THE DISTRIBUTION OF *AEDES AEGYPTI* IN THAILAND

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INTRODUCTION. The distribution and abundance of *Aedes (Stegomyia) aegypti* Linnaeus have been matters of concern to entomologists and other public health workers in Southeast Asia for many years. Initially, this concern arose chiefly from the possibility of the introduction of yellow fever into the area, from Africa or the New World. This has never come to pass, for reasons still not completely understood. James (1913) conducted early investigations of tropical ports because of the fear that yellow fever might reach the British possessions in Asia through shipping using the then newly opened Panama Canal. Stanton (1920) surveyed a number of Asian ports for *aegypti,* and Barraud (1928) compiled a list of the Indian records for the species, again with the yellow fever danger in mind.

More recently, Reid (1954) and Macdonald (1956) studied the species in Malaya, primarily from the viewpoint of implementation of the International Sanitary Regulations governing the inspection of airports and aircraft used in international travel. Since 1952 these regulations have required that international airports in yellow fever receptive areas be kept free of *Aedes aegypti.* The most recent impetus for the study of *Aedes aegypti* in Asia came from the report of Hammon and his associates (1960) concerning the appearance of a hemorrhagic disease in children in Manila and Bangkok. From the beginning of these investigations it appeared quite certain that *Aedes aegypti* was the prime suspect as the vector of this unusual disease. The best evidence available at the time was that hemorrhagic fever, a severe disease of children, was caused by one or more types of dengue virus. Another arthropod-borne agent, chikungunya virus, was also present in the population, but was presumed to play a lesser role in the disease picture. The following notes on the distribution of *Aedes aegypti* are based primarily on studies of the epidemiology of hemorrhagic fever by members of the SEATO Medical Research Laboratory, subsequent to Hammon's initial study.

PRELIMINARY OBSERVATIONS. It is generally agreed by entomologists and zoogeographers that *Aedes aegypti* has its point of origin in Africa. Mattingly (1953) and others have reported that a sylvan form of the species is presently found in Africa, breeding in treeholes, and found far removed from human habitations. This form appears to be darker than the individuals found in urban situations in Africa and elsewhere in the world. There is also reported to be a quite pale form, also domestic in habit, in Australia and elsewhere in the tropics. The precise status of the domestic forms is a matter for further investigation.

All of the specimens examined from Thailand thus far appear fairly dark. There is no evidence available today concerning the earliest time at which the species may have reached Thailand. It may have occurred in antiquity, since Chinese and Arab sailing vessels have visited ports on the Indian Ocean for many centuries. The first record of *aegypti* in Thailand was published in 1907, by Theobald (1907), without indication of locality. Theobald (1910) later reported additional specimens from Phatthumthanee. Macdonald (1956) indicated that Leicester found *aegypti* almost entirely coastal in its distribution in Malaya in the early 1900's and concluded

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that the introduction might have been of fairly recent date. It is not clear, however, how much collection had been done in either Malaya or Thailand prior to these records in the early years of this century.

Stanton (1920) found *aegypti* rather common in Bangkok by 1920. By 1937 Causey (1937) was able to find the species in every village examined along the railroad from Bangkok to Chiengmai (Fig. 1), and in many coastal villages on the

FIG. 1—Outline map of Thailand, showing some of the sites mentioned in text. (U. S. Army photograph, Medical Audio Visual Department, Walter Reed Army Institute of Research.)

Gulf of Thailand accessible only by boat. He did not find *aegypti* in isolated villages more than a few miles from the coast, nor more than a few miles from the main rail, water and road lines of transport. It can be assumed, in the absence of detailed historical information, that *Aedes aegypti* entered Thailand sometime prior to the present century, probably through Bangkok and other ports on the Gulf of Thailand, the Indian Ocean and Andaman Sea. Once having gained a foothold in the country, it was spread rather rapidly along the major lines of commerce, probably by the transport of the relatively hardy egg stage.

PRESENT STUDY. An extensive survey of the Bangkok mosquito fauna by Bhatia (1951) and the collections reported by Rudnick and Hammon (1960) showed that the species has been very abundant in Bangkok in recent years. From 1961 to 1964, personnel of the SEATO Medical Research Laboratory have collected *aegypti* in many parts of the city for virus isolation attempts, and a follow-up of its seasonal distribution. *Aedes aegypti* is one of the most abundant mosquito species in Bangkok, and it is by far the most important day-biting mosquito. It is found throughout the city, even in areas where breeding places are not obviously abundant. The chief breeding places are various containers, mostly large earthenware jars, used for the storage of drinking and cooking water. Adult *A. aegypti* are present all year, but are most abundant in the rainy season (May to November), particularly shortly after the onset of the monsoons.

