RECURRENT ST. LOUIS ENCEPHALITIS INFECTION IN RESIDENTS OF A FLOOD PLAIN OF THE TRINITY RIVER, ROOSEVELT HEIGHTS (DALLAS, TEXAS)

JAMES P. LUBY AND ROBERT W. HALEY

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Luby, J. P. and R. W. Haley (Univ. of Texas Southwestern Medical School at Dallas, Texas 75235). Recurrent St. Louis encephalitis infection in residents of a flood plain of the Trinity River, Roosevelt Heights (Dallas, Texas). Am J Epidemiol 96: 107-113, 1972.—A serologic survey was conducted among nonwhite persons residing in a circumscribed community (Roosevelt Heights) in Dallas, Texas, situated on a flood plain of the Trinity River. In total, 214 sera were collected. St. Louis encephalitis (SLE) neutralizing antibody was found in 13.6% of the sample and rates revealed a statistically significant trend to increase by length of residence, suggesting that this community had experienced recurrent SLE infection. Western equine encephalitis (WEE) antibody was found in 1.9% of the survey population. The finding of a community with recurrent SLE infection approximately 100 miles west of the towns that had previously been investigated was thought basic to the epidemiologic proof that an interaction did exist between the two established transmission cycles for SLE virus in Texas (SLE, WEE-Culex tarsalis mosquitoes and SLE-Culex quinquefasciatus mosquitoes).

antibodies; arbovirus; encephalitis, California, St. Louis, Eastern and Western equine; serology; survey; virus, Tensaw

INTRODUCTION

In a previous report, the antibody status of residents of communities located along the Trinity River between Dallas and Houston, Texas, was investigated for evidence of prior infection with the viruses of St. Louis encephalitis (SLE), Western equine encephalitis (WEE), and the La Crosse strain (LAC) of California encephalitis (1). Houston and Dallas had previously both been the sites of major SLE epidemics (2-7). The study revealed low rates of SLE antibody in five of the six towns surveyed. There was a slight tendency for SLE antibody prevalence to decrease in going down the river from Dallas to Houston. Persons with WEE antibody

1 From the Department of Internal Medicine, University of Texas Southwestern Medical School at Dallas, Texas 75235. (Reprint requests to Dr. Luby.)

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were found only in the towns closest to Dallas. The results seemed best explained by assuming an interaction between the two established transmission cycles of SLE virus in Texas (SLE, WEE-Culex tarsalis and SLE-Culex quinquefasciatus). Although overall SLE antibody rates tended to increase with age, recurrent infection with this virus could not be documented in any of the towns.

We thought that basic to the epidemiologic proof of an interrelationship between the two transmission cycles was finding a community in the central part of the state where recurrent transmission of SLE virus to the human population could be documented and where Culex quinquefasciatus was the primary vector of SLE. A certain background of WEE infection could be expected to be present in such a population. The present study represents an attempt to find such a community on the Trinity River farther west of the towns that previously had been investigated.

To our knowledge, in areas of Texas where Culex quinquefasciatus is the predominant mosquito species responsible for transmission of SLE virus to man, there has been only one prior study (Corpus Christi, 1966) which has suggested recurrent human infection (8). The post-epidemic Houston serologic survey indicated but a single significant episode of SLE virus transmission to the human population (9). The surveys in the Lower Rio Grande Valley after the 1954 epidemic and in Cameron County after its 1957 outbreak were performed using the complement fixation test and could not be expected to yield information on recurrent infection (10, 11). A 1942 study in the Lower Rio Grande Valley, however, revealed evidence that SLE virus had caused human infection in that region previously (12).

**Materials and Methods**

**Description of survey community.** Roosevelt Heights, situated on a flood plain of the Trinity River, in the center of metropolitan Dallas, was chosen as the survey location (figure 1). Approximately 100 non-white families reside here. The community is in a transitional woodland and is about 100 miles distant from Trinidad, previously the town farthest west on the river that had been investigated. Roosevelt Heights is recurrently flooded and because of this is isolated from urban Dallas by a strip of unpopulated land. There is no organized system for the drainage of surface water, and housing conditions thought to predispose to SLE infection such as open foundations, inadequate screening and lack of air conditioning are common (9). Despite the fact that cases of SLE were documented from adjacent populated areas during the 1966 Dallas epidemic, no cases were reported from Roosevelt Heights, suggesting a level of pre-existing immunity to this virus. Culex quinquefasciatus is the predominant mosquito species collected in this community. In 1969, a documented human death due to WEE virus occurred in a rural Dallas County town, approximately five miles southeast of Roosevelt Heights (13).

**Survey procedures.** During July 1970, with the cooperation of the City of Dallas Health Department and community leaders, two teams each consisting of a physician and a public health nurse went from door to door completing interview forms and obtaining a blood specimen from each consenting person. Revisits to households were made when working family members could have been expected to be at home. In total, blood samples were obtained from 214 persons.

