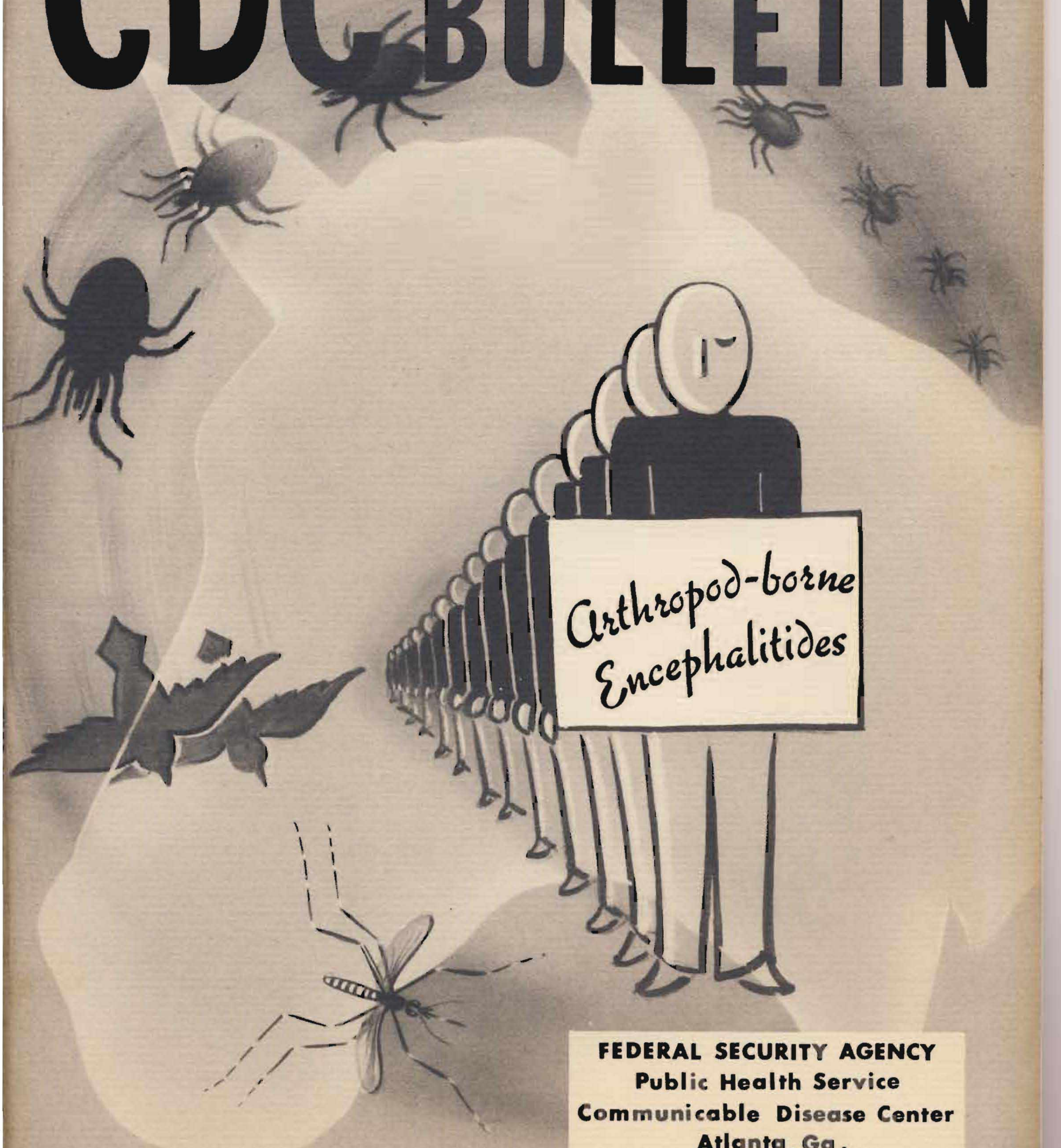
CDC BULLETIN

FEBRUARY 1950



FEDERAL SECURITY AGENCY
Public Health Service
Communicable Disease Center
Atlanta, Ga.

CDC February 1950 BULLETIN
Vol. IX, No. 2

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Encephalitis

Morris Schaeffer

MEDICAL BACTERIOLOGIST*

Pathologists have recognized for a long time that the tissues can respond only in a limited manner to certain invading irritative substances. This is especially true of the brain. Thus, a number of different agents can produce an encephalitis (a nonspecific term meaning, merely, inflammation of the brain) which may be difficult or impossible to differentiate on the basis of the clinical picture alone, or even the appearance of gross and microscopic pathologic changes.

Encephalitis may be caused by a large variety of offending substances including physical and chemical agents, poisons, toxins, bacteria, protozoa, spirochetes, rickettsiae, and viruses. The last-mentioned agents are of special interest because certain viruses produce types of encephalitis which have important public health aspects in that they are readily transmissible through the agencies of animal reservoirs and arthropod vectors and are present in certain localities in endemic and epidemic form.

The virus encephalitides may be divided into two main groups, primary and secondary.

Secondary encephalitides are caused by, or associated with, viruses not ordinarily considered encephalitogenic, which produce familiar diseases such as herpes simplex, measles, mumps, chickenpox, influenza, lymphogranuloma venereum, vaccinia, and infectious hepatitis. A similar form of encephalitis may follow vaccination against smallpox and rabies. These types also have been termed postinfection or postvaccination encephalitis.

The primary virus encephalitides are caused by viruses which have a primary affinity or tropism for the central nervous system and include such diseases as the St. Louis type of encephalitis, Eastern equine encephalomyelitis, Western equine encephalomyelitis, Japanese B encephalitis, Venezuelan equine encephalomyelitis, Russian Far East encephalitis (tick-borne, spring-summer encephalitis), lymphocytic choriomeningitis, louping ill, rabies, and B-virus. In addition, there is a group of virus encephalitis infections less well defined such as pseudolymphocytic choriomeningitis, swineherd disease, and a form of leukencephalitis. There are others still more obscure and exotic like West Nile, Bwamba Fever, Semlike Forest, and Bunyamwera, for which viruses have been isolated from mosquitoes; and in a few instances either the virus or antibodies have been found in the blood of man, but their role or significance has not as yet been clearly indicated. Von Economo's disease, an acute and chronic disseminated encephalomyelitis, is another one of the primary encephalitides which appeared in epidemic form in this country about 30 years ago but rarely has been seen since. A virus etiology for this disease never has been established definitely. The first three diseases mentioned above are the principal epidemic encephalitis problems in this country at present.

It appears therefore that there is a large number of specific agents already known and categorized to some extent which are capable of producing encephalitis; but it is obvious also that there remain other encephalitogenic viruses still to be uncovered and classified. Thus we are dealing with a group of diseases which present many facets of considerable complexity.

Out of the somewhat scrambled and spotty picture which we have of the natural history of the epidemic forms of encephalitis, the information presently available would indicate that the viruses find harborage in a wide variety of birds and fowl and are transmitted among them, and incidentally from them, to man and other mammals (horses in the equine types of encephalitis) by different species of arthropod vectors: mites, lice, mosquitoes, and ticks. There is the suggestion (awaiting adequate confirmation) that the St. Louis encephalitis virus may be propagated by transovarian passage in chicken mites. This would add another missing link and explain one way in which the disease, primarily of summer incidence, may be maintained through the winter. Epidemics may be expected to occur during the summer in potential

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localities where the situation, with respect to climatic conditions for the breeding of arthropod vectors, permits the cyclic chain of events to be completed.

Similarities of the clinical and epidemiologic aspects of some of these diseases and the multiplicity of types and strains of their etiologic agents make it necessary to study elaborately the characteristics of the causal agents, all their possible reservoirs and vectors, and their laboratory diagnosis. The physician and health officer must depend almost entirely on the laboratory for accurate diagnosis, and upon the collaborative efforts of the virologist, epidemiologist, entomologist, and clinician for a complete understanding of these diseases in order to formulate means for their control and prevention.

At present an absolute diagnosis can be made only in one of the following ways:

1. Isolation of the virus from the central nervous system of fatal human cases or horses (in equine encephalomyelitis) involved in the locality. Occasionally virus may be isolated from the blood or spinal fluid of patients if obtained very early in the disease, but this is not dependable. In order to preserve the viability of the virus, material for virus isolation must be frozen (using dry ice) immediately and kept that way until it reaches the laboratory for animal inoculation.
2. Demonstration of the formation of specific antibodies against one of the viruses in the blood of the suspected patient during the course of illness. For this, two blood specimens must be obtained. The first (acute phase specimen) should be obtained as early as possible after onset, preferably within the first 4 days of the disease; the second (convalescent phase specimen), 3 or 4 weeks after onset. At least 20 cubic centimeters of blood should be drawn asceptically; the serum should be separated and saved in the refrigerator in a sterile, sealed container until the second specimen is obtained and the paired specimens, together with appropriate clinical and epidemiologic data, forwarded to the laboratory. No refrigeration is necessary in transit for blood or serum specimens to be tested for antibodies, provided there is no unusual delay. The tests for antibodies are made by complement fixation or neutralization tests. A significant rise in titer between the first and second specimens is accepted as presumptive evidence of infection.

There is no specific therapeutic agent as yet available for any of these diseases. Preventive measures have not been fully formulated but, on the basis of our present knowledge, would consist of vector control and vaccination. Effective vaccines have been prepared for some of these diseases, but their general use is not advocated except in special situations. Studies are in progress with the hope of filling in the many remaining gaps in our understanding of the epidemiology of the encephalitides and ultimately of their complete eradication.

Eastern Equine Encephalomyelitis

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Eastern equine encephalomyelitis is an acute and highly fatal infectious disease caused by a virus which exhibits a wide host range, including horses and mules, pigeons, pheasants, monkeys, and man. It is closely related to, but immunologically distinct from, the viruses of St. Louis encephalitis and Western and Venezuelan equine encephalomyelitis. The virus has a widespread distribution in the tissues of the infected host, but the symptoms of the disease are referable to inva-

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sion of the brain and spinal cord. Differentiation from infection by the related viruses or from other infections of the central nervous system depends upon isolation and identification of the virus or observance of a rise in specific serum antibodies during convalescence.

The typical equine case begins with a short period of high temperature (up to 106° F.) and inappetence, followed by 1 or 2 days of apparent well-being. At the end of this time, a second rise in temperature occurs which usually reaches its peak at about 103°- 104° F. The nervous symptoms appear at this stage. The animal at first appears dazed and will wander aimlessly through fences and into objects or walk in circles. Occasionally it becomes vicious and will attack persons coming near it. Within a few hours facial and pharyngeal paralysis and motor incoordination appear, the animal leaning his head or hindquarters against objects for support, or standing with the feet widely spaced and weaving back and forth. Within 6 to 12 hours the horse falls to the ground, has repeated convulsions, exhibits alternate spasticity and flaccid paralysis of the limbs, and becomes comatose. Death usually occurs within 12 to 72 hours after the onset of nervous symptoms. An occasional animal will recover, but usually shows residual effects such as blindness, partial paralysis, severely impaired "intelligence," or an unstable temperament.

Epizootics of the disease possess certain rather characteristic features. With one exception (Michigan) the disease has appeared only in the coastal areas along the Gulf of Mexico and the Atlantic seaboard. It is a disease of summer and autumn, with a sharp drop in the number of cases with the advent of cooler weather. It usually appears in epizootic form among the equine population. The mortality approaches 90 percent. Accurate morbidity rates are impossible to determine due to inadequacies in reporting; but during one epidemic period, there were approximately 100 cases per 1,000 population among the equines of southwestern Louisiana. The morbidity is much lower in the human population, and there is an apparent predilection for children. Human epidemics may occur in conjunction with an epizootic among the equines and follow the peak of the equine cases by an interval of about 2 weeks or longer. Experimental mosquito transmission has been accomplished, and workers in the virus laboratory at Montgomery, Ala., have demonstrated the virus in nature in *Mansonia perturbans* from Georgia.

Highly efficient vaccines are available for veterinary use. This vaccine may be given to persons who may have special contact with this disease, such as laboratory workers or others unduly exposed.

The U. S. Public Health Service was invited to investigate the medical, veterinary, and entomological aspects of two severe epizootics of Eastern equine encephalomyelitis which affected the horse and mule populations of Louisiana in the summers of 1947 and 1949. During the latter year, the disease extended into central Arkansas where further studies were made. The earliest cases in both instances appeared in late spring (May and June) on the Gulf coast at points separated by approximately 70 miles, the area between consisting of relatively uninhabited swamp and marsh land. Except at the points of origin, the geographical areas involved in these epizootics showed very little overlapping. In 1947 the disease fanned out westward and northward and exhibited a rather sharp northernmost boundary which was approximately 70 miles from the Gulf of Mexico. The western extent involved Texas. In 1949 the disease progressed northward and, to a slight extent, toward the east. It followed the Mississippi Delta region as far north as the middle of Arkansas. Both areas possess a dense horse and mule population as compared to the average of the country. Wild horses, prevalent in both regions, would hinder an adequate immunization program.

