ANNUAL PROGRESS REPORT

SEATO Medic Study No. 40	Arthropod-borne Viruses in the Bangkok Area
Project No. 3A 025601 A 811	Military Medical Research Program S. E. Asia
Task 01:	Military Medical Research Program S. E. Asia
Subtask 01:	Military Medical Research Program SEASIA (Thailand)
Reporting Installation:	US Army-SEATO Medical Research Laboratory APO 146, San Francisco, California
	Division of Medical Research Laboratories
	Department of Medical Entomology
Period Covered by Report:	1 April 1963 to 31 March 1964
Principal Investigator:	Major John E. Scanlon, MSC
Reports Control Symbol:	MEDDH-288
Security Classification:	UNCLASSIFIED

ABSTRACT

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The objective of the study was to collect mosquitoes and from these collections to determine the possible role of man-biting species in the transmission of Thai hemorrhagic fever. Mosquitoes were collected in Bangkok using a variety of techniques from August 1961 to March 1964. Thai hemorrhagic fever is an acute febrile disease of children in Bangkok, with frequent fatal outcome. Over sixty species of mosquitoes were found in the city, but less than a dozen of these fed on man in large numbers. Dengue and chikungunya viruses, the presumed etiological agents of the disease were isolated from Aedes aegypti, and the population curve of this species is related to the curve of the hemorrhagic fever epidemic. Chikungunya virus was also isolated from C. quinquefasciatus, but the population curve for this species is quite different from the epidemic curve. Data are presented on the habits and distribution of several of the other important man-biting mosquitoes of Bangkok, and all of the species found in the city are listed.

BODY OF REPORT

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FINAL REPORT

Objective: To determine the species of mosquitoes which attack man in the Bangkok area; and to further determine which of these may serve as vectors of various diseases in the area. Particular emphasis has been placed on the determination of the vector of Thai hemorrhagic fever. Thai hemorrhagic fever, an acute and often fatal childhood disease, had been seen in the city of Bangkok in epidemic form during the rainy season since 1956. It was strongly urban in character and dengue and chikungunya viruses had been associated with it. The initial approach to the study was to determine: 1. the species of mosquitoes which commonly feed on man in Bangkok and environs, 2. the presence of virus in these mosquito

species, 3. the relationship of mosquito population curves to the epidemic curve in the city.

Description: Initially, mosquitoes were collected in a wide variety of sites in Bangkok and the surrounding rural areas, in order to determine the species present, their relative abundance, and their breeding sites. Collections were made by all standard methods, including: house and animal shelter resting collections, standard New Jersey mosquito 66 light traps, and human and animal biting collections. All living mosquitoes were brought to the laboratory for identification. Females taken in satisfactory condition were frozen and turned over to the Virus Department, SMRL, for virus isolation attempts. From February 1962 to January 1963 the collections were concentrated in five areas of the city with approximately equal population but widely diverging character. Simultaneously, the Virus Department conducted serological and other studies on the human and animal populations in the areas. From April 1963 to March 1964 the mosquito collections were repeated in two of the areas surveyed in 1962-1963.

Progress: This report deals primarily with the populations and biting habits of the various mosquito species encountered in the study. While virus isolations are mentioned and discussed briefly for comparative purposes, the full account of the virus isolation program will be found in the reports of the Virus Department.

At the time the study was initiated approximately fifty species of mosquitoes had been reported from the vicinity of Bangkok by a number of workers. The most complete survey (made by Dr. Bhatia, World Health Organization) covered only a relatively short time span in 1951. No information was available on the seasonal trends of the mosquito populations in the city, although it was generally accepted that the population, as measured by the complaints of human biting, was lowest during the 'summer' months of March to May. Many of the species reported by previous workers from Bangkok were not known to attack man, and the relative abundance of the various human-biting species was unknown. Our initial surveys indicated that relatively few species were attracted to man in sufficient numbers to serve as potential vectors of virus diseases. By the end of 1961 fifty-four species of mosquitoes had appeared in our collections. The species biting man in the greatest numbers were found to be: Culex quinquefasciatus, Aedes aegypti, Mansonia uniformis, Culex tritaeniorhynchus, Culex gelidus, Mansonia indiana, Anopheles annularis, Anopheles vagus and Armigeres subalbatus. Of these, Aedes aegypti and Armigeres subalbatus were predominantly day time biters, while the others were chiefly nocturnal. An analysis of

the 1961 collection data revealed that one species, the uniquitous house mosquito, Culex quinquefasciatus (= fatigans auct.) was overwhelmingly abundant in all sections of the city, and that Aedes aegypti was also widely distributed here. Interest also centered on these species, since previous workers had reported that both of them might be involved in the transmission of the virus or viruses of HF in Bangkok. Some indication of the relative abundance of Culex quinquefasciatus may be had from an examination of Table 1, where the attack rate in human biting collection averaged over 22 per half hour. Aedes aegypti does not appear in the list of species since the collections were entirely nocturnal. The C. quinquefasciatus count was much higher in other parts of the city. The collections listed in Table 1 were made on a rural fringe of Bangkok in order to permit simultaneous collection from large animals. It will also be noted in Table 1 that C. quinquefasciatus is strongly anthropophilic, relatively little attracted to domestic animals. This was found to be equally true of A. aegypti as expected. During this initial period 15,763 C. quinquefasciatus and 739 Aedes aegypti females were preserved for virus isolation, but no agents were recovered.

In January 1962 twenty areas within Bangkok of approximately equal size were selected for a coordinated study of the presence of viruses in the human and mosquito populations. The areas were selected with the aid of statisticians of the World Health Organization in Bangkok, based upon the enumeration districts of the most recent census. Five of the areas were further selected for detailed mosquito studies (fig 1). All of the collection methods mentioned above were employed and collectors were present in the areas from 0400 to 1300 and from 1500 to 2300 hours five days a week, giving a very extensive coverage of the areas. In addition, several all-night collections were made, but it was determined that the catch in these was not sufficiently different from the schedule adopted to warrant using this technique routinely.

The choice of the areas was dictated largely by a desire to include as many different representative types of human environment as possible within practical limits of transportation and time. A general description of each of the areas is given below:

Area 3- Bangsue: A newly developed area, consisting of small homes set among groves of coconut and fruit trees. Many of the orchards are irrigated by ditches in a grid system. Hedgerows of bamboo and other plants are common, and in places it is difficult to see the homes due to dense vegetation. The population is largely Thai, with Chinese merchants in shop-houses along the major streets.

Table 1 Nocturnal mosquito species attacking man and cow - Bangkok.