**Serologic methods.** In addition to SLE and WEE and because of the scarcity of reports from this area of the country regarding infection with other arboviruses, we performed antibody studies on the sera against Eastern equine encephalitis (EEE), the La Crosse strain of California encephalitis, and Tensaw (TEN) viruses.
of the viruses of SLE, WEE and EEE according to standardized techniques (14, 15). The sera were adsorbed with kaolin and goose erythrocytes prior to testing. Sera showing complete inhibition of hemagglutination at a 1:10 dilution were subsequently studied further by plaque reduction neutralization tests (PRNT). To differentiate antibodies specific for SLE from that related to previous dengue 2 infection, neutralization tests against both viruses were performed on all sera shown to have group B antibody by the screening HI test against SLE viral antigen. Dengue is known to have been epidemic in the Houston-Galveston area in 1922 (16).

Due to a lack of ready availability of hemagglutinating antigens for LAC and TEN viruses, we performed PRNTs against these agents on all the sera collected.
Table 1

Roosevelt Heights (Dallas, Texas) serologic survey: neutralizing antibody prevalence by age

<table>
<thead>
<tr>
<th>Age</th>
<th>Sample size</th>
<th>Neutralizing antibody prevalence (%)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>SLE</td>
</tr>
<tr>
<td>0–24</td>
<td>111</td>
<td>10.8</td>
</tr>
<tr>
<td>25–49</td>
<td>40</td>
<td>12.5</td>
</tr>
<tr>
<td>50+</td>
<td>63</td>
<td>19.0</td>
</tr>
<tr>
<td>Total</td>
<td>214</td>
<td>13.6</td>
</tr>
</tbody>
</table>

PRNTs against SLE, WEE, LAC and TEN viruses were performed at a 1:2 dilution of serum on primary hamster kidney monolayers. Dengue 2 PRNTs were performed at the same serum dilution on VERO cell monolayers. All the PRNTs were conducted with approximately 100 plaque-forming units of the viruses listed and a diluent containing 12.5 per cent fresh, non-immune human serum.

The serologic tests employed the following virus strains: SLE (Parton), dengue 2 (Tr 1751), WEE (a 1969 Dallas human brain isolate) (13), EEE (Fleming). The TEN virus strain was originally isolated from mosquitoes in Houston and was obtained from the Texas State Health Laboratory, Austin, Texas.

RESULTS

SLE and dengue 2. Thirty-nine persons, 18.2 per cent of the survey population, had sera with SLE HI test titers ≥1:10. None of these persons had been in the Armed Services and none gave a history of immunization or potential exposure to the viruses of yellow fever or Japanese B encephalitis. By combining the results of differential PRNTs against SLE and dengue 2 viruses, the following four categories of group B arboviral infection could be recognized:

1) SLE—25 persons, 11.7 per cent of the survey population, had sera which reduced SLE virus plaque number >90 per cent; corresponding dengue 2 values were always less than 90 per cent.

2) SLE and dengue 2—four persons, 1.9 per cent, had both SLE and dengue 2 PRNT values >90 per cent.

3) Dengue 2—six persons, 2.8 per cent, had sera which reduced dengue 2 virus plaque number >90 per cent and SLE PRNT values always less than 90 per cent.

4) Group B, undetermined—four persons, 1.9 per cent, had PRNT values against either SLE or dengue 2 viruses <90 per cent; in these persons, SLE HI test titers were either 1:10 or 1:20.

A total of 29 persons, 13.6 per cent of the survey population, thus had specific serologic evidence of preceding SLE infection (SLE; SLE and dengue 2). Persons with specific dengue 2 antibody were 44 years of age or older.

SLE neutralizing antibody prevalence for men in the sample (13.8 per cent) did not differ from that for women (13.3 per cent). The prevalence of both total SLE HI antibody and specific neutralizing antibody directed against the SLE virus increased progressively with age (table 1, figure 2). There was a statistically significant trend (p < 0.01) for SLE neutralizing antibody rates to increase by length of residence (with and without adjustment for age) (figure 3) (17). Crude rates by respective

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**Figure 2.** Roosevelt Heights (Dallas, Texas) serologic survey. Per cent of persons by age and final SLE serologic test results.
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length of residence categories (<5, 5–9, 10–19 and 20+ years) were 3.9 per cent, 11.1 per cent, 15.9 per cent and 20.7 per cent. These same age adjusted rates were 2.9 per cent, 8.2 per cent, 17.1 per cent and 19.9 per cent. Age adjustment was performed so that the proportion of persons by age group (0–24, 25–49 and 50+ years) in each length of residence category corresponded to that for the total sample (18). Within this particular community, specific SLE antibody prevalence showed only a slight tendency to be affected by conditions such as houses with open foundations, inadequate screening and the presence of domestic fowl on the premises (table 2).

WEE, EEE, LAC, and TEN. Three persons, 1.9 per cent of the survey population, each had WEE HI test titers of 1:40 and each serum reduced WEE virus plaque number by 100 per cent. No person had HI antibody directed against EEE virus. Twelve persons, 5.6 per cent, had PRNT values >90 per cent against LAC virus while 29 persons, 13.6 per cent, had sera which reduced TEN virus plaque number >90 per cent.

