sideration as vectors, primarily on the basis of their distributions, which were inconsistent with those of the haemorrhagic fever cases.

Of 14 strains of dengue virus isolated from the mosquitos processed, 12 were from pools of *A. aegypti*, one from *C. tritaeniorhynchus*, and one from *A. albopictus*. Significantly fewer *A. aegypti* were collected than any other species under consideration. The 12 dengue isolations from 3867 specimens of the single species *A. aegypti* contrasted sharply with the two isolations from the remaining 69 479 mosquitos processed. The isolation of a virus from a mosquito in nature does not in itself imply that the mosquito can transmit the virus. Since the distribution of *C. tritaeniorhynchus* is primarily rural and suburban, in contrast to the urban distribution of haemorrhagic fever, the isolation from that species was not considered significant. The distribution of *A. albopictus* was also inconsistent with the haemorrhagic fever distribution, especially in Bangkok, where only a few specimens could be found. *A. albopictus*, however, is an efficient vector of dengue experimentally and in some areas is considered a vector of classical dengue on epidemiological grounds. Although the evidence suggests that *A. albopictus* was not a vector of haemorrhagic fever, it may be a vector of mild endemic dengue disease, the distribution of which may differ from that of haemorrhagic fever.

A. aegypti occurred most commonly in urban areas, and within them in greater numbers in the most densely populated districts. Its distribution corresponded to that of haemorrhagic fever cases, and such cases were known to have occurred in *A. aegypti*-free areas.

The data assembled in the surveys reported here appeared to incriminate *A. aegypti* as the primary vector of the viruses causing haemorrhagic fever in the Philippines, Thailand, and Malaysia.

1815

Epidemiology of Haemorrhagic Fever in Singapore *

K. A. LIM & Y. C. CHAN

Haemorrhagic fever first appeared in Singapore in 1960 when over 200 cases were reported, mostly in young adults. Dengue type 1 and type 2 viruses were isolated in this outbreak.

Since 1960, cases have continued to occur sporadically, and up to July 1964 there had been a total of 1224 hospitalized patients. About half of these cases were confirmed by serological tests as infections caused by dengue-type viruses.

The proportion of cases occurring in young children is increasing from year to year, but the mortality remains low. The case-fatality rate among hospitalized patients for the years 1963 and 1964 was estimated to lie between 4% and 15%. There was no sex or ethnic difference in incidence.

* From the Department of Bacteriology, University of Singapore, Singapore. Originally issued as document IR/Haem.Fever/Sem.1/WP/41.

1816

Studies of the Ecology of Dengue in Malaysia *

ALBERT RUDNICK [1]

In August 1962, preliminary studies of the ecology of dengue viruses, based on the hypothesis that dengue is a zoonosis, were initiated in Malaysia. Over 2000 animals, representing more than 45 species of 20 genera, and approximately 25 000 live adult mosquitos were collected in areas of differing ecology.

Attempts to isolate dengue virus in infant mice from the mosquitos and animal sera and tissues failed. Most of the animal sera are still untested serologically, but, of 223 wild monkey sera collected in areas away from normal human activity, 62.8% neutralized 2 log or more of dengue virus and 10% neutralized more than 4 log. Only 4.3% of 46 monkey sera tested had related Japanese encephalitis

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[1] International Center for Medical Research and Training, G. W. Hooper Foundation, University of California Medical Center, San Francisco, Calif., USA; and Institute for Medical Research, Kuala Lumpur, Malaysia.

neutralizing antibody and none of 18, positive by haemagglutination-inhibition for dengue and Japanese encephalitis, had yellow-fever neutralizing antibody.

In Malaysia, where several closely related arbovirus group B agents are active, it is difficult to conclude on the basis of serological evidence alone that any one virus of the group is present in an area. Nevertheless, careful and critical interpretation of serological results may provide valuable clues and good presumptive evidence. The analysis of the limited serological data available so far suggests very strongly that strains of dengue virus were infecting monkeys in forest areas away from normal human activity and in the absence of *Aedes aegypti* mosquitos.

Of the potential forest vectors of dengue, *Aedes albopictus* is the most likely candidate. It is a known efficient experimental vector, is abundant in most areas surveyed, and is active in the forest canopy as well as at ground level. Other suspect forest vectors might include species of *Armigeres*, *Heizmannia*, and *Aedes* (*Stegomyia*), but many of these occur in relatively small numbers and are spotty in their distribution.

One of the most striking features observed in this study, as well as in previous surveys made in the Philippines, Thailand, and Singapore, was the contrasting distributions of *A. aegypti* and *A. albopictus* and their relationship to the distributions of dengue and haemorrhagic fevers. If it is accepted that dengue originated in South-East Asia and *A. aegypti* in Africa, then the native *A. albopictus* has had a longer-standing association with dengue than *A. aegypti* and may be the primary vector. *A. albopictus* occurs in areas away from man as well as in urban centres, and undoubtedly, has primary or preferred hosts other than man in its active forest habitats, while the recently introduced *A. aegypti* is found only in association with man. The apparent detection of dengue neutralizing antibody in high titre in monkeys in isolated forest areas and its apparent presence in man in areas free from *A. aegypti*, together with the distribution pattern of *A. albopictus*, suggest that dengue also has vertebrate hosts other than man. Introduced into the *A. albopictus* environment, man may be an aberrant host for the virus. Evidence suggests that the native *A. albopictus*-transmitted dengue is a mild, often unrecognized disease, while dengue transmitted by the introduced *A. aegypti* is a more serious illness which may appear in epidemic form. This apparent difference may represent a modification in virus strains due to a change from a native to an introduced invertebrate host.

A. aegypti is continuing its spread in South-East Asia, along with the postwar growth of cities and towns, as evidenced by its progressive replacement of the competing native *A. albopictus*. In urban Bangkok, *A. aegypti* has almost completely replaced *A. albopictus*. The mosquito-borne haemorrhagic fever syndrome may possibly result from further virus modification associated with the progressive replacement of *A. albopictus* by *A. aegypti* in urban areas of South-East Asia. This thesis would help explain the apparent absence of haemorrhagic fever cases in resident European and American children who usually live in areas where their exposure to *A. aegypti* is less than to *A. albopictus*. The displacement of *A. albopictus* may leave the human population virtually unprotected against the *A. aegypti* strains of dengue, where the former had been supplying immunizing doses with the original mild strains. Haemorrhagic fever incidence in Bangkok, Manila, Singapore, and Penang appears to be directly related to the *A. aegypti*–*A. albopictus* population balance in those cities.

1817

Occurrence of Haemorrhagic Fever in Thailand, 1958-64 *

SUJARTI JATANASEN [1]

The first big outbreak of haemorrhagic fever in Thailand occurred in Bangkok in 1958. The numbers of cases admitted to hospital in Bangkok and Thonburi during the six years 1958-63 were 2418, 124, 1742, 481, 4185 and 1657, respectively—a pattern showing a higher incidence of the disease in alternate years. During the first seven months of 1964, 3936 cases were admitted to hospital.

Analysis of data concerning the hospitalized cases in Bangkok and Thonburi has shown that in 1958 the over-all case-fatality rate was 10%, the rate in different age-groups varying from 3.3% to 14%.

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