Estimates, from various sources, of livestock losses in the earlier epidemic ranged from 3,713 to 11,727. Information from the latter source would indicate that the mortality was about 82 percent. A census taken 2 years previously shows 175,364 horses and mules in the parishes involved in this outbreak. If these figures can be accepted as expressing the equine population in 1947, the morbidity was about 12 percent. These figures, gathered by sending questionnaires to the practicing veterinarians, would not include cases in which a veterinarian was not consulted or those among the wild horses. The general impression was that horses were more susceptible than mules. From six farms on which Eastern equine encephalomyelitis appeared, 13 of 18 horses were affected while only 1 of 27 mules developed the disease. There was no apparent age or sex preference.

The area involved in the 1947 outbreak is flat coastal plain traversed by numerous bayous and streams. The land bordering the Gulf of Mexico is principally salt marsh with an occasional salt dome or "island" rising above the surrounding plain. The arable land is devoted almost exclusively to the raising of sugarcane. Farther inland the epizootic area consisted of large farms on which the principal crop was rice. The northernmost limit of the epizootic was in the region where the rolling "piney woods" begin. The weather had been exceedingly dry except in the immediate vicinity of the Gulf where short daily thundershowers were the rule. Due to the impassability of the roads in the winter for automobiles, most of the families had one or more riding or driving horses, and horses and buggies were almost as common as automobiles along the roads.

The first cases of encephalomyelitis were observed in May in Iberia Parish (one of the coastal parishes). From here it radiated in a northwesterly manner at a rate which progressed approximately 25 miles every 2 weeks. As the epizootic continued, the interval between the appearance of the first case in an area and the attainment of the peak of infection in that area became shorter, requiring approximately 1 month at the outset and shortening to 2 weeks toward the end of the epizootic. Losses from the disease stopped rather abruptly during the first week of October.

Despite the heavy importation of horses into the area following the epizootic, to replace those lost, the ensuing 2 years revealed few cases of equine encephalomyelitis.

During the second week of June 1949, the Louisiana State Health Department was notified of the existence of 18 cases of encephalomyelitis in horses and mules in Lafourche Parish, an area not too far distant from the point of origin of the 1947 outbreak. By the last of June, cases had been reported from almost every parish in the southeastern part of the State, having progressed as far north as the Mississippi border. The total number of reported cases had reached 202 on July 25, the date of arrival of the CDC epidemiology team. This figure did not include a possible 400 unreported cases among wild horses in the swamps in one parish. On this date the disease had progressed northward to a point almost 200 miles from its origin.

At the time of arrival of the team, the disease seemed to be currently most active in the northern section, and it was decided to conduct the major investigation here. Seven farms on which cases of encephalomyelitis had occurred were surveyed, and serum specimens were obtained from healthy and recovered horses and other domestic animals. Brains removed from sacrificed, acutely ill animals or those recently dead from encephalomyelitis, were prepared for laboratory examination.

The best available information on mortality in this area indicated that more than 90 percent of the affected animals died within 3 days after onset of symptoms, implicating the Eastern type of equine encephalomyelitis, on a clinical basis. This was later confirmed by laboratory investigations. Although there was a heavy mule population in the area, it was affected little by the disease – a fact concurring with observations in previous epidemics. There was no apparent overlapping between the two epidemics. The greatest concentration of cases in the parish surveyed (Avoyelles) existed in an area made up of large farms with long narrow pastures bordered on one side by a bayou and on the other by a large cypress swamp, approximately 4 miles wide and 10 miles long. A substantial horse and cattle population grazed here and had access to the swamp. Another severely affected area, about 15-20 miles west of the area of greatest concentration, consisted of many rice and cotton farms, averaging 30-40 acres each, with a dense human and horse population. There was no body of water within 2 miles, but the rice fields had been irrigated earlier and served as an excellent breeding place for mosquitoes. Egrets and blackbirds were the only wild birds known to be common to both areas.

This epizootic later extended to the Arkansas border and also appeared in central Arkansas, giving the opportunity for further study. The two epizootic areas apparently were not contiguous since no cases were reported in southern Arkansas. The Arkansas outbreak followed the character of that in Louisiana in that each affected region was near a great waterway – the Mississippi River in Louisiana and the Arkansas River and bayous in Arkansas. The preponderance of cases in Arkansas occurred in an area of typical, flat Mississippi Delta country, around England, Ark. A rice and cotton agriculture prevailed, with a heavy mosquito population. This region was separated by the Arkansas River on the west from a wooded, hilly area south of Little Rock, in which a moderate number of cases (35-40) had existed. The reporting in Arkansas was very irregular and no accurate estimate could be made of the total number of cases, nor could any reliable data be obtained on wild bird movements.

One thousand four hundred eighty-nine cases had been reported in the horses and mules of Louisiana as of the first of September. DDT spraying operations for reduction of insect populations in farm buildings, which were proceeding during the outbreak of the disease in Avoyelles Parish, did not appear to reduce the number of cases reported in this area, which rose from 40-42 on July 25 to 650 on September 1. Too few horses were vaccinated with Eastern equine encephalomyelitis vaccine to affect the course of the epidemic in this parish. Whether or not spraying may have had some effect on the incidence of human cases is a matter of speculation. It is interesting that in both Louisiana and Arkansas human cases remained relatively few or unrecognized. Certainly, there were no reports to indicate significant human involvement.

Various species of mosquitoes were collected for virus studies which have not yet been completed. The outstanding feature of the 1949 epidemic was its apparent tendency to follow water courses northward.

Surveys of serum antibodies have led toward the incrimination of wild and domestic birds as a possible reservoir for the virus of Western equine encephalomyelitis. Information in this regard has been lacking for Eastern equine encephalomyelitis. One hundred sixty domestic fowl were sampled in the area involved in the 1947 epizootic in Louisiana and tested for neutralizing antibodies at the Montgomery, Ala., virus laboratory. Only 2 chickens of 109 gallinaceous birds (chickens and turkeys) gave positive titers for neutralizing antibodies against Eastern equine encephalomyelitis. No positive sera were observed in 13 anserines (ducks and geese) or 38 Columbiformes (pigeons). Two cormorants (diving sea birds) showed neutralizing antibodies.

Six of eighteen unvaccinated horses with no history of encephalitic symptoms gave positive neutralization indices. Ten of eleven recovered equines were positive and all of four horses bled in the terminal stages gave positive titers.

SUMMARY

CDC investigated epizootics of Eastern equine encephalomyelitis in Louisiana and Arkansas during the summers of 1947 and 1949. These two epizootics possessed certain things in common. Both started on the Gulf coast within a few miles of each other in the late spring and spread at a rather regular rate covering approximately 25 miles every 2 weeks. Both occurred in districts which have large areas covered by still water such as swamps, bayous, and rice fields. The equine population was dense in each case, the morbidity high, and the mortality about 90 percent. Under apparently equal conditions for exposure, mules were more resistant to the disease than horses. Serum surveys revealed very few domestic fowl with significant antibody titers. Wild fowl, such as wading birds and blackbirds, were common in the epizootic areas and the mosquito population was high. Further investigation, with emphasis on the role of birds and associated arthropod vectors, has been planned by the Virus and Rickettsia Section of the Communicable Disease Center. This will be carried out in the near future in cooperation with Epidemiologic and Veterinary Public Health Services.

Western Equine Encephalomyelitis

E. R. Price

VETERINARIAN (R)*

History bears out the fact that Western equine encephalomyelitis has been with us for a long time. As early as the middle of the nineteenth century, western veterinary practitioners recognized and reported outbreaks of a febrile disease of horses, with symptoms comparable to those observed in equine encephalomyelitis today. The literature contains information on about 10 major epizootics

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occurring between 1847 and 1930; undoubtedly there were many other outbreaks that were not recorded.

It is of historical interest to note that reports of the U. S. Bureau of Animal Industry for 1912 show that 16 States had a high incidence of the disease. Kansas and Nebraska had the greatest incidence. Estimates indicate that in these two States about 35,000 equines died of this disease. Early reports of these epizootics referred to the infection under several names such as "Kansas-Nebraska horse plague," "forage poisoning," "cerebral spinal meningitis," "Borna disease," and "sleeping sickness." Some of these terms are still being used by farm people.

Specific knowledge of this disease dates from the work of Meyer, Herring, and Howitt, who in 1931 isolated the causal agent of Western equine encephalomyelitis from the central nervous system of horses.

The importance of this virus in relation to human disease became established in 1938, when Howitt isolated the Western equine strain from brain tissue of a child.

The incidence of this disease in horses is reported annually to the U. S. Bureau of Animal Industry by nearly every State west of the Appalachian Mountains. The highest incidence is found in the agricultural areas of the Midwest and the West Coast where it is endemic over wide areas and where it produces large epizootics periodically. For instance, in 1936, the 10 States in the Missouri River Basin reported a total of only 2,926 cases, whereas in 1937, some 146,587 cases were reported in the same States. The first cases usually appear with the advent of warm weather, continuing until the first freezing weather in the fall. Western equine encephalomyelitis is so closely related to the other encephalitides, that it is impossible to differentiate between them clinically or pathologically. To make a specific diagnosis, it is necessary to identify the virus by serological determinations or by isolation of the virus itself.

During 1941, 10 Midwestern States reported 28,899 equine infections. This epizootic was almost concurrent with one of the largest outbreaks of human encephalitis which occurred in the same general area. There were approximately 4,000 human cases in this epidemic with mortality of 8 to 15 percent as compared with the equine rate of 25 to 30 percent.

Animal care consists chiefly of good nursing in quiet, cool, comfortable, well-bedded quarters, protected from sun and rain. The use of anti-encephalomyelitis serum has not proved to be very satisfactory. However, there is available a very satisfactory vaccine which will produce, in 10 days to 2 weeks, nearly 100 percent immunity lasting upwards of 6 months.

The epidemiology of this virus infection is not clearly defined and, although considerable work has been done, the relationship of known facts cannot be explained at this time. Evidence of the virus has been found in many species of animals. Of the mammals, the horse seems to be the most susceptible; however, antibodies have been found in other domestic animals as well as in wild animals. Sufficient work has not been done in the Midwest to ascertain the percentage of mammals with antibodies present.

Very little has been published relative to the frequency of the disease in midwestern birds. From work done by Hammon in Oklahoma, only about 8 percent of the domestic birds and 5 percent of the wild birds showed Western equine encephalomyelitis antibodies. This is considerably lower than a comparable study made in California where 50 percent of the domestic birds and 17 percent of wild birds were found positive.

Several of the arthropods apparently play a very important part in the transmission of the disease. However, much additional work in this field is necessary before the complete cycle of the disease can be described. Several varieties of mosquitoes, mites, lice, as well as *Triatoma*, have been found harboring the virus in nature.

Realizing the importance of encephalomyelitis, the CDC is supporting an expanded investigation of this disease. An epidemiological study of encephalomyelitis in the Midwest was started in 1949. This work involves studies of the ecology of the various strains present, during both epidemic and interepidemic periods. A considerable amount of data has been obtained during the past season. Reports delineating the problem in the Midwest and presenting results of investigation to date are being prepared for publication.

Relation of Arthropods to the Epidemiology of Virus Encephalitis in Kern County, Calif.

Bernard Brookman

SANITARIAN (R) *

Kern County is situated at the southern end of the San Joaquin Valley, in the central valley area of California. The valley portion of the county, about 2,000 square miles in area, is relatively flat and has an average elevation of 490 feet above sea level. It is bordered on the south, west, and east by mountain ranges. The climate of this section of the county is characterized in the summer by high daytime temperatures and low humidities, and by comparatively cool nights; in the winter, the temperatures remain relatively low. Precipitation occurs chiefly during the spring months and seldom totals more than 8 inches per year. The chief industries in the valley are agriculture and petroleum. All crops are irrigated, the water being obtained from the Kern River through a system of canals and in many areas from deep wells. The population of Kern County for the census year 1940 was 135,124; that of 1948 has been estimated as between 214,000 and 220,000, of which approximately 121,000 live in or close to Bakersfield, the county seat.

Outbreaks of encephalitis in horses have been recognized in Kern County at least since 1930, and in man since 1938. Cases are reported each year, usually during the period from late June or early July until the end of September, or occasionally into October. In Some years the cases have appeared in epidemic proportions; in other years there have been only sporadic cases.

Three encephalitis viruses are known to occur in this area; the Western equine virus appears to be the most important; the St. Louis encephalitis virus apparently is equally prevalent but does not affect horses; and the California virus. The latter virus first was isolated from mosquitoes, and later was found to have caused a severe case of encephalitis in a child and to have produced specific serum antibodies in a number of apparently normal persons, horses, and rodents. Relatively little is known as yet about the California virus, and it will not be considered in this discussion.

Studies on arthropods and their relation to encephalitis in Kern County were started in 1943 by Drs. W. McD. Hammon and W. C. Reeves of the Hooper Foundation. In 1945, The U. S. Public Health Service began the cooperative program of research with the Hooper Foundation which has continued up to the present. This study has been conducted under the direction of Dr. Hammon, with Dr. Reeves in charge of the field studies.