By the end of 1963 this organization had made a number of dengue virus isolations, and had confirmed the observations of Rudnick and Hammon (1960) which tended to incriminate *A. aegypti* as the vector of the virus of hemorrhagic fever. Chikungunya virus was also isolated from *A. aegypti* during the study. A related mosquito, *Aedes albopictus,* was found in very small numbers in Bangkok and Dhonburi, usually breeding in bamboo stumps.

In 1962, cases of hemorrhagic fever were reported for the first time from cities and villages outside the Bangkok-Dhonburi metropolitan area. No comprehensive countrywide survey for *Aedes aegypti* had been recorded for Thailand, but preliminary observations by our collectors, and conversations with Thai public health workers, indicated that *A. aegypti* was probably present in most of the urban

centers. As our investigations of the numerous 1962 outbreaks proceeded, it became apparent that this was indeed the case. Collections in the coastal towns of Rayong Province, and along the railroad in Southern Thailand disclosed populations of *aegypti* which equalled or exceeded those of Bangkok. Outbreaks occurred in several other cities in Thailand in 1962, and in each of them where mosquitoes were collected, *Aedes aegypti* was present in large numbers.

During the same year, however, mosquito collections were being made in other parts of the country in connection with other studies, and *Aedes aegypti* also appeared in some of these collections in large numbers, in the absence of obvious cases of hemorrhagic fever. Therefore, in 1963 a more systematic series of collections was made in various parts of the country to obtain additional information on the distribution of *aegypti*. In addition, technicians collecting mosquitoes for other studies were asked to pay particular attention to *Aedes aegypti,* especially when working in the more remote areas.

By the end of the 1963 collecting season it was apparent that the initial impression was correct, and that *Aedes aegypti* could be found in Thailand almost anywhere that there was a significant concentration of people and dwellings. Specimens were collected from Chiengrai in the north, from Udorn and Ubol in the east, from all of the cities of the Central Plain which were examined, and from villages and towns in Southern Thailand and on the Southeastern coastal plain. The cities of Bang-Pa-In, in the central rice plain, and Pakchong, on the edge of the Korat Plateau, were visited at frequent intervals in 1963, and *A. aegypti* was found throughout the year. The city of Pakchong had a particularly high population, approaching an *aegypti*-index of 100 percent. It may be worth noting again at this point that many of these cities, such as Pakchong, appeared to escape the hemorrhagic fever epidemic of 1962, and the smaller epidemic of 1963.

One of the more important questions involved in the distribution of *Aedes aegypti* in Thailand is its possible extension to isolated areas, particularly in forested or jungle regions. The problems of control or eradication of the species would be immensely complicated by such an adaptation. As noted above, some forms of *A. aegypti* are sylvan in their African habitat, the larvae being found in treeholes, or in rock holes. The urban forms of the species have also been reported to breed in treeholes occasionally in Malaya (Macdonald, 1956), Bangkok (Scanlon, 1963) and the Caribbean (Kellett and Omadeen, 1957). In the latter cases however, the trees involved have always been very near large concentrations of humans. During the course of intensive mosquito surveys by our collectors evidence was sought of a possible extension of *Aedes aegypti* to purely sylvan situations, both in isolated human dwellings, and in forested areas.

A few *aegypti* larvae were found in a single water jug at an isolated house in the Ban Lamung District of Cholburi Province, during malaria surveys. This house was located on a busy jeep track which permitted access to the coastal highway some 20 kilometers distant. There was no evidence that *aegypti* had become permanently established at this house, or at any of the numerous other isolated farm houses in the area. A small number of larvae were found at the schoolhouse and at homes in the nearest village, some three kilometers distant. This same experience was repeated at many places in the country. In southern Thailand, for instance, many *aegypti* were collected in villages in Surathani Province where hemorrhagic fever occurred in 1962. These villages were strung out in a linear pattern along the railroad, and the *aegypti*-index approached 100 percent. Lateral roads in the area were very poorly developed, but passable during the dry season. A team of experienced collectors was unable to find any *aegypti* adults or larvae in isolated villages some miles from the railroad, nor did they detect any sylvan breeding by *aegypti* despite the fact

that they examined several hundred treeholes and collected many other mosquito species from them.

As noted above, the city of Pakchong on the Khorat plateau yielded large numbers of *aegypti* during routine surveillance in 1963. The Khao Yai National Park, located some 40 kilometers by road to the south of Pakchong, was also visited by mosquito collectors several times during the year. The Park was found to have a particularly rich mosquito fauna, but no *aegypti* were found.