Species	Human (318 collections[1].) Total	Human (318 collections[1].) Per Collection[2].	Cow (84 collections) Total	Cow (84 collections) Per Collection
Anopheles aconitus	2		2	
Anopheles annularis	4		69	0.8
Anopheles argyropus	1	-	49	0.6
Anopheles barbirostris	2	-	2	
Anopheles nigerrimus	3		47	0.6
Anopheles peditaeniatus	2		36	0.4
Anopheles sinensis	1	-	20	0.2
Anopheles subpictus	-		9	0.1
Anopheles vagus	11	-	897	10.7
Culex bitaeniorhynchus	2		5	
Culex fuscanus		-	1	
Culex fuscocephalus			65	0.8
Culex gelidus	47	0.2	1174	14.0
Culex quinquefasciatus	7031	22.1	58	0.7
Culex sitiens	21		4	
Culex tritaeniorhynchus	162	0.5	1193	14.2
Mansonia annulifera	29	-	35	0.4
Mansonia indiana	105	0.3	39	0.4
Mansonia uniformis	270	0.9	1944	23.1
Total	7693	24.2	5649	67.3

1. A collection consists of the female mosquitoes collected in one half hour by one man, from his bare legs, or a bait animal.

2. Values less than 0.1 not recorded.

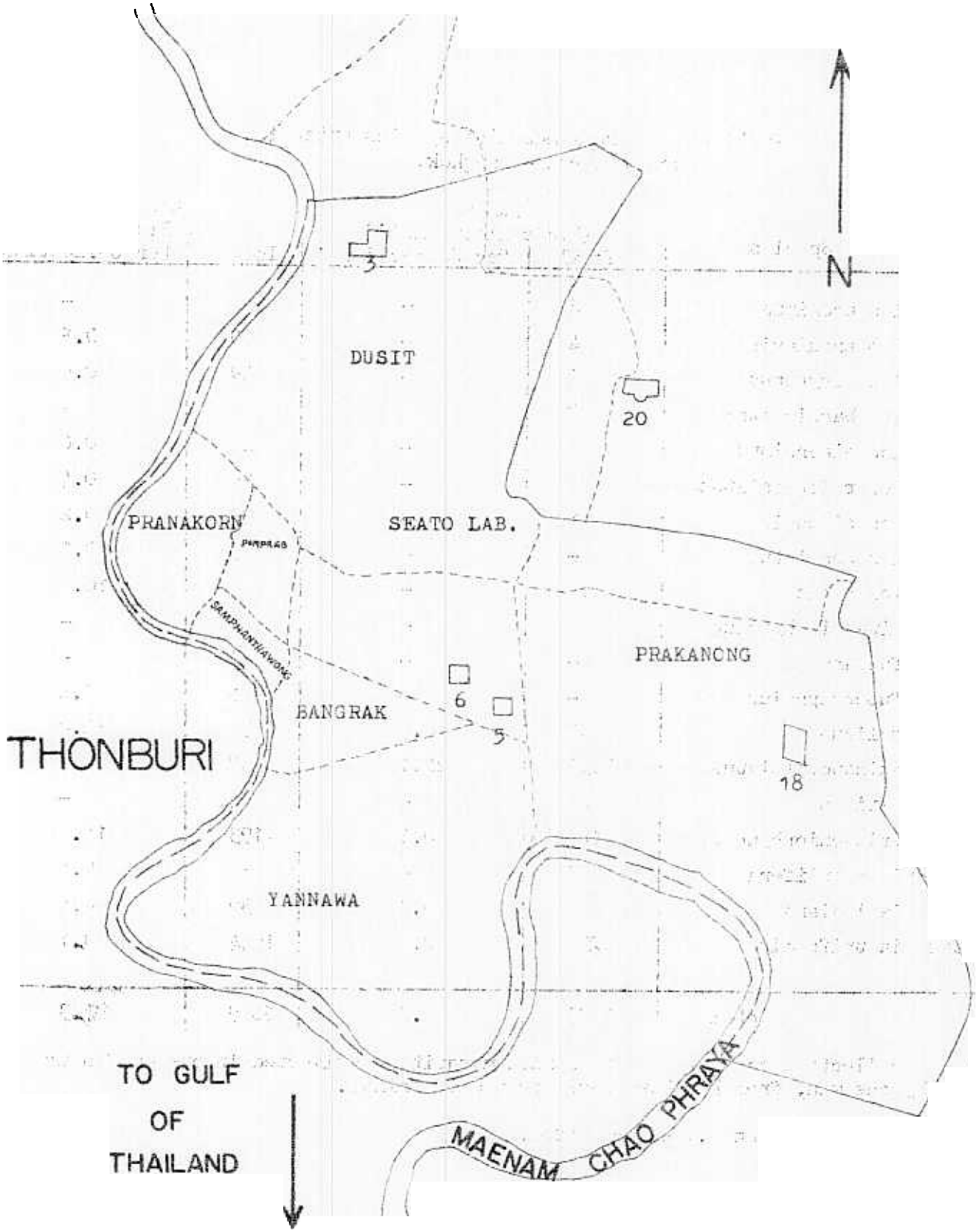

Figure 1. Hemorrhagic Fever Study Areas.
Bangkok 1962.

Area 5- Lumpini: An urban area with a dense, predominantly Thai, population. There is little vegetation in the area proper, but it is adjacent to the open areas of the Bangkok Polo Club, Lumpini Park and Tabacco Monopoly factory and warehouses. Street drains and open ditches are common.

Area 6- Pathumwan: An area of intense human concentration, chiefly Chinese. Only one tree was found in the area, which consisted of closely packed rows of houses, chiefly of wooden construction. Another very similar area had originally been chosen for the study, but this burned completely just as the collections were beginning.

Area 18- Eckamai: A suburban residential area, characterized by large compounds and houses of a more Western type. The population includes middle class Thais and Chinese, with a large proportion of Americans and other foreigners. There is abundant vegetation in the area, but of a rather diffuse nature.

Area 20- Huay Kwang: Row housing, double and triple units of wooden construction. This is a government housing project, with a mostly Thai population. The area is rather isolated from the city proper, and surrounded by extensive rice fields.

From January 1962 to January 1963 over 92,000 mosquitoes from the five study areas were frozen and submitted to the Virus Department for isolation attempts. Only two species, Aedes aegypti and Culex quinquefasciatus yielded virus. Twenty-one strains of dengue virus and 7 strains of chikungunya virus were isolated from pools of Aedes aegypti; while chikungunya virus was isolated once from C. quinquefasciatus. Several other unidentified viruses were recovered, and a discussion of these will be found in the report of the Virus Department. Clinical and virological studies by members of the Virus Department clearly indicated by the end of the 1962 epidemic that Thai hemorrhagic fever, as seen in the severe form in children, was caused by dengue virus of a number of serological types, while chikungunya virus apparently caused a less severe illness.