Since 1943, studies have been carried on each summer in Kern County. Our primary purpose is to establish with certainty the infection chain of encephalitis as it occurs in that endemic area. When such knowledge is obtained, it theoretically would be possible to determine the weakest link of the chain, attack it at that point, and thus control the disease. To obtain such knowledge, however, it is necessary to determine the answers to the following questions: (1) What species of hematophagous arthropods are naturally infected with the encephalitis viruses? (2) Are these arthropods capable of transmitting the viruses after they become infected? (3) Do these arthropods normally feed on susceptible vertebrate hosts? (4) Are these arthropods abundant in the area during the time when encephalitis is known to be transmitted? (5) Which, if any, of the susceptible vertebrate hosts can serve as reservoirs of the viruses; that is, do any of these hosts exhibit viremia over relatively long periods of time, or do they have recurrent

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viremias? (6) If they do not have recurrent viremias, what animal does serve as a reservoir for the virus?

It appears from our present knowledge that only one species of mosquito, *Culex tarsalis*, and one species of mite, *Liponyssus sylviarum*, are commonly associated with the encephalitis viruses in Kern County. Two other mosquitoes, *Culex stigmatosoma* and *Aedes dorsalis*, occasionally have been found infected, but not with the frequency or regularity of *C. tarsalis*. Both *C. tarsalis* and *A. dorsalis* are proven vectors of the Western equine type of virus, and the former mosquito species is capable of transmitting the St. Louis virus. Transmission experiments with *C. stigmatosoma* have not been conclusive, due to the technical difficulty of inducing it to feed on experimental animals. Experiments designed to test the ability of *A. dorsalis* to transmit the St. Louis virus were conducted last summer, but the results have been inconclusive, and they must be repeated. In the case of the mite *L. sylviarum*, technical difficulties have been encountered in our attempts to effect transmission through the agency of this arthropod, since it does not lend itself readily to laboratory manipulation. Our latest attempt to transmit virus by means of *L. sylviarum* were undertaken last summer under simulated natural conditions; however, the results are not yet available.

By precipitin tests of blood meals, it has been shown that *C. tarsalis* feeds primarily on birds, but frequently feeds also on large domestic mammals, as well as on man. In addition, studies on the epidemiology of avian malaria in Kern County have proved that *C. tarsalis* feeds very frequently on wild birds – a fact that could not be ascertained by the precipitin test. In our malaria studies we found that *C. tarsalis* is the chief vector of avian *Plasmodium*, a very common parasite in the blood of wild birds in Kern County. On the other hand, *A. dorsalis* obtains its blood chiefly from large domestic animals and occasionally from man, but only infrequently from birds. In Kern County, *L. sylviarum* has been found to be specifically parasitic on wild birds. Although this mite occurs on domestic fowl in other parts of the United States, we have secured no evidence that it will attack domestic birds in Kern County; nor is there evidence that it attacks man or other mammals under natural conditions.

Extensive biological studies have been carried out both on *C. tarsalis* and on *L. sylviarum*, and it has been found that both of these arthropods are at their peak of abundance during the period when the encephalitis viruses are most active; that is, from June to September.

Results of experiments conducted in the Hooper Foundation laboratories indicate that infected domestic and wild birds are better sources of virus for arthropods than are susceptible mammalian hosts. However, avian hosts cannot be considered true reservoirs of the virus since they contain circulating virus for only a few days, and they are not known to have recurrent viremias. Apparently the immunity developed after an initial infection is sufficient to control the virus thereafter. Thus we must look elsewhere for the reservoir. At present, our best lead is the mite, *L. sylviarum*, which acquires the virus by feeding on an infected bird during the short period of viremia. It is entirely possible that this mite could transmit the virus by the transovarian route to its offspring, as has been shown for other mite-borne diseases, and later the offspring could transmit it to another susceptible bird. However, additional research is necessary to prove this point definitely.

In 1946, control operations directed specifically against *C. tarsalis* were started by the Kern Mosquito Abatement District in an attempt to break the infection chain. Sufficient time has not elapsed as yet to determine the effect of such control on the over-all incidence of encephalitis.

The writer has attempted in the above discussion to point out the known, as well as the unknown, in the infection chain of encephalitis in Kern County, in as brief a manner as possible. The infection chain may be presented graphically as follows, the unknown links being indicated by question marks:

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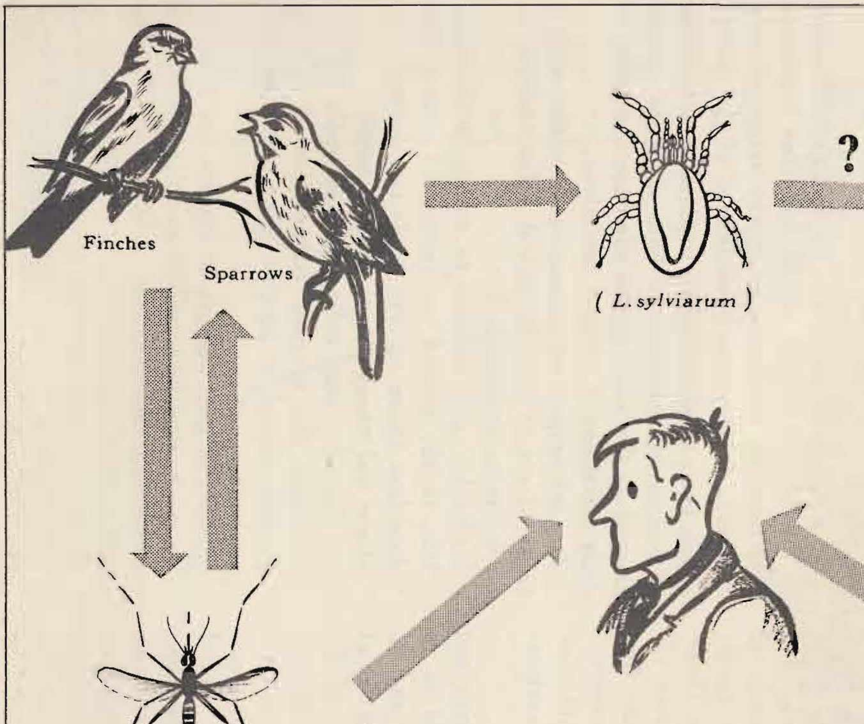
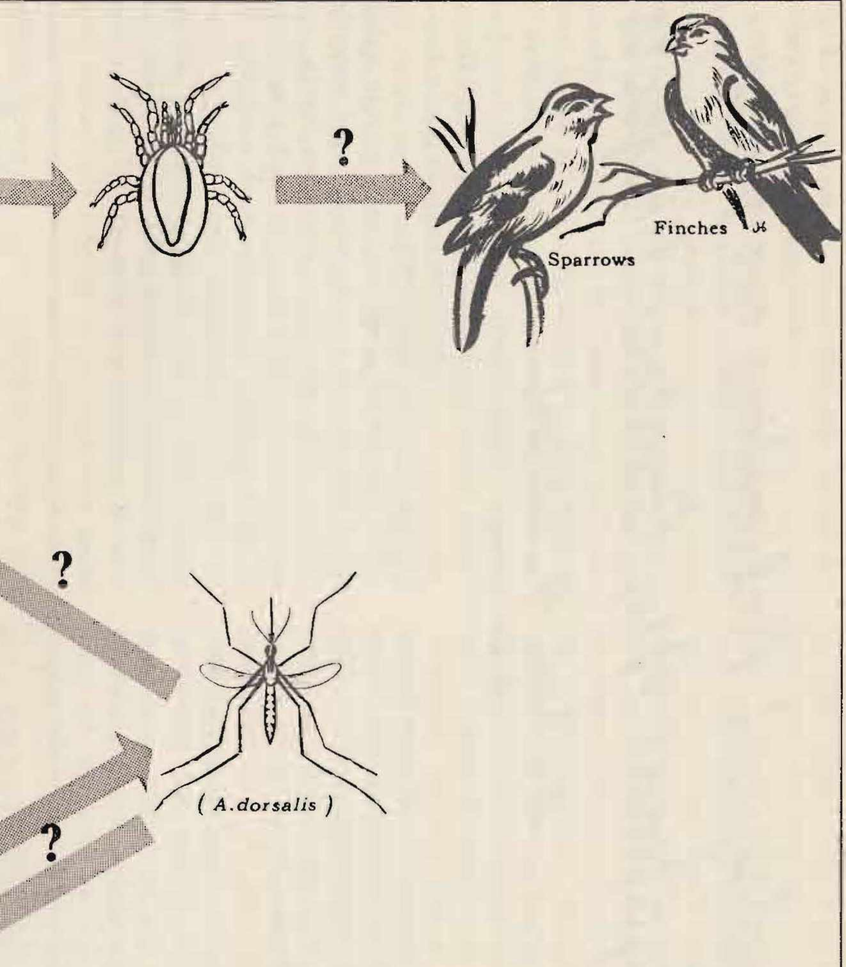




CHAIN OF ENCEPHALITIS

Entomological Activities on Polio Investigations Fly Control Projects

Herbert F. Schoof
SCIENTIST (R)

In July 1948, the Communicable Disease Center established investigative programs in five States to study the possible relationship between flies and the transmission of poliomyelitis. The projects are located at Phoenix, Ariz.; Topeka, Kans.; Muskegon, Mich.; Charleston, W. Va.; and Troy, N. Y. During the 5-year tenure of these programs, detailed epidemiological studies and operational fly control activities will be carried on at each city. The epidemiologic studies have been broadened to include other disease problems. All municipalities bear a significant portion of the operating cost of their respective programs.

The participating cities fall within the same population range (75,000–100,000), but differ widely in their relation to topography, area, prevalent species of flies, extent and magnitude of the fly breeding season, climate, sanitary conditions, racial composition, and other factors. These variations, while augmenting the difficulties of establishing uniform control practices in the five communities, also afford an excellent opportunity for conducting fly control operations and epidemiological investigations under a gamut of environmental conditions.

In the city, the responsibility for securing and maintaining effective fly control is vested in an operations team composed of an engineer and an entomologist. To obtain fly control, principal emphasis is placed upon the elimination of fly breeding foci through the improvement of the current municipal practices employed in the collection, storage, and disposal of refuse. Supplementing this phase is a generalized chemical control program involving the use of exterior space sprays, residual sprays, and larvicides. Guiding these sanitary and insecticidal control activities are entomological surveys which, as an integral part of the operations program, serve to determine the need for, as well as the effectiveness of, the various suppressive measures.

For operational purposes, each city is subdivided into five to nine sections, based upon the criteria of fly densities, sanitation levels, and socio-economic conditions. The block composition of these sections fluctuates, some containing 60 to 100 blocks (business areas) while others include 200 to 400 blocks (residential areas). Operations are formulated on a weekly cycle, the over-all treatment and inspection of each section being scheduled for a definite time-period each week. Adjustments of this schedule are made whenever weather conditions disrupt the normal operating routine.

As a necessary adjunct to the evaluation studies in the treated cities, similar but less extensive activities are conducted in nearby untreated communities, to obtain a measurement of the normal trends in an uncontrolled fly population. Inspection of comparable sections in both cities is accomplished on the same day to minimize the effect of daily variations in weather conditions.

At each project the entomologist, assisted by a corps of six to nine biological aides, carries on the following activities:

(a) Weekly grill surveys to determine fly densities in the treated and untreated cities. The data from these surveys guide the control operations and measure their effectiveness.

(b) Periodic trap collections of adult flies to ascertain the species composition of the fly population and to provide flies for virological analysis.

(c) Special grill surveys to explore the feasibility of a stratified random sampling method in evaluating fly densities (Charleston, W. Va., and Topeka, Kans.).

(d) Special grill surveys to study the residual effectiveness of the new insecticide dieldrin (497) (Phoenix, Ariz.).

(e) Investigations on the biology and ecology of the prevalent domestic flies.

