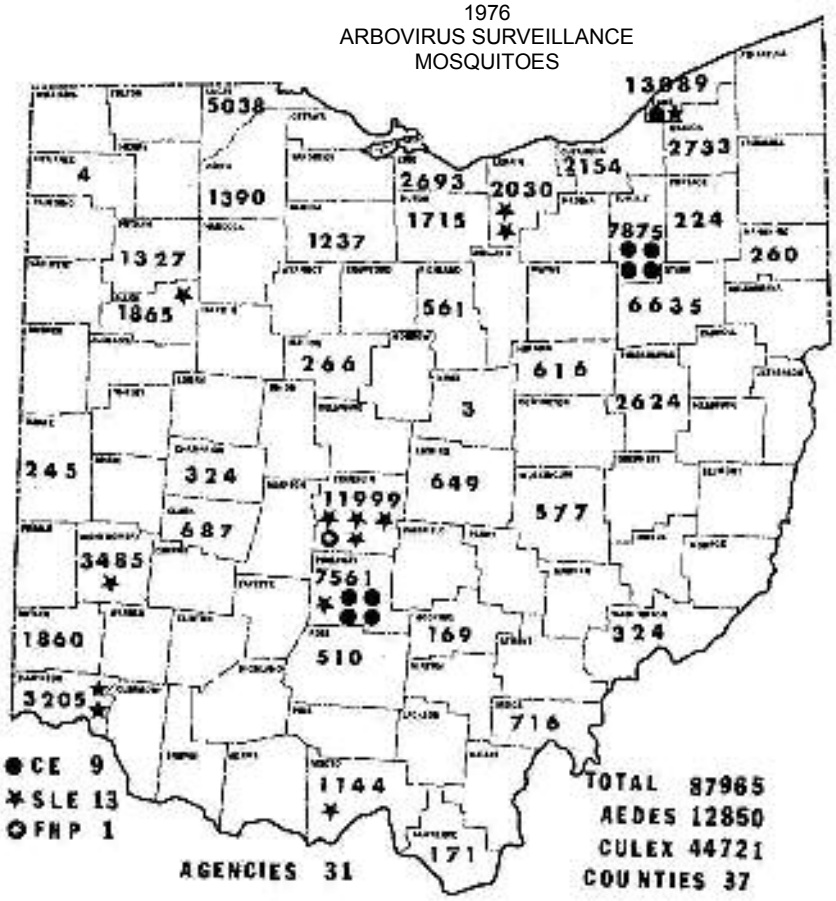

Figure 8

OHIO DEPARTMENT OF HEALTH
1976
ARBOVIRUS SURVEILLANCE
AVIANS

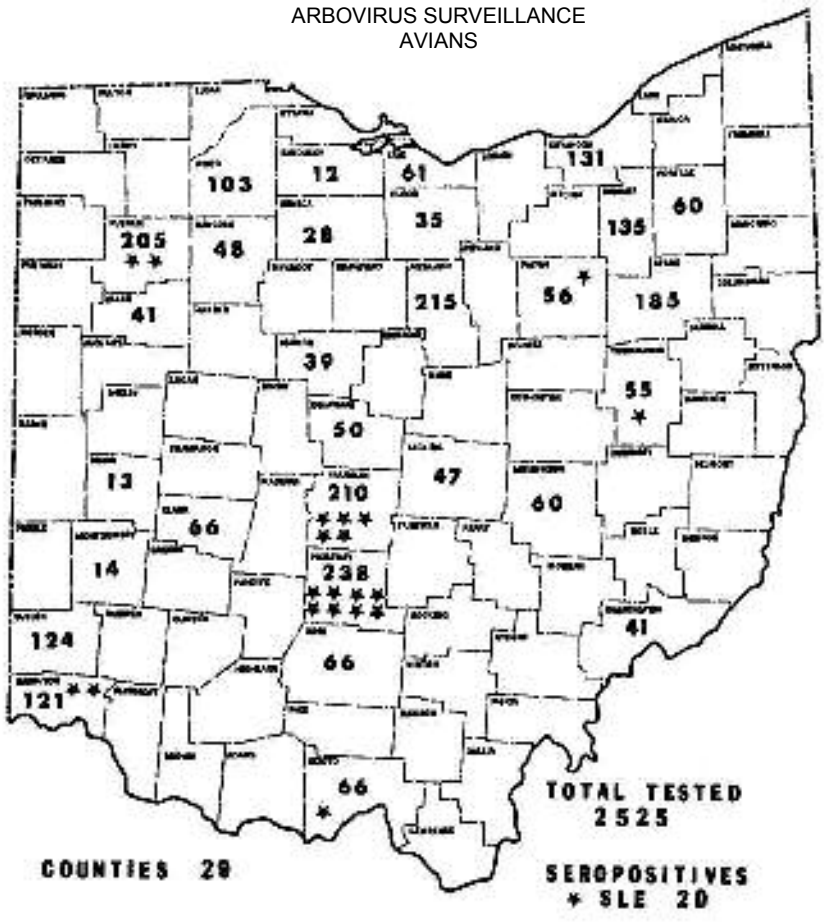

FIGURE 9

OHIO DEPARTMENT OF HEALTH
1976
HUMAN ARBOVIRAL
ENCEPHALITIS
CASES

Figure 10

OHIO DEPARTMENT OF HEALTH
MOSQUITO CONTROL PROGRAMS
1976