The 1962 epidemic was the most severe yet seen in Thailand, and the number of cases encountered permitted an analysis of the population trends of the mosquito species encountered during the year in comparison with the trend of the epidemic, as determined by members of the Virus Department. By the end of the collection program in the study areas in January 1963, sixty species had been found in our collections. As in the preliminary study, relatively few of these were found to feed on man in numbers sufficient to account for transmission of the disease. Each of the important species

will be discussed in detail below, while a list of all of the mosquito species collected in Bangkok through March 1964 will be found in table 8.

Aedes aegypti Linnaeus

This species, the classical vector of the viruses of yellow fever and dengue, is widely distributed in urban areas of SE Asia and elsewhere in the tropics. In Africa, where the species presumably originated, it is encountered frequently in jungle areas far from human habitation. In the other parts of the tropics and sub-tropics where it occurs it is firmly tied to man and his habitations, being only rarely found in small villages or isolated homes. Many aspects of human activity in Bangkok make the city particularly suitable for this mosquito. Chief among these is the habit of storing drinking and washing in large jars or barrels, for this mosquito is predominantly a container breeder, requiring clean water. In several of the areas studied, particularly areas 5 and 6, there is no piped water supply to each house. Residents obtain water from a community stand pipe and store it in jugs. Even where piped water is available, such as in most of Area 18, the uncertain water pressure causes householders to store water. There were A. aegypti present in variable numbers in almost every home examined. Table 2 presents the collection data for A. aegypti in the five study areas by method of collection and area. The species feeds primarily indoors. It may pass its entire life cycle indoors, the eggs being deposited for instance in the ant guards frequently found in homes in Bangkok. The deposition of eggs resistant to drying permits the species to pass through dry periods of the year, although breeding is continuous in the Bangkok region. The onset of heavy rains in May and June in the city permits a rapid hatching of a large number of eggs, and a marked rise in the population which parallels and preceeds the epidemic of hemorrhagic fever (fig. 2)

Culex quinquefasciatus Say

While Aedes aegypti requires clean water for breeding, this species is found primarily in water heavily polluted with organic matter. It is by far, and by all collection methods used, the most common mosquito in Bangkok, and the cause of most complaints of mosquito attack. It is particularly common in the sullage water under houses raised on pilings in the city, and in open and covered street drains. Larval counts of several hundred per dip were found in such breeding sites. It is approximately equally abundant in most parts of the city, as was the case in our study areas (table 3). C. quinquefasciatus feeds equally well indoors and outdoors, and while it is predominantly a night time feeder, it is also somewhat crepuscular, and will feed indoors in the daytime in subdued light. Its

TABLE 2

Aedes aegypti Collections - Bangkok Area Study - 1962
Total Females Collected

Collection Method	Area 3	5	6	18	20	Total
Resting	874	1402	1176	1756	575	5783
Human biting-indoor	479	988	723	993	491	3674
Human biting-outdoor	20	60	31	43	37	191
Total	1373	2450	1930	2792	1103	9648
Percent	14.2	25.4	20.0	28.9	11.4	

TABLE 3

Culex quinquefasciatus Collections - Bangkok Area Study - 1962
Total Females Collected

Collection Method	3	5	6	18	20	Total
Resting	20247	20080	21629	18052	16848	96856
Human biting-indoor	5003	4439	853	4462	5551	20308
Human biting-outdoor	3978	3183	3829	4385	4736	20111
Light trap	1242	9105	7539	6528	11101	35515
Total	30470	36807	33850	33427	38236	172790
Percent	17.6	21.3	19.6	19.3	22.1	