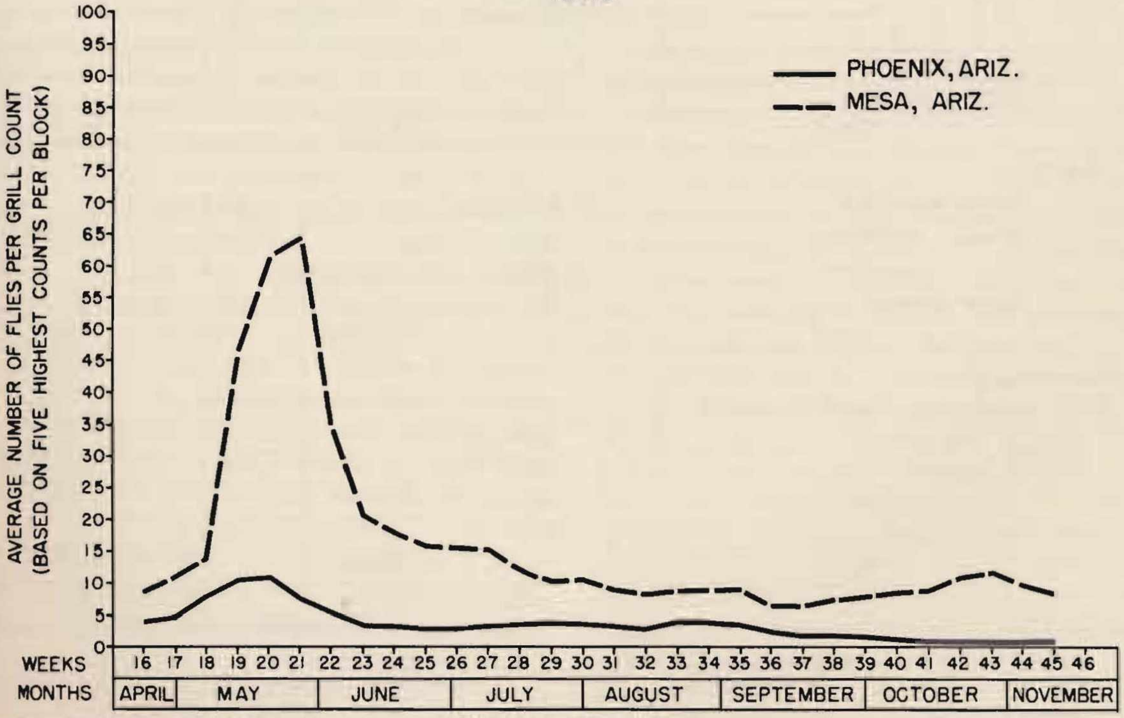
Weekly grill surveys are the chief means of measuring the fly densities in these municipalities. Such surveys entail the inspection of individual blocks, with the degree of block coverage in any given section being contingent upon the fly potentialities and/or the fly densities of that area. Because the principal fly control problems occur in sections composed of business or low-class residential blocks, these receive much greater coverage than do the high-class residential areas. In each block, an effort is made to locate and make grill counts on all major attractants (for example, garbage, animal excrement, and other refuse), with the five highest grill readings being recorded and averaged to serve as the block rating. By combining block ratings, sectional averages are derived and compared with averages for similar sections in the untreated check town (figure 1). In turn, a city index can be computed; however, the value of a city-wide index is debatable because the preponderance of low density blocks evolving from the better-class residential areas frequently tends to obscure the true control status of smaller sections where the higher fly densities prevail.

In guiding the control operations, pretreatment grill surveys are made to determine the need for treatment and to provide data to aid in the selection and placement of the control measure. A post-treatment coverage then serves as a check upon the effectiveness of the measures employed. In sections of intensive fly breeding where the levels of fly prevalence consistently are such as to require routine treatment, pretreatment inspections frequently are discontinued. While the grill surveys provide the bulk of the data upon which control operations are based, these data require interpretation in regard to prevailing weather conditions, larval findings, and other pertinent factors before plans for effective fly abatement can be formulated.

Fly-trap collections are made at the rate of 40 to 60 per week at each of the five cities. Each trap is operated for a period of 24 hours, using a bait composed of a mixture of fish or meat, and

FIGURE I

THE AVERAGE NUMBER OF FLIES PER GRILL COUNT IN THE TREATED BUSINESS SECTION OF PHOENIX, ARIZ., AS COMPARED WITH THE UNTREATED BUSINESS SECTION OF MESA, ARIZ., BASED ON A 3-WEEK MOVING AVERAGE 1949



FED. SEC. AGENCY PUB. HEALTH SERV. COMMUNICABLE DISEASE CENTER ATLANTA, GA. JAN. 1950 rotten vegetables and fruit. The flies collected are inactivated and killed by placing the trap in a cardboard drum containing dry ice. Samples obtained for qualitative studies of the fly population are dried, stored in containers with naphthalene flakes to prevent insect damage, and identified during the winter (table 1). Specimens for virological study are stored in freezer plants at subzero temperatures to preserve the polio virus until the samples are analyzed.

The collection of flies for virological examination is part of a cooperative study being conducted by the National Foundation for Infantile Paralysis, the Yale University School of Preventive Medicine, and the Communicable Disease Center to determine the occurrence and spread of polio virus in a city during pre-epidemic, epidemic, and postepidemic periods of an outbreak of this disease. Concurrent with the collection of flies, sewage samples are being taken for similar analysis, and possible correlation, between the dispersion patterns of polio virus in these two extrahuman sources.

In the special grill surveys, the sampling design consists of a stratified random sample of blocks for each weekly survey, in contrast to the operational technique whereby the areas of high fly densities receive the more intensive surveillance. Although random in its distribution, the stratified random sampling method is based on statistical principles which require larger weekly samples from those sections in which the blocks exhibit a greater degree of variance in the fly potential and sanitary standard.

To evaluate the residual effectiveness of the

TABLE 1
Species of Flies Recovered from Fly Traps Operated for 24-Hour Periods from September 1 to November 5, 1948, in Residential and Business Sections of Topeka, Kans.

Species	Number of Specimens*		Percent	
Calliphoridae:				
Callitroga macellaria	690		0.5	
Cynomyopsis cadaverina	1,343		0.9	
Phaenicia caeruleviridis	2,371		1.6	
P. pallescens	36,331		24.5	
P. sericata	18,314		12.4	
Phormia regina	6,717		4.5	
Minor species	272		0.2	
Total		66,038		44.6
Muscidae:				
Musca domestica	65,837		44.4	
Muscina stabulans	1,149		0.8	
Ophyra leucostoma	2,105		1.4	
Minor species	2,626		1.7	
Total		71,717		48.3
Sarcophagidae:				
Sarcophage haemorrhoidalis	617		0.4	
S. latisetosa	489		0.3	
S. rapax	755		0.5	
S. ventricosa	3,903		2.6	
Minor species	3,607		2.4	
Total		9,371		6.2
Minor families:		1,320		0.9
Grand Total		148,446		100.0

*Total number of collections — 64

promising new insecticide dieldrin (497) under field conditions, tests involving treatment of approximately 330 blocks were initiated at the Phoenix project in August 1949. To date the results have been promising, but are as yet inconclusive.

Investigations on the overwintering habits of flies were begun during the winter of 1949–50. Future plans include expanding these investigations and initiating others on the developmental cycles, breeding habitats, and the daily activities of the prevalent domestic flies in each of the cities.

Virus Encephalitis in the Missouri River Basin

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The arthropod-borne virus encephalitides include the well recognized entities of Eastern, Western, and Venezuelan equine encephalomyelitis and St. Louis, Japanese B, and Russian Far East encephalitis. Other new viruses, the importance of which is still not clearly defined, are constantly being discovered in various parts of the world, among them being those of West Nile, Semlike Forest, Bwamba Forest, Bunyamwera Ilheus, and California.

Although widespread infections of equines involving the central nervous system have occurred repeatedly in many parts of the United States since the early part of the nineteenth century, the etiology of such epizootics or plagues remained unknown until Meyer, Haring, and Howitt (1) isolated a virus (Western encephalomyelitis strain) from equine brain tissue in 1930. The identification of an Eastern strain as distinct from that of the Western one was made in 1933 by TenBroeck and Merrill (2). The possibility that human disease may be caused by the equine viruses was suggested by Meyer in 1932 (3), but it was not until 1938 that Howitt (4) recovered the Western strain and Webster and Wright (5) the Eastern strain from human cases. In 1933, a sharp epidemic of about three thousand human cases of an unknown encephalitis occurred primarily in the city and county of St. Louis, Mo. It quickly was shown that this outbreak was due to a neurotropic virus which is now identified as the St. Louis strain. In 1945, Hammon *et al.* (6) isolated what may be a new strain from mosquitoes in California. This is known tentatively as the California strain, and serum from a child suffering from encephalitis gave significant serological reactions to it (7). The first clue to the method of spread of these viruses was provided by Kelser in 1932 (8) when he demonstrated that *Aedes aegypti* mosquitoes could transmit an equine encephalomyelitis virus from infected guinea pigs to susceptible ones. Following this lead, the work of other investigators showed that a relatively large number of arthropods can pass the virus to susceptible animals under laboratory conditions. It was not until 1941, however, that Hammon and his associates (9) recovered encephalitis virus from wild mosquitoes. Since 1941 the viruses of Western and Eastern encephalomyelitis, St. Louis encephalitis, and the California strain have been recovered from a wide range of arthropods, many of which have been shown to be capable of passing the virus from one vertebrate to another under laboratory conditions. Furthermore, indications of infection with these strains have been found in birds and mammals, and the serological data would indicate that these infections are rather common occurrences. The results of major contributions with respect to possible vectors and reservoirs are summarized in table 1.

*Midwestern CDC Services, Kansas City, Mo.

TABLE 1

Summary of Encephalitis Virus Transmission Studies and of Natural Infections Involving Arthropods

SPECIES	LABORATORY TRANSMISSION			NATURAL INFECTIONS			
Anopheles	**Eastern**	**Western**	**St. Louis**	**Eastern**	**Western**	**St. Louis**	**Others**
maculipennis	-	-	-		+(20)		
freeborni	-	-	-				
		(20, 22)					
Aedes							
aegypti	+(8, 13)	+(13)	+(21)				
sollicitans	+(13)	+(13)					
cantator	+(13)						
dorsalis		+(14)	+(40)		+(24)	+(40)	California (24)
nigromaculis		+(15)	+(21)				
vexans		+(16)	+(21)				
albopictus		+(9)					
taeniorhynchus		+(16)	+(21)				
campestris		+(9)					
atropalpus	+(17)						
triseriatus	+(17)						
lateralis			+(21)				
Culex	-	-					
pipiens		(13, 17, 22)	+(19)			+(20)	
tarsalis	+(21)		+(18)		+(9)	+(9)	California (27)
salinarius							
coronator			+(18)				
stigmatosoma					+(24)		
restuans					+(23)		
Culiseta							
inornata			+(21)		+(20)		
incidens			–(21)				
Mansonia							
tittilans							Venezuelan (25)
perturbans				+(26)			
Dermacentor							
andersoni		+(28)	+(30)				
andersoni			transovarian passage (31)				
Triatoma							
sanguisuga					+(29)		
Dermanyssus *gallinae*			+(37)		+(33)	+(32)	
Liponyssus *sylviarum*			transovarian passage (37)		+(34)		BFS-867 strain (35)
Eomenacanthus *stramineus*				+(37)			
Liponyssus *bursa*					+(36)		

With the exception of sporadic investigations during the more severe epidemics and epizootics, little has been done which would specifically review or point up the encephalitis problem in the Midwestern area. Present conditions and contemplated future developments in the Missouri River Basin emphasize the need for such a review. The object of this paper is to present and discuss existing data for the purpose of clarifying the status of the encephalitis problem in these 10 States: Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wyoming.

INCIDENCE IN THE MISSOURI RIVER BASIN

According to published reports, two strains of the arthropod-borne encephalitides have been identified in the States herein considered. These are Western equine encephalomyelitis and St. Louis encephalitis. Since these strains infect both horses and humans, a review of their distribution and occurrence must include equine as well as human infections.

Equine Infections. Since the etiological agent of encephalomyelitis in horses was not discovered until 1931, the incidence of equine infections prior to that time cannot be established positively. Nevertheless, the numerous reports by veterinary scientists dating from 1850 which are referred to by Meyer (3) and the Botulism Commission (11) indicate that many extensive epizootics described as "Cerebrospinal Meningitis," "Borna Disease," "Nonpurulent Encephalitis," "Forage Poisoning," "Kansas-Nebraska Horse Plague," and "Botulism" occurred during the latter part of the nineteenth century, and periodically during the twentieth century. In the opinion of many investigators, these widespread outbreaks were due, at least in part, to one or more of the encephalitis viruses. The severity of these early epizootics is emphasized in reports describing such losses as 35,000 equines in Kansas and Nebraska in 1912; 1,000 in Colorado in 1919; 17 outbreaks involving 1,004 animals in Montana in 1919, and 1,500 in South Dakota in 1918.

In 1935, the U. S. Department of Agriculture, Bureau of Animal Industry, began accumulating data on the incidence of equine encephalomyelitis infections throughout the country. During the period 1935 to 1948, approximately 495,609 cases were reported. Further analysis of these reported cases show that over 385,000, or approximately 77 percent occurred in 10 Midwestern States. Details of these data are presented in table 2 and figure 1.

TABLE 2

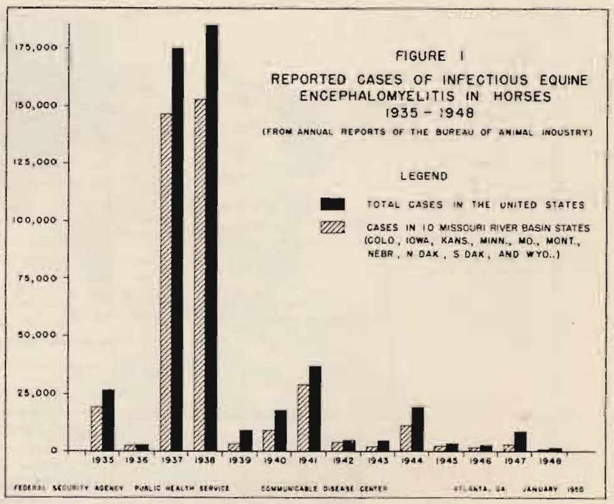
Equine Encephalomyelitis Cases Reported from the United States* and Those from 10 Midwestern States 1935-1948**

Year	United States	Midwestern States
1935	25,000***	19,980
1936	3,300***	2,926
1937	175,000***	146,587
1938	184,662	152,620
1939	8,008	3,352
1940	16,941	9,273
1941	36,872	28,899
1942	4,939	3,117
1943	4,768	1,973
1944	19,590	11,231
1945	3,212	1,442
1946	2,805	1,202
1947	8,716	2,405
1948	1,796	628
	495,609***	385,635

*U. S. Department of Agriculture Reports.

**Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wyoming.

***Approximated.



In the Midwestern area, major epizootics occurred in 1935, 1937, 1938, 1941, and 1944. During these years approximately 359,405 cases were reported. As indicated in table 3, the epizootics of 1937 and 1938 were very severe, particularly in the States of Iowa, Kansas, Minnesota, North Dakota, and South Dakota. From the tables it may also be noted that over the country generally, and in Midwestern States as well, the total number of reported cases and the size of epizootics have gradually diminished since 1938. Many factors, such as the total number of horses, number of susceptible horses, number of vaccinations, the economic value of equines, and others must be considered in interpreting these trends.

Further analysis of the incidence of horse infections for the epizootic years 1941 and 1944 are shown on figures 2 and 3 respectively. It will be noted that the geographical area involved in the epizootic of 1941 differs somewhat from that of 1944 within the States considered. During both of these epizootics, however, the incidence in hundreds of counties distributed throughout several States was considerably above the normal rate of approximately 2 cases per 1,000 animals. Furthermore, many counties had the significantly high rate of more than 10 cases per 1,000 animals. On the same basis, a review of the reported cases for the period 1941 to 1949 was completed. This is shown on figure 4. It is evident that over this

TABLE 3

Equine Encephalomyelitis Infections in the 10 Midwestern States during Five Major Epizootics*

States	1935	1937	1938	1941	1944
Colorado	1,456	2,074	3,656	1,040	255
Iowa	**	31,884	66,092	5,963	2,121
Kansas	3,000	16,257	10,250	886	1,157
Minnesota	3,337	41,159	23,686	6,777	1,470
Missouri	17	4,632	10,242	8,671	4,160
Montana	111	743	13,102	167	42
Nebraska	3,400	**	13,881	1,030	1,571
N. Dakota	8,244	20,226	2,553	2,552	126
S. Dakota	115	29,702	5,203	1,304	268
Wyoming	300	**	3,955	507	61
Total	19,980	146,677	152,620	28,897	11,231
Grand Total					359,405

*U. S. Department of Agriculture and Bureau of Animal Industry Reports.
**No data available.

FIGURE 2 EQUINE ENCEPHALOMYELITIS
MISSOURI RIVER BASIN STATES
EPIZOOTIC OF 1941

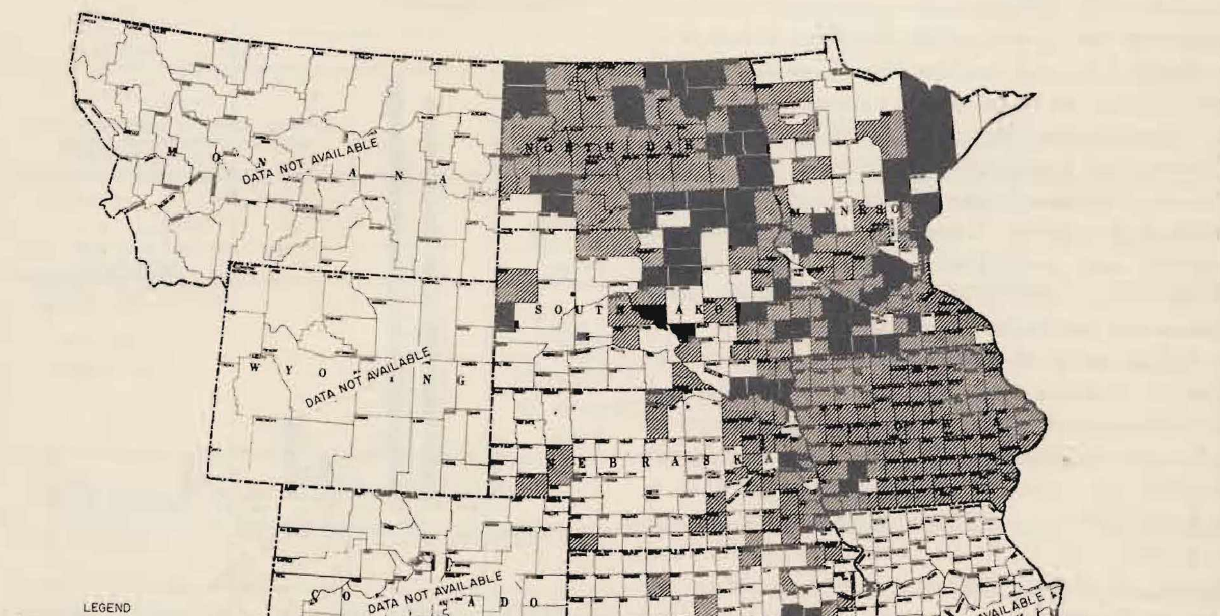


FIGURE 3 EQUINE ENCEPHALOMYELITIS
MISSOURI RIVER BASIN STATES
EPIZOOTIC OF 1944

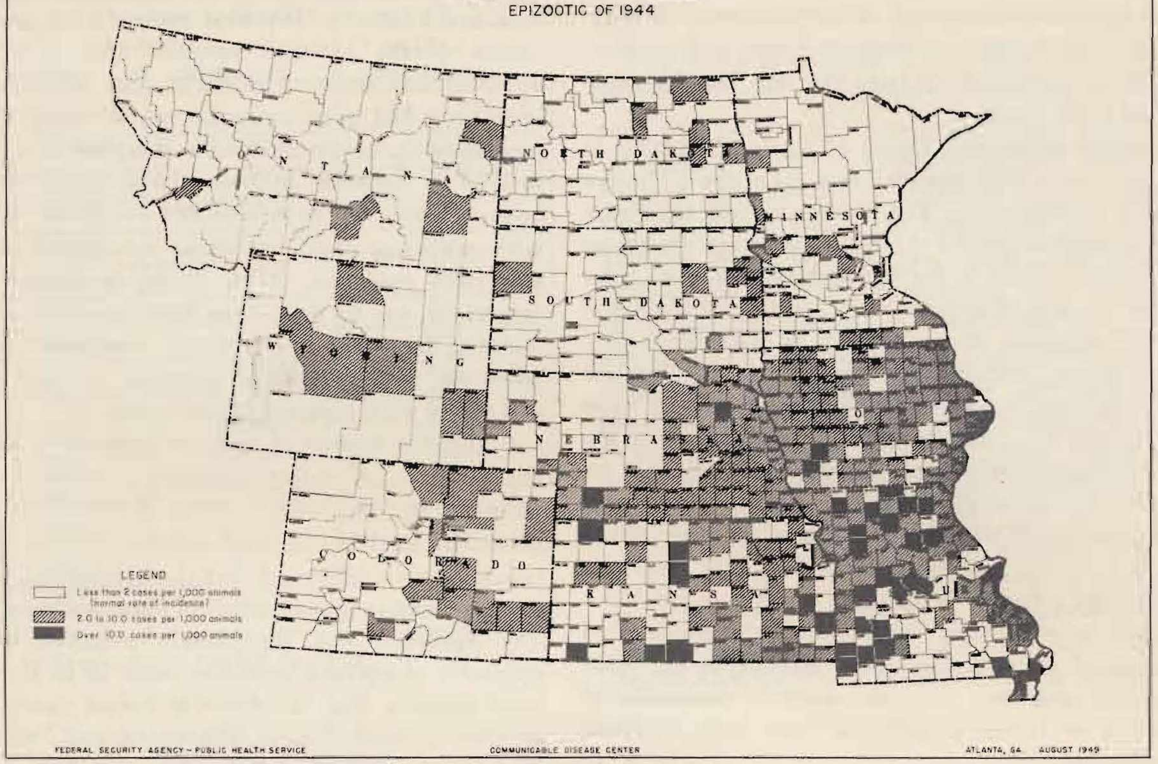
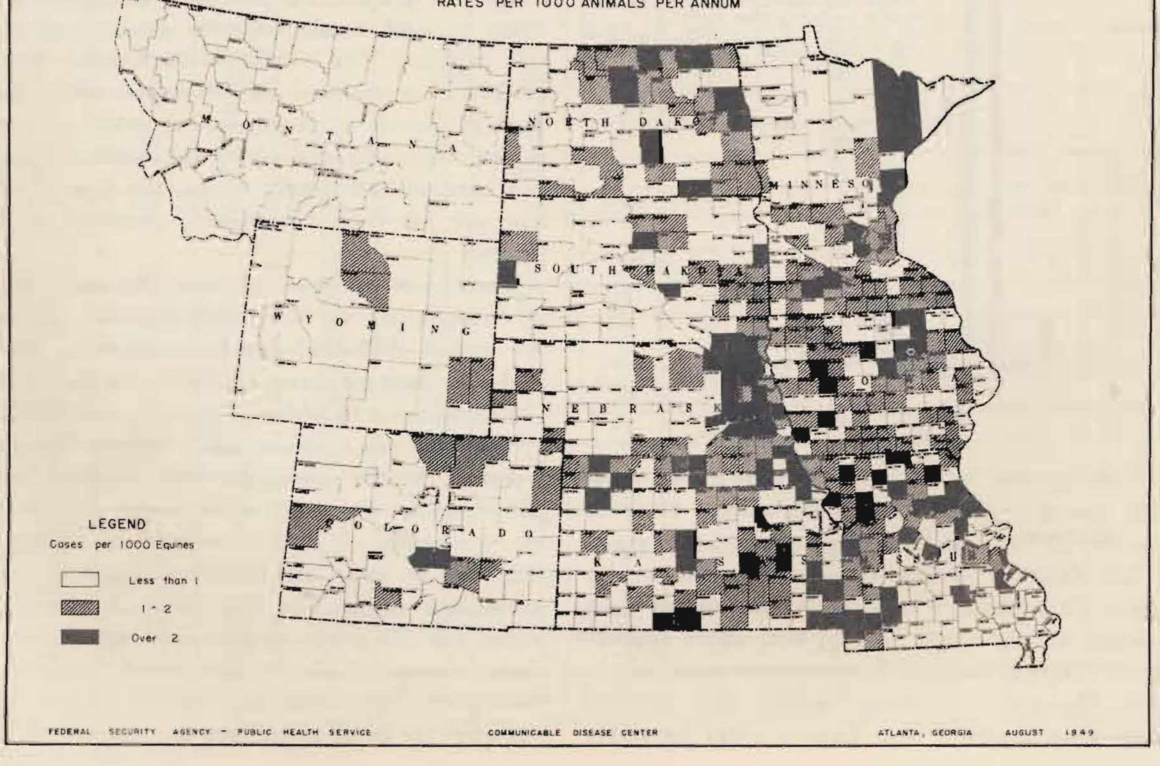
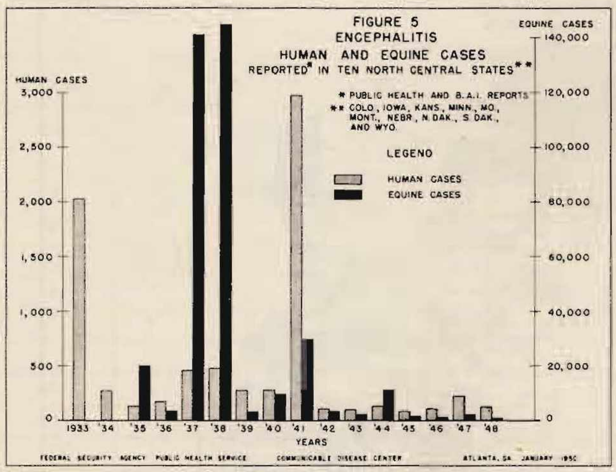


FIGURE 4 EQUINE ENCEPHALOMYELITIS
MISSOURI RIVER BASIN STATES
1941 -- 1949
RATES PER 1000 ANIMALS PER ANNUM



period the encephalitis viruses were widely distributed within nine States. In these States, nearly one hundred counties had an average rate of more than 2 infections per 1,000 animals, and in hundreds of additional counties the rate was between 1 and 2 per 1,000.

Human Infections. Cases of encephalitis in humans have been reported from all of the 10 States under consideration. The viruses of both the Western equine strain and the St. Louis strain are known to infect humans in the Midwestern area. As in the case of many diseases, the reporting of encephalitis infections among humans is considered very incomplete. Probably the biggest single reason for this is that positive clinical diagnosis is quite impossible, and that the identification of the particular strain causing an infection can only be made by serological examination. Furthermore, many encephalitic infections have occurred which do not exhibit characteristic serological reactions of known viruses. In spite of these complications which seriously affect adequate reporting, scattered cases of encephalitis occur throughout the Midwestern area each year, and sporadic outbreaks of greater or lesser proportions have been recorded (figure 5).