The three persons with WEE neutralizing antibody were all 50 years of age or older and each was a long-term resident of Roosevelt Heights (table 1). None had either resided in or traveled to West Texas. Although LAC antibody prevalence increased progressively with age, there was no tendency for this rate to increase by length of residence; 11.8 per cent of persons residing in Roosevelt Heights less than five years had LAC antibody, as opposed to 5.2 per cent of the sample residing in this community for 20 years or longer. All of the persons with LAC antibody had been born either in Arkansas, Louisiana or East Texas. In contrast, TEN virus antibody rates increased both by age and length of residence. One family of 10 members, recent migrants from Arkansas, had five persons with positive TEN virus PRNTs. If this family was excluded from analysis, 7.3 per cent of persons residing in Roosevelt Heights less than five years had specific TEN antibody as opposed to 13.8 per cent of persons residing in this community 20 years or longer.

![Figure 3. Roosevelt Heights (Dallas, Texas) serologic survey. SLE neutralizing antibody prevalence by length of residence (adjusted for age).](image)

*Sample size shown in parentheses.

**Table 2**

| Roosevelt Heights (Dallas, Texas) serologic survey: SLE neutralizing antibody prevalence by various environmental conditions* |
|---|---|---|---|---|
| Housing foundation | Air conditioning† | Adequate screening | Domestic fowl on premises |
| | Open | Closed | Absent | Present | Absent | Present | Yes | No |
| SLE+ (No. of persons) | 14 | 9 | 17 | 11 | 10 | 17 | 6 | 23 |
| Total at risk | 86 | 78 | 127 | 71 | 63 | 123 | 34 | 178 |
| SLE+ (%) | 16.3 | 11.5 | 13.4 | 15.5 | 15.9 | 13.8 | 17.6 | 12.9 |

*Excludes persons where response is unknown.
†Includes evaporative coolers.
DISCUSSION

The demonstration of a progressive increase in SLE neutralizing antibody prevalence both by age and length of residence establishes that persons in Roosevelt Heights have, in all probability, experienced several episodes of exposure to infection with this virus. Specific WEE antibody was found in three persons, 1.9 per cent of the survey population, and all were long-term residents of this community.

The existence of a community such as Roosevelt Heights with recurrent SLE infection on the Trinity River farther west of the towns that previously had been surveyed provides further epidemiologic evidence consistent with the hypothesis that an interaction did exist between the two established transmission cycles for SLE virus in Texas. The significance of the present study and the previously published Trinity River serologic survey is that along a 250 mile west-to-east stretch of a single ecological setting, the Trinity River, human antibody prevalence patterns suggest the presence of a transition zone between these two transmission cycles. From the viewpoint of West Texas or Houston, the cycles appear distinct. In Dallas (Roosevelt Heights), recurrent SLE infection is observed along with a low rate of preceding WEE infection. In rural towns closest to Dallas, on the Trinity River, sporadic SLE and WEE infections coexist. Near Houston, only sporadic SLE infections can be shown to have occurred.

It is of interest to compare these results with a serologic survey performed in Hale County in West Texas during 1965 (19). In that region, Culex tarsalis is the mosquito vector and SLE and WEE viruses are generally considered to be enzootic. As uncovered by that survey, overall human antibody rates for SLE and WEE were 18 per cent and 27 per cent, respectively. Rates for both viruses showed a progressive tendency to increase both by age and length of residence.

Recurrent SLE infection in residents of Roosevelt Heights implies a regular mechanism by which this virus is maintained in Dallas or for its periodic introduction. Since, in general, urban epidemics of SLE are characterized by their abrupt occurrence followed by the disappearance of manifest virus activity during the ensuing years, it has been postulated that discrete introductions of the virus into cities explain these outbreaks. The findings of the present study argue against the thesis that the 1966 Dallas epidemic represented the solitary exposure of its population to the SLE virus and that the outbreak was somehow related to the events that had occurred two years earlier in Houston. In view of the lack of direct evidence supporting the concept that migrant birds from Central or South America contribute significantly to the epidemiology of SLE virus in Texas, it is tempting to suggest that the Dallas epidemic resulted from spillover of SLE virus into the urban epidemic transmission cycle (SLE-Culex quinquefasciatus) from the rural endemic-epidemic transmission cycle (SLE, WEE-Culex tarsalis) (20). It is noteworthy that both SLE and WEE virus activity in West Texas was at an increased level during the period 1963–1965, just prior to the Dallas epidemic (21–23). During 1965, in one county in West Texas, between 58 and 75 per cent of sentinel chickens sampled had serologic evidence of recent SLE infection (24).

The present survey revealed the absence of EEE virus antibody in persons residing in Roosevelt Heights. LAC antibody rates seem best explained by the migration of previously infected persons into this community. The antibody prevalence pattern with regard to TEN virus can probably be accounted for by assuming both indigenous transmission and migration of persons with specific antibody from the rural, southeastern portion of the country. TEN virus has been isolated from mosquitoes in Dallas County, in a location close to Roosevelt...
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The significance of this latter agent in the causation of human disease remains to be determined.

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