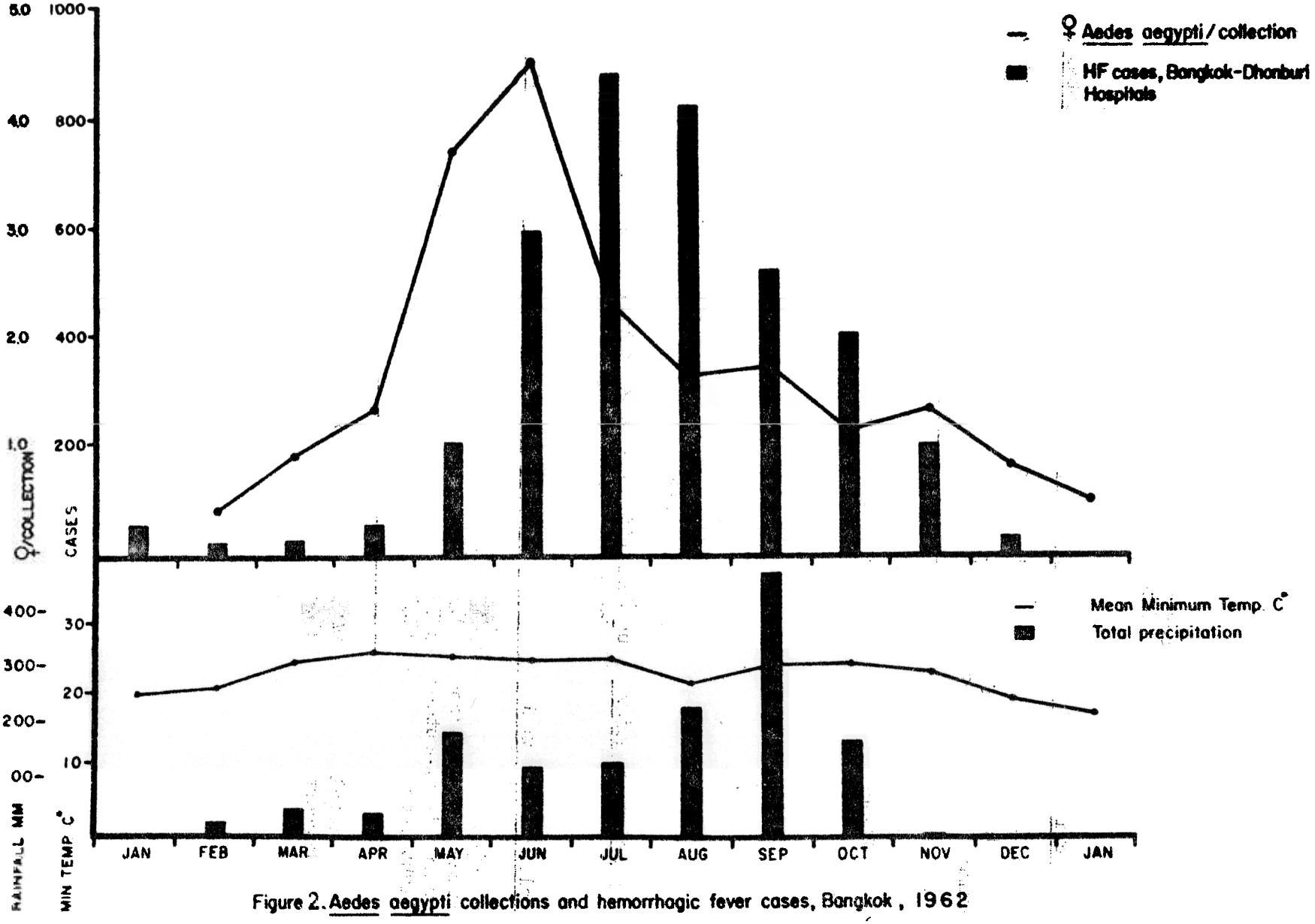

Figure 2. Aedes aegypti collections and hemorrhagic fever cases, Bangkok, 1962

habits would seem to fit it particularly well as a vector of human disease, and in some areas it is a potent vector of filariasis. As noted above, however, it does not appear to be involved in the transmission of hemorrhagic fever in Bangkok, and certainly not of dengue virus. The isolation of chikungunya virus from the species may have been due to the accidental grinding of an engorged specimen, since in allimited number of trails we were unable to obtain transmission of the virus to mice by the bite of laboratory infected females. Furthermore, the population curve for the species, as shown in fig.3, is quite different from the epidemic curve. As is the case with the other species breeding in ground pools, C. quinquefasciatus tends to reach its peak at the end of the rainy season, when water surfaces are at their maximum, and stable. During the rainy season proper the heavy tropical rains tend to continually flush larvae down drains into the open canals and rivers where their chances of survival are much less. The same population curve was seen in the 1963 collections, which will be discussed below.

Culex tritaeniorhynchus summorosus Dyar

The collection data presented in table 4 shows the difference in distribution between this species and the more urbanized species, such as Culex quinquefasciatus or Aedes aegypti. While a small number of females were collected in the heart of the city, and both males and females were taken in the light traps in densely settled areas, there is a marked shift of the population toward the more rural areas. Areas 18 and 20 both are within easy flight range of rice paddies and open pools with heavy growth of emergant vegetation. These are the favored breeding sites for C. tritaeniorhynchus around Bangkok, although the larvae may also develop in water with some degree of pollution, such as pools contaminated by stable run-off. As indicated in tabel 1, C. tritaeniorhynchus feeds to a great extent on large domestic animals. This pattern of feeding indicates the possibility that in Bangkok, as a elsewhere in Asia, the species may serve as a vector of Japanese encephalitis. The population of C. tritaeniorhynchus reached a peak in the Bangkok area in 1962 at the time of initial flooding of the open fields and rice paddies (figure 4), somewhat paralleling the rise in the epidemic curve. However, the disparity between the distribution of the species and the cases of hemorrhagic fever in the city in 1962 makes it most unlikely that C. tritaeniorhynchus played any role in the epidemic. No viruses were isolated from the species in 1962.

Culex gelidus Theobald

The seasonal distribution (fig. 5), distribution within the city (Table 5), feeding and breeding habits of this species closely parallel

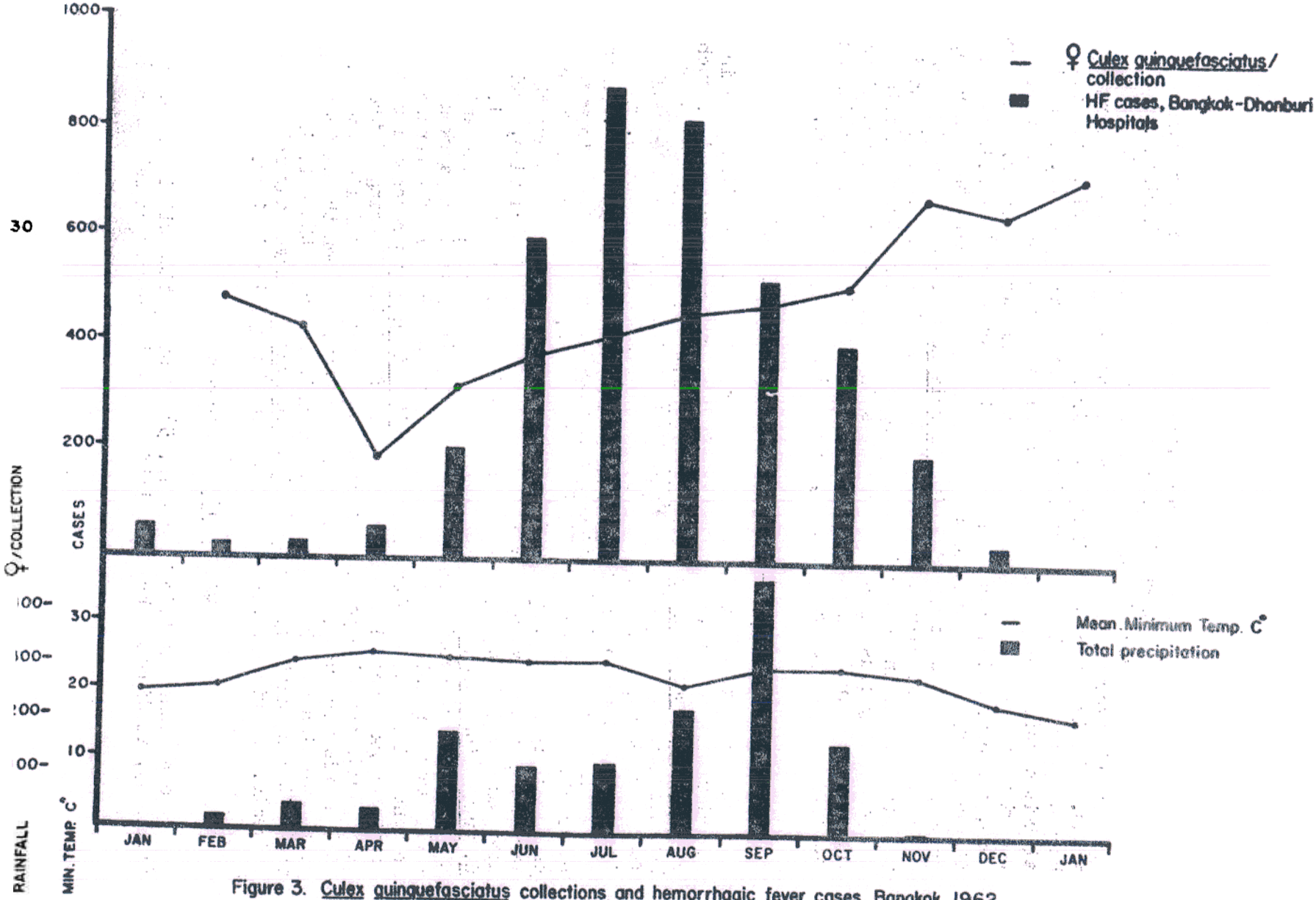

Figure 3. Culex quinquefasciatus collections and hemorrhagic fever cases, Bangkok, 1962