In the summer of 1933, approximately two thousand human cases of encephalitis were reported from the 10-State area. The major causative agent of this outbreak is now known as the St. Louis strain. The epidemic apparently was centered in St. Louis and St. Louis County, Mo., where approximately eleven hundred cases were reported. In other Missouri localities, nearly two hundred cases were reported from Kansas City; forty-five from St. Joseph, and roughly a score from Columbia. Cases also were reported from cities in Illinois and Kentucky. Inquiries made during investigation of the outbreak revealed that a similar epidemic had occurred in Paris, Ill., in 1932, but apparently had been unrecognized. Reviews of the records of St. Louis Children's Hospital from 1915 to 1933 by Hartman (38) showed that approximately forty children had been admitted during the period with symptoms similar to those recognized during the 1933 epidemic. It is likely, therefore, that infections due to this virus have occurred in the Midwest for many years. Later manifestations of infection with this virus occurred in 1937 when 338 cases were reported in St. Louis.

During the summer of 1941 an outbreak of human encephalitis, of rather alarming proportions, occurred in the North Central States. This outbreak was centered in North Dakota and Minnesota; investigations indicated that the etiological agent was the Western equine strain of encephalomyelitis. The epidemic was immediately preceded by an epizootic of equines involving some 10 to 15 thousand animals. The incidence of human cases was greatest in North Dakota, Minnesota, and Nebraska which reported 1,100, 669, and 366 cases, respectively.

Within the 10-State area, local outbreaks of undiagnosed types of encephalitis are reported almost every year. A small outbreak involving 11 cases was reported from southwestern Kansas in 1948. In 1949, an outbreak of 69 human infections of Western equine etiology was reported from north central Colorado; and during the same year, about one hundred and twenty cases, the type of which has not yet been determined, occurred in North Dakota.

Records of the reported morbidity and mortality of encephalitis for the 10 Midwestern States for the period 1933-1947 are summarized in table 4. Morbidity data for these States for the period 1930-1948 are shown in table 5. In many years the totals approximate one another, and in three of the years, reported deaths exceeded the reported cases. Allowing for the many difficulties of diagnosis, the probability is that the mortality figures are likely to be more accurate than are those of the morbidity totals. The conclusion is drawn that either the diagnosis or the reporting, or both, in those cases which do not result in death, is inadequate. If a mortality rate of 20 percent in encephalitis is allowed, then the number of cases

TABLE 4

Human Encephalitis in 10 Midwestern States

Year	Total* Morbidity	Total* Mortality
1933	2,047	-
1934	255	169
1935	147	151
1936	173	122
1937	394	265
1938	448	200
1939	268	155
1940	262	109
1941	2,824	404
1942	120	106
1943	97	128
1944	133	88
1945	66	86
1946	78	71
1947	211	87
Total	7,261	2,141

*From Public Health Reports.

must be nearly five times that of the deaths, instead of being approximately equal, as the statistics would indicate.

Infections in Animals Other Than Equines and Humans. There is considerable evidence to indicate that viruses of the arthropod-borne encephalitides may be found in numerous animals other than equines and humans. As indicated in table 1, the Eastern equine strain has been found in one species of mosquito, and one biting louse (Mallophaga). The Western equine strain has been found in at least six species of mosquitoes, one assassin-bug *(Triatoma sanguisuga)*, and three species of mites. It is important to note that this strain has been found repeatedly in the mosquito, *Culex tarsalis* Coquillette. The St. Louis strain has been found in three species of mosquitoes, and one mite, *Dermanyssus gallinae* (De Geer). The California strain was found in at least two species of mosquitoes. A neurotropic virus of unknown identity was found in the mite, *Liponyssus sylviarum* (Canestrini and Fanzago) in California. In Central America, the Venezuelan equine strain was

TABLE 5

Human Encephalitis Cases Reported from 10 Midwestern States*
1930 - 1948

Year	Colo.	Iowa	Kans.	Minn.	Mo.	Mont.	Nebr.	N. Dak.	S. Dak.	Wyo.	Total
1930	9	52	14	38	36	11	10	23	2	1	196
1931	7	40	14	28	2	7	4	10	4	2	118
1932	12	29	9	29	35	10	8	23	3	3	161
1933	14	56	167	68	1,660	10	42	24	4	2	2,047
1934	9	21	61	45	75	5	25	7	2	5	255
1935	8	17	41	31	31	8	7		4		147
1936	40	16	39	23	19	17	7	5	3	4	173
1937	9	15	77	33	190	13	21	7	27	2	394
1938	90	31	40	50	36	72	11	107	9	2	448
1939	37	24	74	14	21	65	8	19	3	3	268
1940	46	38	46	18	10	58	14	24	1	7	262
1941	158	129	69	669	18	91	366	1,100	194	30	2,824
1942	14	13	25	5	6	16	0	27	11	3	120
1943	16	9	32	3	11	2	3	9	6	6	97
1944	24	9	16	9	8	8	0	50	4	5	133
1945	8	5	21	4	7	4	5	11	1	0	66
1946	8	9	19	3	9	2	7	15	0	6	78
1947	14	32	20	13	6	11	19	91	2	3	211
1948	2	19	21	6	4	2	8	34	30	4	130
Total	525	564	805	1,089	2,184	412	565	1,586	310	88	8,128

*From Public Health Reports.

found in the mosquito, *Mansonia tittilans* (Walker). All of these arthropods, except the last, are known to occur in the Midwestern States.

Numerous published reports of serum surveys completed during epidemic and interepidemic periods show that the viruses evidently infect a comparatively large number of species of wild birds, domestic birds, and wild mammals. This is not surprising when the magnitudes of epidemics and epizootics such as occurred in 1937, 1938, and 1941 are considered.

Relatively few published reports are available which indicate the presence or absence of the viruses in animals other than humans and equines in the 10-State area. The Western equine virus has been found in the hog (12), the deer (10), the prairie chicken (10), the assassin-bug (*T. sanguisuga*), and the *C. tarsalis* mosquito (6). Hammon (39) found evidences of the Western equine strain in the chicken, mourning dove, and meadow lark, and of the St. Louis strain in the meadow lark, a woodpecker, a jack rabbit, and the red fox squirrel in Oklahoma in 1944. Extensive surveys of rodents completed by Canadian workers in Saskatchewan and Manitoba (23) have failed to demonstrate any evidence of infection.

EPIDEMIOLOGY

At present, a simple and factual description of the epidemiology of the arthropod-borne encephalitides cannot be given. Although a mass of pertinent facts has been established, certain missing information is needed before coherent and conclusive accounts are possible. Obviously, however, the data at hand permit the formulation of working hypotheses.

One such hypothesis is that blood-sucking mites, parasitic upon birds and domestic fowl, serve as a permanent reservoir of the viruses. The viruses are maintained from year to year by transovarial passage, or in overwintering populations of infected mites. These parasites initially infect their hosts, the birds; but bird-to-bird infection is largely completed by culicine mosquitoes, principally *C. tarsalis*. Repeated isolations of the viruses from culicine mosquitoes, together with successful laboratory transmission studies, quite conclusively implicate these mosquitoes in the maintenance of the infection and possibly its spread to equines and humans. At the moment, *C. tarsalis* appears to be the principal vector; but since naturally infected *Aedes* mosquitoes have been found, and since species of this genus are often very abundant and attack man and animals in large numbers, their importance as vectors cannot be discounted. The roles played by other biting arthropods cannot be evaluated on the data at present available.

DISCUSSION

It is firmly established that virus encephalitis in both humans and horses is a substantial problem in the 10 States grouped around the Missouri River. Every year a hundred or more deaths are reported, while from time to time severe epidemics appear, affecting thousands of humans, and tens of thousands of horses. The chain of events that leads to this disease is not fully understood, and no feasible methods of prevention are available at present. When an epidemic occurs, little can be done to stop it.

The incidence of encephalitis is probably much greater than would appear from official statistics. This is due to a variety of reasons, the first and most important being that virus encephalitis is extraordinarily difficult to diagnose, except possibly when it occurs in epidemic form. There are a number of organisms which can give rise to the general symptoms of encephalitis, and it is often impossible to distinguish these clinically, whereas for specific virus encephalitis infections, definite diagnosis cannot be made without laboratory assistance of a most specialized nature. In the 10-State area, such laboratory services for routine examination are almost completely lacking; therefore, encephalitis as reported in official statistics includes the epidemiological manifestations of several diseases, and it is impossible to state the relative importance of any specific one.

Another important reason for the inadequate reporting of encephalitis is that practicing physicians generally are not accustomed to contacting public health representatives in their State on such matters. This is partially due to the lack of local health services throughout large areas in many of the States. Furthermore, the distribution of physicians definitely congregated in larger towns leaves large rural areas inadequately supplied with medical attention.

Factors which would greatly improve the reporting of encephalitis as well as other diseases are:

1. Provision of adequate laboratory services, which are available to the general physician, for diagnosis of suspected encephalitis infections.
2. Provisions for the establishment of increased local health services, and closer liaison of these

services with practicing physicians.

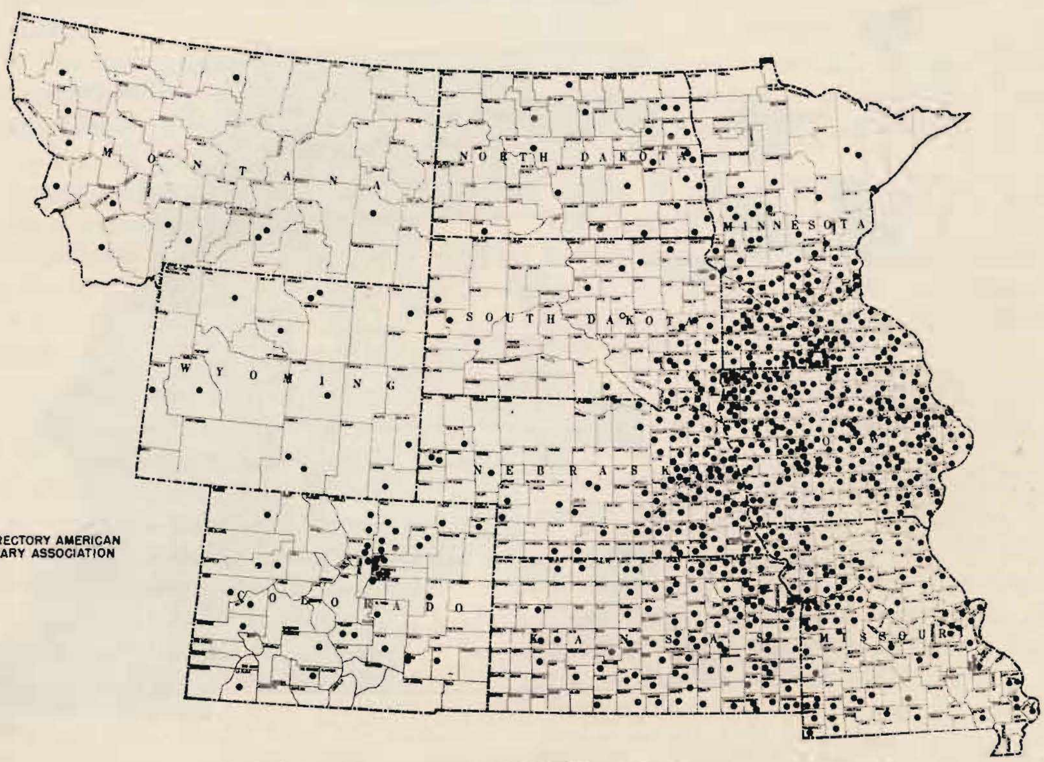
3. General recognition by practitioners that it is their responsibility to report notifiable diseases promptly.

Reporting of equine infections appears to be much more satisfactory than reporting of human infections. In the Midwestern area, where agriculture is the dominant industry, interest in the reporting of equine cases might be expected because of economic reasons. It should be recognized, however, that the distribution of veterinarians is such (figure 6) that there are large areas of the country having substantial horse populations (figure 7) where veterinary services are inadequate, and where little knowledge is available on the incidence of virus infections. Insufficient work has been done on the typing of organisms causing specific infections. Most infections reported are classified provisionally as being of Western equine etiology, whereas in actual fact these assumptions may not be justifiable. Efforts are needed to discover the relative importance of various neurotropic strains which affect equines in the Midwestern area.