A survey was therefore made in June 1964, beginning at Pakchong, and ending in the Park. Several groups of villages were visited along the Thanarat highway, the only good road leading into the Park area, and the *aegypti* index was calculated for each village. At the time of the survey (1–5 June, 1964) the city of Pakchong had an *aegypti*-index of 93.6 percent calculated on the basis of 507 houses examined. Over 25,000 adult *Aedes aegypti* were taken by the four collectors. The five villages examined along the highway leading to the Park were located at distances ranging up to 1,500 meters from the road. The *aegypti*-indices for these villages are shown in Table 1. Large numbers of *aegypti* were found up to 25 kilometers from Pakchong. Beyond that point the terrain rises rapidly and tropical evergreen forest replaces the cleared agricultural land along the road. No other dwellings were found near the road until approximately the 40 kilometer mark. In that vicinity about one hundred Park employees live in several groups of houses in or near the jungle. No *Aedes aegypti* were found in or near these houses, nor were any found feeding in the jungle, despite the intense breeding just a few miles away, and the frequent vehicular traffic along the Park road. *Aedes albopictus* and *Armigeres subalbatus* were the most common man-biting mosquitoes in the Park and were also the most abundant among the approximately forty species found breeding in treeholes in the forest.

TABLE 1.—*Aedes aegypti*-indices in villages on the Thanarat Highway (Pakchong to Khao Yai) Thailand. June 1964.

Distance from Pakchong (Km)	Houses examined	Index [1]
0–1 [2]	507	93.7
1–10	36	81.6
11–20	18	94.4
21–25	42	93.3
40	8 [3]	0.

[1] Percentage of houses examined having adult and/or immature *Aedes aegypti*.

[2] Pakchong City, and three houses one kilometer distant.

[3] Houses of forestry workers in Khao Yai National Park.

DISCUSSION. The results of these various surveys bear out the initial impression that *Aedes aegypti* is primarily an urban mosquito in Thailand, with some extension to small villages along the lines of water or land communication, and with a very infrequent extension to more isolated locations. Macdonald (1956) reported a very similar situation in Malaya. There, too, the species was most abundant in urban areas, and in well populated coastal villages, with an occasional extension to more isolated villages. Macdonald felt that the possibility of the establishment of a sylvan segment of the population was a possibility which should be kept constantly in mind.

With the present distribution of the species there seems little chance that *Aedes aegypti* can be eradicated from Thailand without tremendous expense and organization. The experience of the Pan American Health Organization in the New World shows that *Aedes aegypti* can be controlled or eradicated in tropical areas under favorable circumstances. However, if the species becomes established in a sylvan situation eradication will become a practical impossibility. The fact that this has not happened in the period of at least sixty years since *Aedes aegypti* entered Thailand is somewhat reassuring. But, the obvious plasticity of a species which has permitted it to follow man almost everywhere in the moist tropics should give us pause. Effective control measures in the cities and large

towns of Thailand should be instituted to interrupt the transmission of dengue in these centers. Control in the smaller villages should be considered as well. It should be borne in mind, however, that there is at least one native species of mosquito, *Aedes albopictus,* which is an effective laboratory vector of dengue virus, and has been implicated on epidemiological grounds. Complete eradication of dengue virus thus appears to be beyond the capability of present technology. There is also a possibility that a sylvan cycle of dengue exists, involving *Aedes albopictus,* possibly other mosquitoes—and jungle-dwelling vertebrates.

SUMMARY. *Aedes aegypti,* a mosquito believed to be African in origin, has become widespread and abundant in Thailand. It has been distributed largely through human activity, and it is strongly tied to man as a source of blood meals. In Thailand, it is primarily an urban species, but large populations may be found in smaller towns and villages, particularly along the main lines of commerce and travel. *Aedes aegypti* larvae are sometimes found in treeholes near human habitations in Thailand, but there is no indication that it has become completely sylvan, as some forms are known to be in Africa. In forested areas of Thailand *Aedes aegypti* is replaced by other members of the subgenus *Stegomyia,* notably *Aedes albopictus.* Both of these species are believed to be vectors of dengue fever virus, but only *Aedes aegypti* has been associated thus far with the hemorrhagic form of the disease which has appeared in children in some parts of Thailand. The distribution of *aegypti* appears to be much wider than the hemorrhagic form of the disease in Thailand. No satisfactory explanation for this pattern of distribution is available as yet. Effective control or eradication of *Aedes aegypti* should reduce or eliminate epidemics of classical dengue fever and hemorrhagic fever in urban areas, but the presence of natural populations of *Aedes albopictus* may make eradication of the diseases impossible.

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