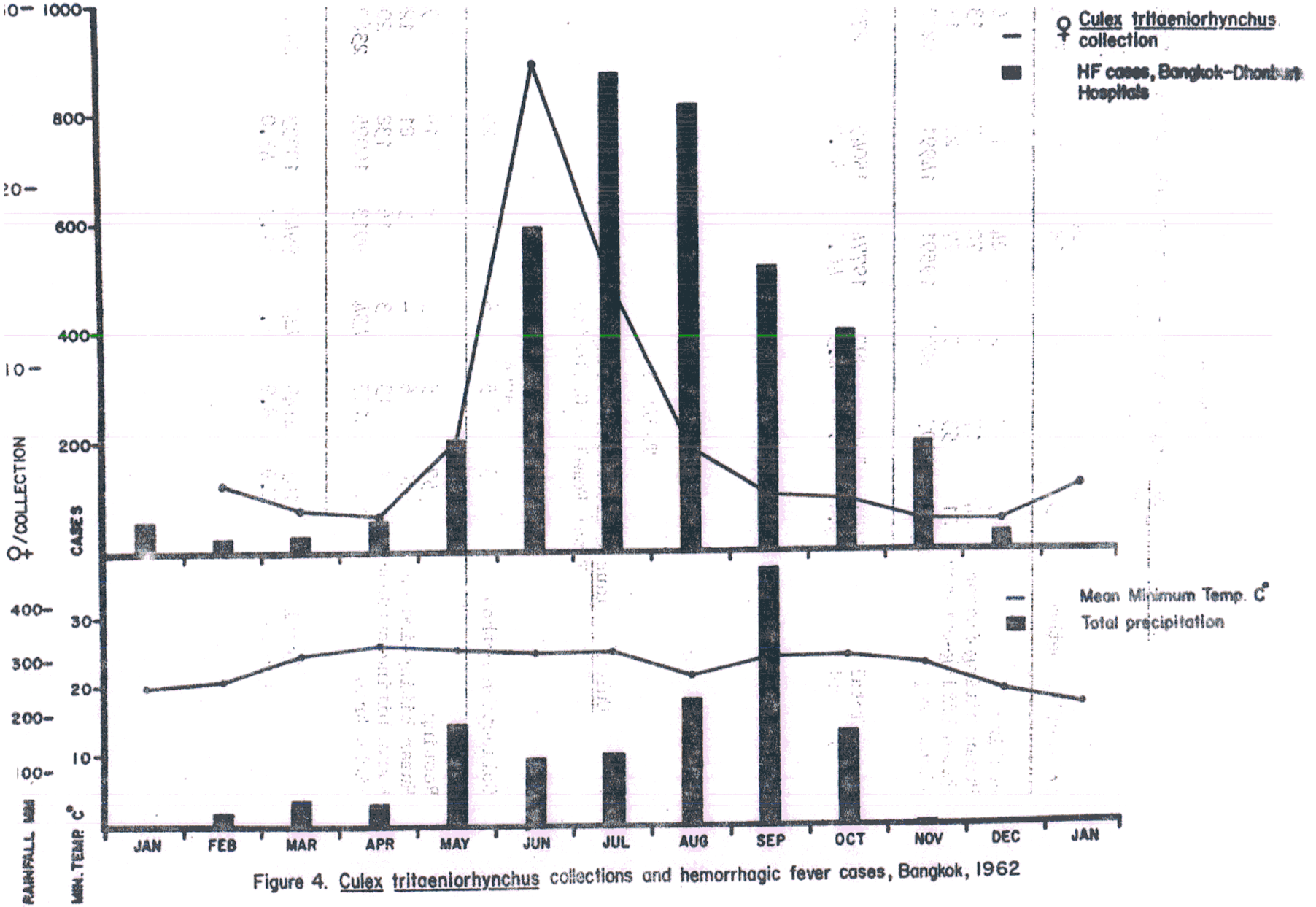

Figure 4. Culex tritaeniorhynchus collections and hemorrhagic fever cases, Bangkok, 1962

TABLE 4

Culex tritaeniorhynchus Collections - Bangkok Area Study - 1962
Total Females Collected

Collection Method	Area 3	5	6	18	20	Total
Resting	9	8	2	24	19	62
Human biting-indoor	24	17	1	72	19	133
Human biting-outdoor	21	53	5	87	20	186
Light trap	1447	5309	987	19591	14991	42325
Total	1501	5387	995	19774	15049	42706
Percent	3.5	12.6	2.3	46.3	35.2	

TABLE 5

Culex gelidus Collections - Bangkok Area Study - 1962
Total Females Collected

Collection Method	Area 3	5	6	18	20	Total
Resting	57	5	3	8	19	92
Human biting-indoor	30	6	-	3	81	120
Human biting-outdoor	38	13	3	16	138	208
Light trap	1058	2125	434	9913	10095	23625
Total	1183	2149	440	9940	10333	24045
Percent	4.9	8.9	1.8	41.3	43.0	