Basic Biological Studies. It is evident that the virus encephalitic infections of humans and horses are only portions of a most complicated ecological process which involves many forms of animal life. Most of the studies which have been made in the past have been concentrated properly around the virus and its recovery from various host animals. It is obvious that the bionomics and interrelationship of many arthropods and animal species, such as birds and mammals, are involved in the perpetuation in nature of these infections. These phenomena are also of prime importance to those public health workers whose job it is to develop adequate control measures. Relatively little is known in the Midwestern area concerning specific bionomical features of the various animals which are undoubtedly associated with the spread of these infections. Much remains to be done in these respects before the ecology of the viruses can be properly explained, and before practical control methods can be developed. Of primary significance are:

1. The discovery of natural reservoirs of the

FIGURE 6 AREAS SERVED BY PRACTICING VETERINARIANS
MISSOURI RIVER BASIN STATES
1947*



*1947 DIRECTORY AMERICAN VETERINARY ASSOCIATION

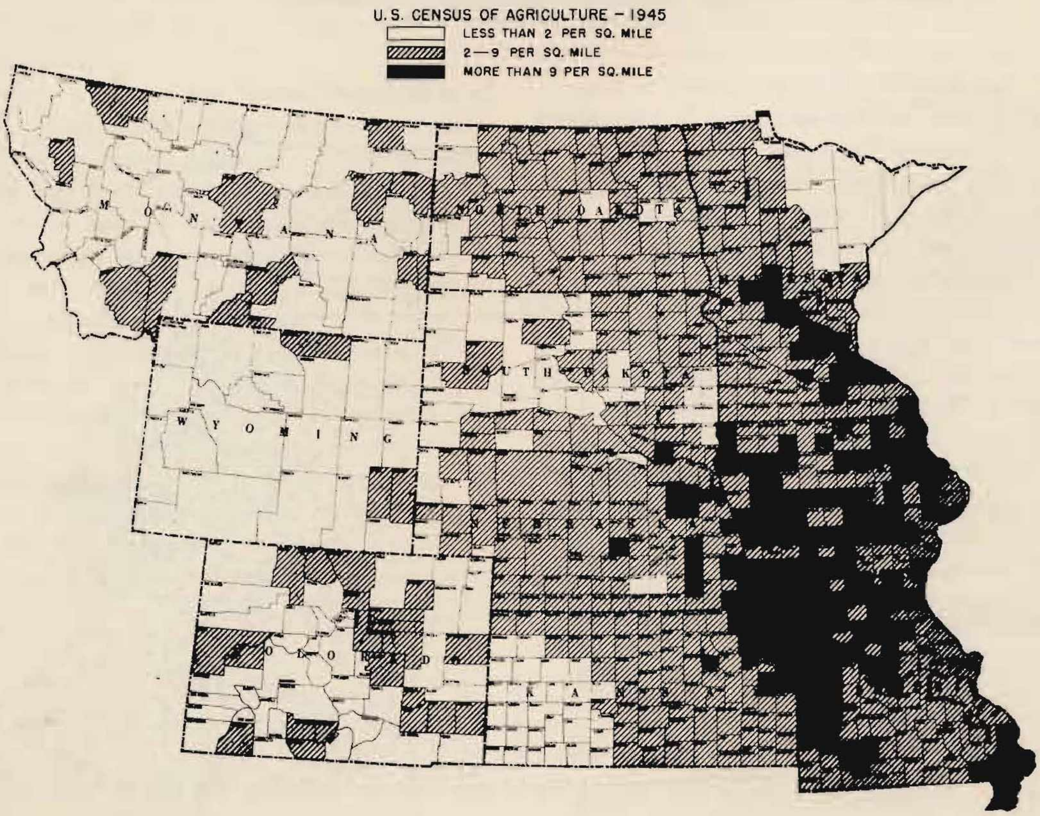
FEDERAL SECURITY AGENCY PUBLIC HEALTH SERVICE COMMUNICABLE DISEASE CENTER ATLANTA, GEORGIA JAN 1950 infections and the means by which they are maintained from year to year. If the mite-to-bird association comprises a natural cycle, such matters as taxonomy, physiology, and ecology of the mites, as well as the birds, must be thoroughly explored.

2. Additional evidence which will confirm the role of culicine mosquitoes as vectors is urgently needed, including clarification of the relative importance of the various species. The accumulation of much additional data on the bionomics of mosquitoes inhabiting the Missouri River Basin for this purpose, as well as for formulating possible means of control, is necessary.

3. In view of the close association of equine epizootics and human epidemics, further studies are needed to determine their exact relationship. Should it be that the horse is a necessary host in the chain of transmission of the virus to humans, the decrease in their numbers should be similarly paralleled by a reduction in human cases, and certainly in recent years the number of cases has shown a steady reduction. If, on the other hand, both horses and humans are in the nature of "dead ends" so far as the life cycle of the virus is concerned, then the smaller number of horses should have little effect upon the human incidence of the disease.

4. An obvious factor common to all outbreaks of encephalitis is that of water. It is water that determines where the maximum populations of people will be found, as well as that of horses, birds, mites, and mosquitoes. The area of maximum incidence of encephalitis in general coincides with that of maximum rainfall; where locations are found outside of this, usually some other source of water such as irrigation is there also. It is likely that transmission of the viruses of encephalitis is dependent upon culicine mosquitoes, and therefore any activity which involves the manipulation of water in which these mosquitoes might breed should include provisions to minimize this possibility. The construction of a large number of dams in the Missouri River Basin and the concur-

FIGURE 7 HORSE POPULATION
MISSOURI RIVER BASIN STATES



FEDERAL SECURITY AGENCY PUBLIC HEALTH SERVICE COMMUNICABLE DISEASE CENTER ATLANTA, GEORGIA DECEMBER, 1949 rent widespread use of irrigation waters, might well lead to an increase in incidence of the various virus encephalitides, unless appropriate control measures are incorporated in the project during the developmental period.

The Program of Study at Midwestern CDC Services. The primary aim is to assist the various States in their campaigns against infectious diseases. At the moment, this is limited to furnishing advice on the diagnosing of cases, and to consulting on the various epidemics, when such assistance is requested by the State health officers.

Little more than the above can be done until the epidemiology of the disease has been clarified. In the meantime, a full-scale attack is being made by a well-coordinated team of biologists, working out of Kansas City. Such a problem requires scientists trained in many branches, and the group includes an epidemiologist, a veterinarian, an ornithologist, an acarologist, and many entomologists. Cooperating with these teams are virologists from the University of Kansas Medical School, as well as the CDC Virus and Rickettsia Laboratory at Montgomery, Ala., and the Bureau of Reclamation and other government agencies. Additional specialized consultants are scattered throughout the United States. This encephalitis project covers so many fields of biology that it is only by the teamwork of scientists of many specialties that an answer can be found to the problem.

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Need for Regulations on Mosquito Control in Irrigation Systems

Nelson H. Rector
SENIOR SANITARY ENGINEER (R)

Irrigation agriculture often produces hordes of mosquitoes – particularly floodwater *Aedes* and *Culex tarsalis* – throughout the summer months. Such mosquitoes are potentially hazardous from a public health standpoint since culicine mosquitoes in general and *C. tarsalis* in particular are known to carry and are able to transmit certain viruses of the encephalitides, including equine encephalomyelitis and human encephalitis.

It is noteworthy that the most favorable mosquito breeding habitats provided by irrigation systems include water wasted through improperly designed and operated distribution systems, and seepage water through dams, levees, and drainage ditches. At present, there is urgent need for formulation of regulations to forestall the misuse of water diverted for irrigation purposes.

While it is realized that the agency which constructs a reservoir may not retain jurisdiction over water which may be released for irrigation purposes, it is likely that public health hazards resulting from improper use of irrigation water may create prejudice against the entire water system from source to point of use. For this reason, it is essential that even in the planning stages of the reservoir, consideration be given to providing the operating agency with authority to utilize regulations and/or contract provisions designed to prevent the use of irrigation water on private lands in a manner which may result in the creation of a public health hazard.

It may be desirable to provide a clause in the contract between the operating agency and the individual, corporation, or subdivision of government receiving the water requiring the latter to follow practices which would result in a minimum production of mosquitoes. The operating agency simply may wish to stipulate that it will not provide water to any water user unless the user will agree to conform with State regulations governing the impounding and use of water, and unless the State health department approves arrangements made for the proper handling and disposal of water.

If the establishment of regulations for water use is deemed advisable, such regulations should, in addition to requiring disposal of the water without undue wastage, require the contracting individual to prevent the formation of surface pools from wastage or seepage. Also it may be indicated that the water should be finally disposed of in such a manner as to prevent the formation or maintenance of mosquito breeding habitats in the disposal outlets or ditches. It is not anticipated that the operating agency will provide routine inspection or surveillance to obtain compliance with such regulations where water from the reservoir is being used on private lands, but it is envisioned that contract provisions would be a most useful means of obtaining compliance with regulations by the individuals concerned in the event of infraction of regulations.

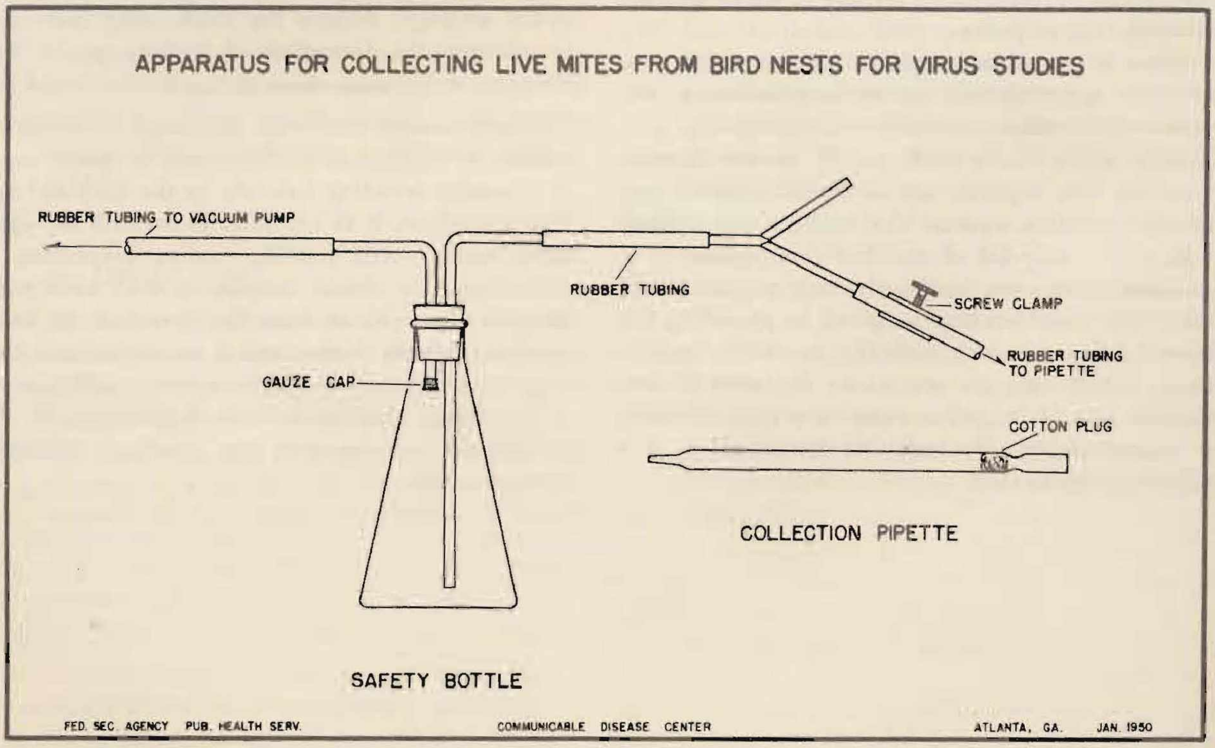
Collecting Large Numbers of Live Mites from Bird Nests for Virus Studies

Bernard Brookman

SANITARIAN (R)*

A. For the past few years interest has been focused on the mites of domestic and wild birds (particularly species of *Dermanyssus* and *Liponyssus*) as potential vectors of both the St. Louis and Western equine encephalitis types of viruses. In order to test such mites for virus infection, it is necessary to obtain adequate samples of living material either from the bird nests, or from nestling birds themselves. The method described below was developed for the purpose of obtaining such samples with a minimum of effort and loss of mites.

B. The apparatus, in essence, consists of a vacuum pump connected, by means of rubber tubing through a "safety bottle," with one or two collecting pipettes. The "safety bottle," the purpose of which is to intercept any large particles drawn by accident through the system before they reach the pump, is an ordinary 500-cubic centimeter flask. This is furnished with a two-hole rubber stopper, through which extends an exhaust tube leading to the pump, as well as an intake tube to which the collecting pipettes are connected. These tubes are



*California Encephalitis Project, George Williams Hooper Foundation, University of California Medical Center, San Francisco, Calif.

of 3/8-inch glass tubing bent at right angles a short distance above the stopper. The end of the exhaust tube which extends into the bottle is covered with a small square of cotton gauze, fastened by thread.

Collecting pipettes are made from 1/4-inch soft glass tubing. They are first drawn as ordinary Pasteur pipettes, and the points are broken off relatively short. Cotton plugs are inserted about 1 inch from the wide-open ends. Tubes then are heated between the cotton plug and the wide-open end and are drawn sufficiently to hold the plug in place when vacuum is applied. The pipettes are connected to the vacuum system by rubber tubing of any desired length. Screw clamps may be attached to the rubber tubing in order to control the flow of air through the pipettes. If clamps are used, or if two persons must collect at the same time, a glass Y-joint may be placed between the "safety bottle" and the pipette attachments.

C. Nests usually are collected just before, or as soon as possible after, they are vacated by the young birds, since we have found that the mite population is then at a maximum. The nests are placed in large paper sacks, the open ends of which are folded over several times and then carefully stapled. In the laboratory, the individual sacks are held in white enamel pans and are kept separated from each other by water barriers. This is to prevent the mites in one nest from contaminating another nest, since, in spite of all precautions, they are usually capable of escaping from the sacks.

D. In collecting, the mites are counted as they are drawn into the pipette. When the desired sample is obtained, the pipette is detached from the vacuum system. Both ends of the tube then are sealed off in a flame, the tube is labeled, and finally placed in a dry-ice box, where it is held frozen until time for inoculation.

E. Whenever possible, 1,000 mites are collected from each nest. However, since inoculation pools are limited to 250 mites each, four collecting pipettes are used for each heavily infested nest.

F. Additional specimens of mites from the same nests should be preserved in alcohol for later identification. It has been our policy to collect for identification purposes, a number equivalent to 10 percent of the frozen sample.

Missouri River Basin Health Council

The Missouri River Basin Health Council was organized approximately 2 years ago to plan and prosecute health programs associated with the Land and Water Resources Development Program of the Basin.

The Council was established by the State health departments of Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wyoming. It is composed of the State health officer and the State sanitary engineer of each of the 10 States. The Engineering Section of the Council is composed of the respective State sanitary engineers.

In the organization agreement, the Council said that the Missouri River Basin is "entering a phase of development of its natural resources that is of paramount importance to the States, communities and industries located in the Basin from the standpoint of health, water supply, industrial waste disposal, sewage disposal, recreation, irrigation, power and flood control."

The Council agreed to cooperate with the Public Health Service and other agencies involved in carrying out a policy for the protection and improvement of the waters of the Basin. The Chairman of the Council is W. S. Petty, M.D., Nebraska State Board of Health. The Secretary is Mr. L. E. Ordelheide, Director of the Bureau of Environmental Sanitation, State Division of Health for Missouri. Mr. Ordelheide is also the Chairman of the Engineering Section of the Council.

BOOK REVIEW

Malaria: The Biography of a Killer

LEON J. WARSHAW, M.D.

New York, Toronto: Rinehart & Company, Inc., 1949. 348 pp.

If it takes anything to prove that malariologists are not made in libraries, this book does it! The author is a physician practicing in New York City. He has found the time to read a considerable number of books and articles about malaria. He has merged his literary findings into a picturesque but not very critical account of developing knowledge about the disease. The major part of the book – almost nine-tenths – deals with the cause, transmission, symptomatology, and prevention of malaria. In the main, this is excellent. It is written well and interestingly and, as far as the reviewer can judge, it is a faithful piece of reporting. Perhaps the most serious criticism of this section is Dr. Warshaw's frequent failure to give credit to the authors whose works he quotes or paraphrases so freely.

The rest of the book deals with the influence of malaria on history – always an interesting but highly speculative topic – and with the present incidence and significance of the disease. It is with this last that malariologists, public health authorities, and some practitioners in the South may take violent exception.

The most quotable line in the book, according to American reviewers, is Dr. Warshaw's statement (page 6) that "it is estimated that throughout the country there is an average of 4,000,000 cases every year." Again, the doctor forgets to mention whether this is his own estimate or that of someone else – but it sounds strangely similar to one made in 1938 based on conditions prevailing during the last peak prevalence of malaria in this country. Without arguing the validity of these figures for that period, it is preposterous to claim that they represent current conditions. Dr. Warshaw either is not aware of or chooses to ignore the uniformly downward trends of reported malaria mortality and morbidity in this country since 1936. From 1945 to 1948, inclusive, the malaria cases reported by years for the nation totaled 61,411; 47,903; 16,205; and 9,868 – including extracontinentally acquired infections – and there is good reason for believing that the numbers of indigenous cases are spuriously high. Admitting the numerical fallibility of malaria case reporting, it is hard to make anything like 4 million out of these figures.

Dr. Warshaw also has failed to inform himself about the antimalarial programs carried on by the various southeastern State health departments during and since World War II in cooperation with the U. S. Public Health Service. Since 1947 these operations have been continued with the object of eradicating malaria as an endemic disease from this country. The Federal, State, and local appropriations made for the support of these programs does not indicate a "false sense of security" or "complacency" regarding the disease or a "feeble attack on it" as indicated by the author of this book.

Dr. Warshaw is very pessimistic about the world malaria problem which, he states, is as serious today as it ever has been. This is scant ackowledgment of the splendid results already obtained in the malaria vector eradication programs now under way in Sardinia, Cyprus, Tobago, and Mauritius, and the vigorous malaria control programs in Venezuela, Brazil, Argentina, Panama, Mexico, Italy, Pakistan, and India – to mention only a few of the more outstanding developments. The World Health Organization is assisting many other nations in the establishment of strong antimalaria organizations and the application of modern therapeutic and insecticidal techniques and materials. Actual incidence data to support or refute Dr. Warshaw's contention are not available but the consistent reports from these areas of diminishing malaria morbidity and mortality strongly suggest that the world malaria picture is significantly brighter now than it has been in the past.

Dr. Warshaw should have read further – or said less!

Justin M. Andrews,
Scientist Director

CDC Training Courses

Listed below are training courses, sponsored by Services of the Communicable Disease Center, to be held in the near future. Further information on the courses may be obtained from the *Bulletin of Field Training Programs* issued by the Center.

TRAINING SERVICES

1. **ENVIRONMENTAL SANITATION FIELD TRAINING**, March 6 to May 26, 1950. Twelve weeks. Denver, Colo.

2. **ADMINISTRATION OF A PUBLIC HEALTH AUDIO-VISUAL PROGRAM**, March 13-17, 1950. One week. Atlanta, Ga.

3. **RAT-BORNE DISEASE PREVENTION AND CONTROL**, March 13-31, 1950. Three weeks. Atlanta, Ga.

4. **FIELD SURVEY AND EVALUATION METHODS IN HOUSING SANITATION**, March 13 to April 14, 1950. Five weeks. Atlanta, Ga. Also March 27 to April 28, 1950. Five weeks. Syracuse, N. Y.

5. **ADVANCED SANITARY ENGINEERING TRAINING IN WATER POLLUTION ABATEMENT PROGRAMS**, March 20-31, 1950. Two weeks. Cincinnati, Ohio.

6. **FIELD SURVEY AND EVALUATION METHODS FOR MEASURING QUALITY OF HOUSING ENVIRONMENT**, April 3-8, 1950. One week. Atlanta, Ga. Also April 17-22, 1950. One week. Syracuse, N. Y.

7. **ENVIRONMENTAL SANITATION FIELD TRAINING**, April 10 to June 30, 1950. Twelve weeks. Amherst, Mass.

8. **ORIENTATION COURSE FOR SANITARY ENGINEERS IN WATER POLLUTION AND INDUSTRIAL WASTE SURVEY METHODS**, April 17 to May 26, 1950. Six weeks. Cincinnati, Ohio.

LABORATORY SERVICES

1. **LABORATORY DIAGNOSIS OF ENTERIC DISEASES – INTRODUCTORY ENTERIC BACTERIOLOGY**, March 20-24, 1950. One week. Atlanta, Ga.

2. **LABORATORY DIAGNOSIS OF PARASITIC DISEASES. PART 1. INTESTINAL PARASITES**, March 27 to April 14, 1950. Three weeks. Atlanta, Ga.

3. **LABORATORY DIAGNOSIS OF PARASITIC DISEASES. PART 2. BLOOD PARASITES**, April 17 to May 5, 1950. Three weeks. Atlanta, Ga.

VETERINARY PUBLIC HEALTH SERVICES

1. **LABORATORY DIAGNOSIS OF RABIES**, May 8-12, 1950. One week. Atlanta, Ga.

Recent Malaria Publications by CDC Personnel

MANUSCRIPTS PUBLISHED

Bradley, George H. and Goodwin, Melvin H., Jr.: Malaria observation stations of the Public Health Service. J. Nat. Malaria Soc., 8(3): 181-191 (1949).

Goodwin, Melvin H., Jr.: Observations on dispersal of *Anopheles quadrimaculatus* Say from a breeding area. J. Nat. Malaria Soc., 8(3): 192-197 (1949).

Zukel, John W.: A winter study of *Anopheles* mosquitoes in southwestern Georgia with notes on some culicine species. J. Nat. Malaria Soc., 8(3): 224-233 (1949).

Zukel, John W.: Observations on ovarian development and fat accumulation in *Anopheles quadrimaculatus* and *Anopheles punctipennis*. J. Nat. Malaria Soc., 8(3): 234-237 (1949).

MANUSCRIPTS CLEARED FOR PUBLICATION AND/OR PRESENTATION

Andrews, Justin M.: Advancing frontiers in insect vector control.

Andrews, Justin M.: The eradication of malaria in the United States.

Andrews, Justin M. and Gilbertson, Wesley E.: Final phases of malaria eradication in the United States.

Andrews, Justin M.: The physician's role in national malaria eradication.

Bradley, George H. and Lyman, F. Earle: Discussion of five years' use of DDT residuals against *Anopheles quadrimaculatus*.

Bradley, George H. and Saylor, L. W.: Malaria control through the use of new insecticides as residual sprays against adult mosquitoes.

Bradley, George H.: The Public Health Service malaria program.

Bradley, George H. and Lyman, F. Earle: Recent developments in the antimosquito work of the Communicable Disease Center, U. S. Public Health Service.

Bellamy, R. Edward and Repass, Robert P.: Notes on the ova of *Anopheles georgianus* King.

Bellamy, R. Edward: An unusual winter population of *Anopheles quadrimaculatus* Say.

Fay, R. W.: The toxicological aspect of the selection or induction of DDT resistance.

Fellton, Herman L., Barnes, Ralph C., and Wilson, Clifton A.: New distribution records for the mosquitoes of New England.

Frohne, William C., Weathersbee, Albert A., Williams, Giles M., and Hart, John W.: Observations on the persistence of *Plasmodium* infections in *Anopheles* mosquitoes in an area of low observed human malaria parasitemia in South Carolina.

Goodwin, Melvin H., Jr. and Bellamy, R. Edward: Factors influencing variations in populations of *Anopheles quadrimaculatus* Say.

Goodwin, Melvin H., Jr.: Observations on saurian malaria in southwestern Georgia.

Hendricks, E. L. and Goodwin, Melvin H., Jr.: Observations on factors influencing water levels in ponds in limestone sinks in southwestern Georgia, with particular reference to breeding places of *Anopheles quadrimaculatus* Say.

Mathis, Willis V. and Quarterman, Kenneth D.: Field investigations on the use of heavy dosages of several chlorinated hydrocarbons as mosquito larvicides.

Mathis, Willis V., Ferguson, Frederick F., Upholt, William M., and Quarterman, Kenneth D.: The relative effectiveness of DDT and DDD as anopheline mosquito larvicides under field conditions.

Pal, Rajindar, McCauley, Robert H., Jr., and Fay, R. W.: The relationship between the physical forms of DDT and biological effectiveness on water surfaces.

Peters, Richard F., Thurman, Deed C., Jr., Markos, Basil G., and Mulhern, Thomas D.: The unfolding program of vector control in California with reference to studies of mosquito biology.

Pratt, Harry D.: Notes on *Anopheles earlei* and other species of the *Anopheles maculipennis* complex.

Quarterman, Kenneth D. and Jensen, Jens A.: The outdoor residual effectiveness of several new insecticides.

Scudder, Harvey I. and Tarzwell, Clarence M.: Effects of DDT mosquito larviciding on wildlife. Part IV. The effects on terrestrial insect populations of routine DDT larviciding by airplane.

Simmons, Samuel W., and Upholt, William M.: A resume of disease control with insecticides.

Simmons, Samuel W.: A resume of recent developments on insecticides and rodenticides at the U. S. Public Health Service Laboratory, Savannah, Ga.

Stephens, Porter A.: Some recent reports on the ground application of insecticides with power equipment for the control of mosquitoes.

Tarzwell, Clarence M.: Effects of DDT mosquito larviciding on wildlife. Part V. The effects on fishes of the routine manual and airplane application of DDT and other mosquito larvicides.

Tetzlaff, Frank: Insect vector control activities of the U. S. Public Health Service.

Upholt, W. M. and Fay, R. W.: Insecticide investigations.

Some Recent Manuscripts on Encephalitis and Mosquito Control by CDC Personnel

MANUSCRIPTS CLEARED FOR PRESENTATION AND/OR PUBLICATION

Andrews, Justin M.: Advancing frontiers in insect vector control.

Bradley, George H. and Lyman, F. Earle: Recent developments in the antimosquito work of the Communicable Disease Center, U. S. Public Health Service.

Chamberlain, Roy W. and Sikes, Robert K.: A safe way of handling mosquitoes for virus transmission experiments.

Fellton, Herman L., Barnes, Ralph C., and Wilson, Clifton A.: New distribution records for the mosquitoes of New England.

Hayes, W. J., Jr. and Simmons, S. W.: The benefits and hazards of insecticides to public health.

Mathis, Willis V. and Quarterman, Kenneth D.: Field investigations on the use of heavy dosages of several chlorinated hydrocarbons as mosquito larvicides.

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FEDERAL SECURITY AGENCY

U.S. PUBLIC HEALTH SERVICE
1798
COMMUNICABLE DISEASE CENTER
ATLANTA, GA.

Material in this bulletin is not for publication.

The printing of this publication has been approved by the Director of the Bureau of the Budget, January 19, 1950.

U. S. GOVERNMENT PRINTING OFFICE : O—1950