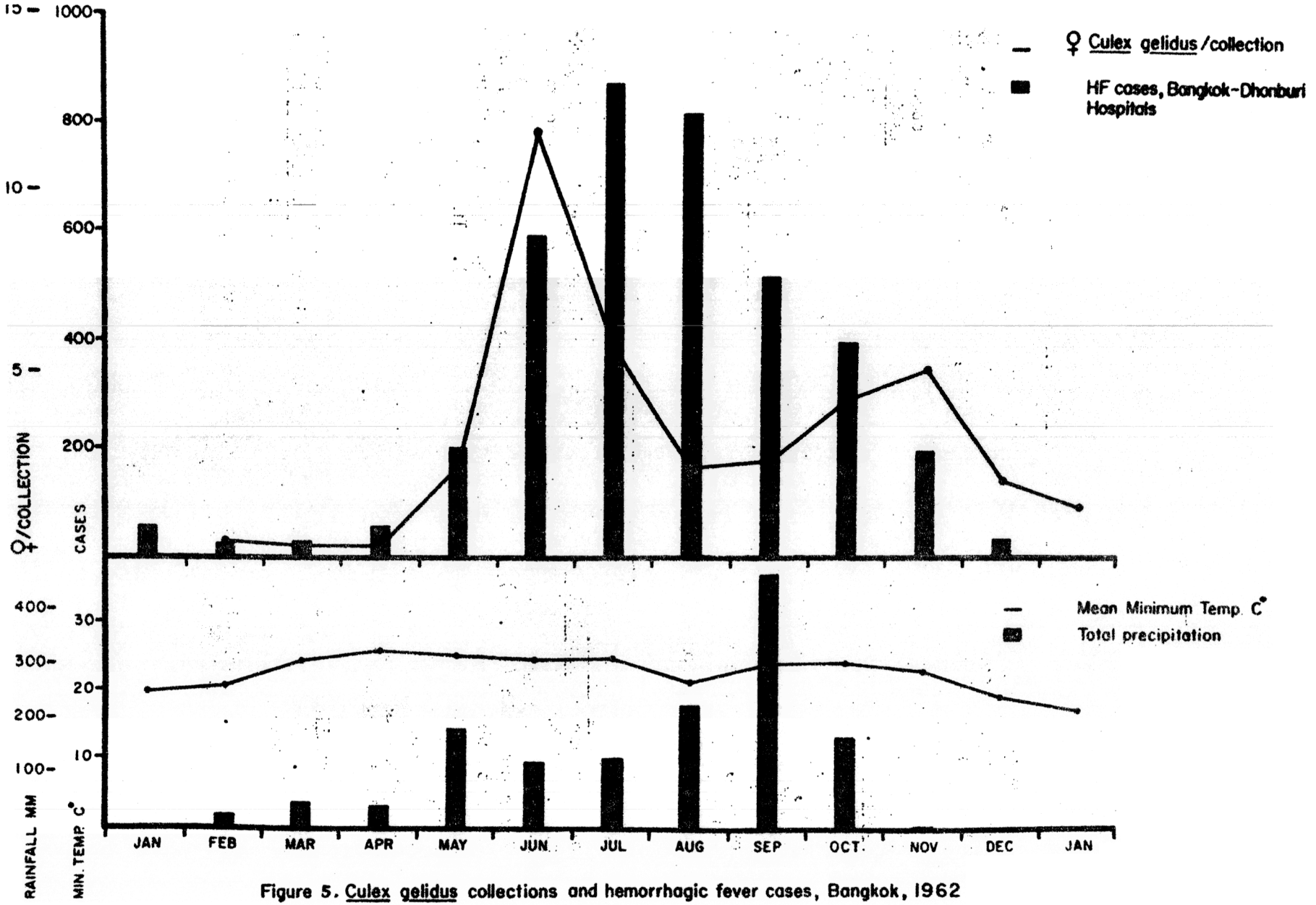

Figure 5. Culex gelidus collections and hemorrhagic fever cases, Bangkok, 1962

those of C. tritaeniorhynchus. It too is a vector of Japanese B encephalitis in some parts of Asia, and may play a role in the dissemination of this virus in the Bangkok area. There is no evidence that it is involved in the transmission of the agent of Thai hemorrhagic fever.

Mansonia uniformis (Theobald)

This species showed two distinct population peaks, with a depression of collections during the heavy rains of September (fig. 6). The cause of this depression is not known, but it may have been due to the disturbance of the water surfaces in the ponds and ditches where the larvae are found. The larvae and pupae of this species attach themselves to the roots of floating aquatic plants such as Pistia and Eichornia. These, and other aquatic plants, are particularly abundant in the open lands around Bangkok which become flooded early in the rainy season, and remain so during much of the year. The most urban study area, with almost no open water capable of supporting plant growth, was almost free of this species, which is however, a serious pest in rural areas, such as 18 and 20 (Table 6). While M. uniformis feeds readily on man, it feeds readily on man, it feeds preferentially on large domestic animals in the Bangkok area, and is not involved in the transmission of the virus of hemorrhagic fever.

Anopheles annularis Van der Vulp

This Anopheles was chosen as an example of the seasonal distribution of a number of Anopheles species which occur in numbers in the Bangkok area. It breeds chiefly in rice paddies and similar water concentrations, and becomes abundant in Bangkok long after the peak of the hemorrhagic fever epidemic (fig. 7), while surface waters are at their maximum extent, and not subject to rapid fluctuations. As might be expected, it was quite rarely collected in the more urban areas (Table 7). In distribution, therefore, it bears no relationship to the virus disease under discussion. It has been reported that A. annularis was involved in a malaria epidemic in suburban Monthaburi some thirty years ago, but it does not appear to be serving as a malaria vector in the area at present.

A similar analysis has been prepared for all of the species collected in 1962. On the basis of the following criteria only Aedes aegypti appeared to be involved in the transmission of hemorrhagic fever:

a. Isolation of the presumed causative agents (dengue and chikungunya viruses)

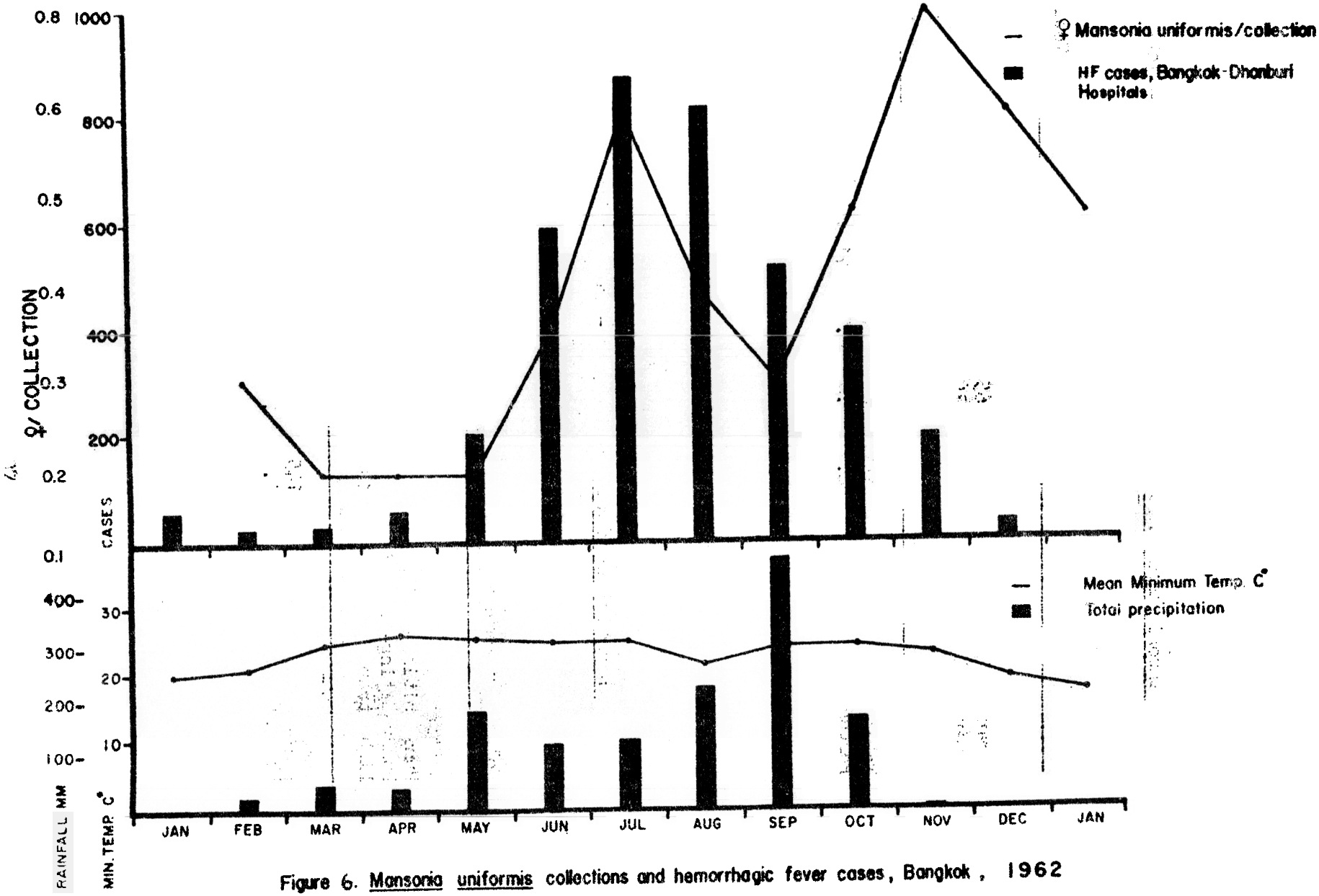

Figure 6. Mansonia uniformis collections and hemorrhagic fever cases, Bangkok, 1962

TABLE 6

Mansonia uniformis Collections - Bangkok Area Study - 1962
Total Feamles Collected

Collection Method	3	5	6	18	20	Total
Resting	5	2	4	35	1	47
Human biting-indoor	24	65	1	253	5	348
Human biting-outdoor	30	36	-	467	35	568
Light trap	84	139	15	1405	425	2068
Total	143	242	20	2160	466	
Percent	4.7	8.0	0.7	71.3	15.4	

TABLE 7

Anopheles annularis Collections - Bangkok Area Study
Total Females Collected

	Area					
Collection Method	3	5	6	18	20	Total
Resting	-	-	-	-	-	-
Human biting-indoor	-	-	-	1	1	2
Human biting-outdoor	1	-	-	-	8	9
Light trap	144	64	7	1201	7521	8937
Total	145	64	7	1202	7530	8948
Percent	1.2	0.7	0.1	13.4	84.2	

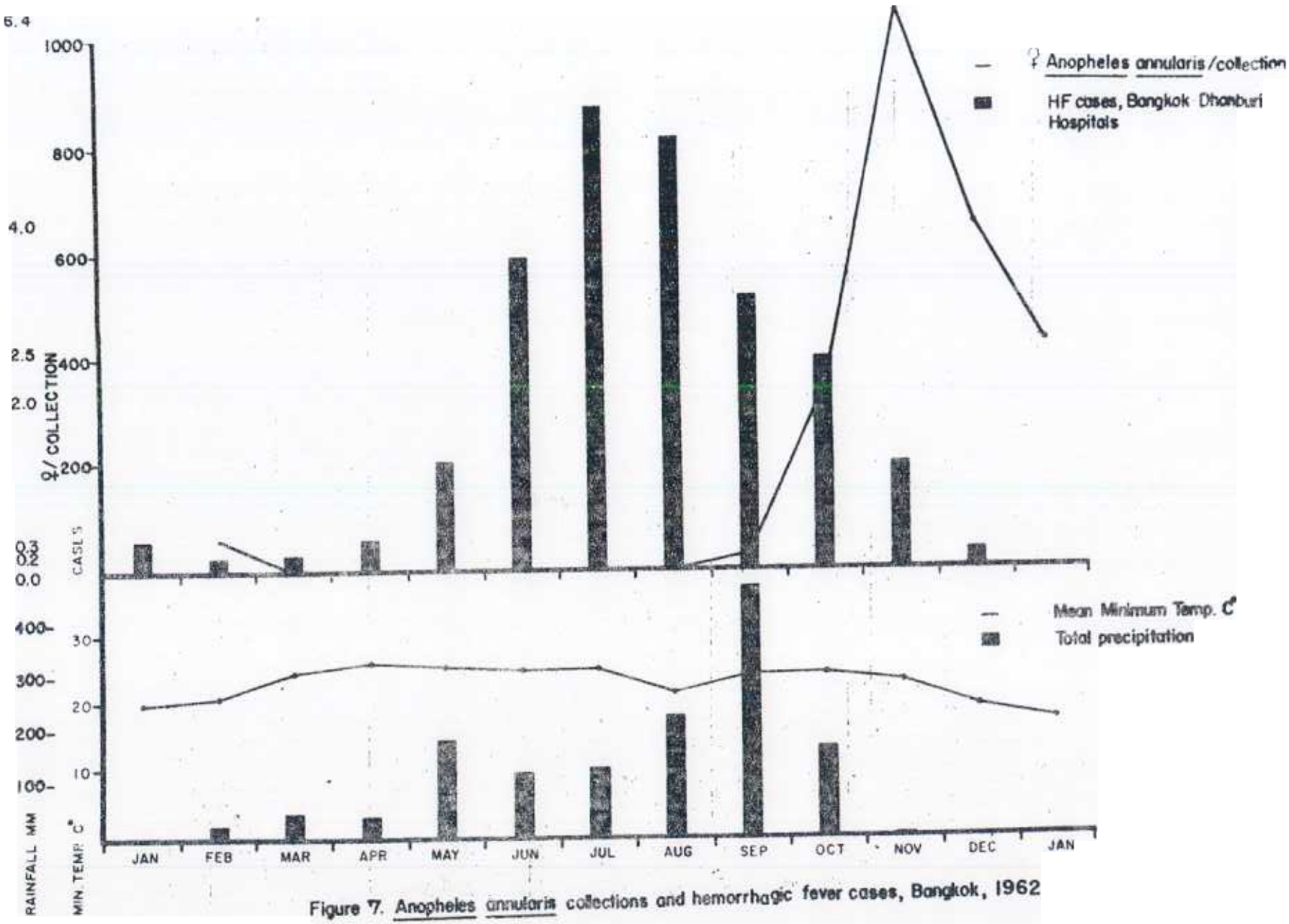

Figure 7. Anopheles annularis collections and hemorrhagic fever cases, Bangkok, 1962

b. Association of the peak of the epidemic with the peak of the mosquito population.

c. Distribution within the city, and human feeding habits.

While chikungunya virus was isolated from C. quinquefasciatus, it does not appear to play a major role in the dissemination of the virus.

From April 1963 to March 1964 mosquito collections were repeated in two of the study areas, as a check on the 1962 results. The same general pattern of seasonal distribution was obtained for Aedes aegypti (fig. 8) and C. quinquefasciatus (fig. 9). However, the population peak for A. aegypti was much less abrupt, and the C. quinquefasciatus population showed an earlier (June-July) peak than in 1962. It had been expected that the epidemic would be very small in 1963, but this did not prove to be the case.

As a result of the 1963-1964 collections, 4467 Aedes aegypti and 60,157 Culex quinquefasciatus were furnished to the Virus Department for additional isolation attempts. These isolation studies are still incomplete, and a discussion of them will be found in the report of the Virus Department. None of the observations in 1963-1964, however, indicated the necessity for changes in the conclusions reached at the end of the full area study.

In the course of collections in 1963, it was determined that Aedes aegypti was breeding in some numbers in tree holes in the city. A similar situation has been reported from Trinidad. Unlike the situation in Africa, this tree hole breeding is restricted to trees in the immediate vicinity of human habitation, and we have examined many hundreds of trees in deep forest without finding this species. The examination of tree holes in Bangkok in connection with this study revealed the presence of a number of mosquito species which had not been expected in the city, such as: Armigeres magnus, Armigeres annulioalpis and Tripteroides armoides. A list of all of the species collected in tree holes and bamboo is given in Table 8. The finding of tree hole breeding A. aegypti may complicate control measures in the city, but not greatly, once the fact is taken into consideration. Control of A. aegypti in Bangkok is possible, using proven methods of premises inspection, residual spraying and larval control. It will, however, require a high degree of performance, due to the high aegypti index found (over 90% in most areas), and the short life cycle at this latitude. Our collections also indicate a high degree of movement of the species in water jugs, water containers on boats and other possible

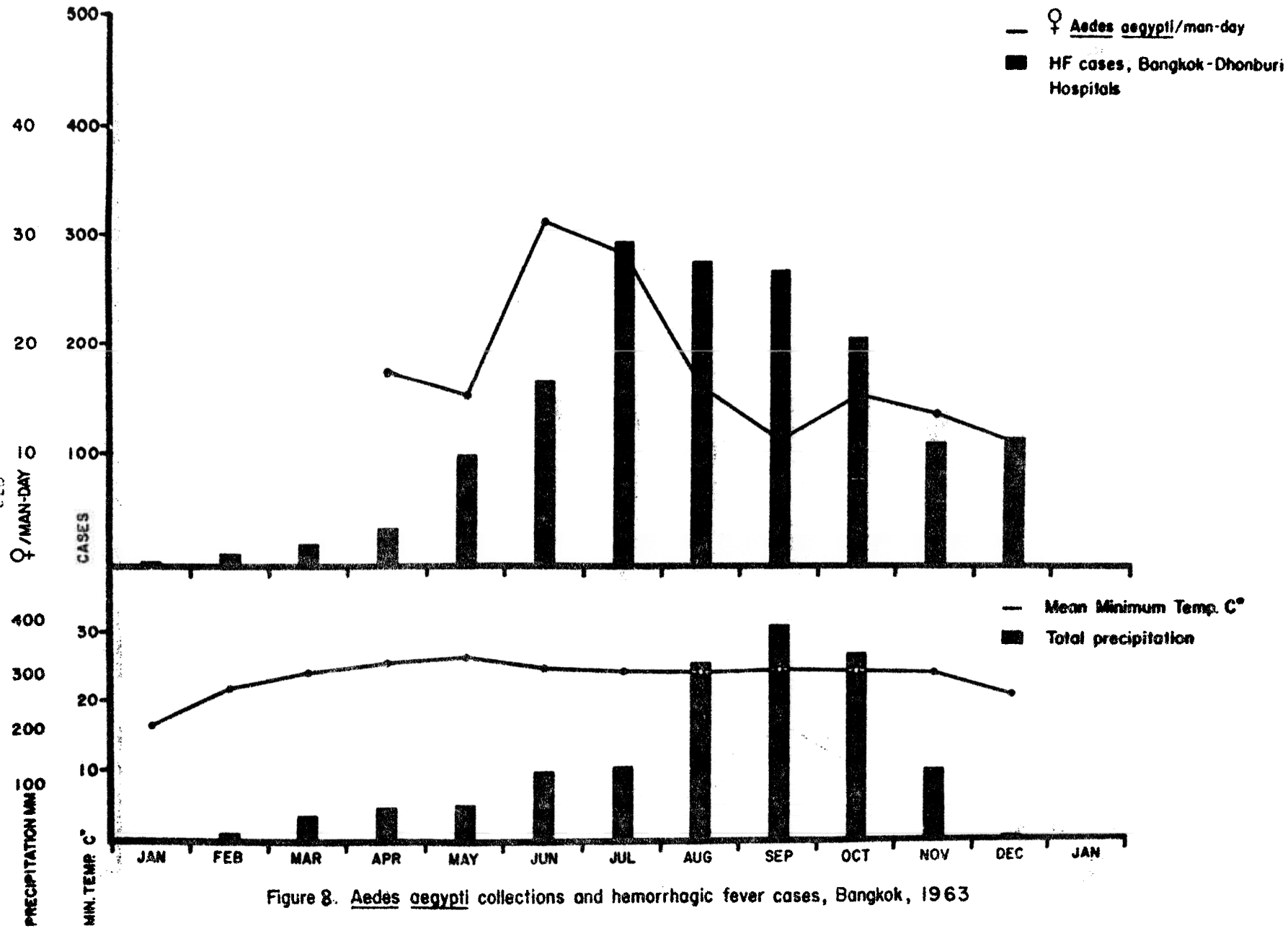

Figure 8. Aedes aegypti collections and hemorrhagic fever cases, Bangkok, 1963

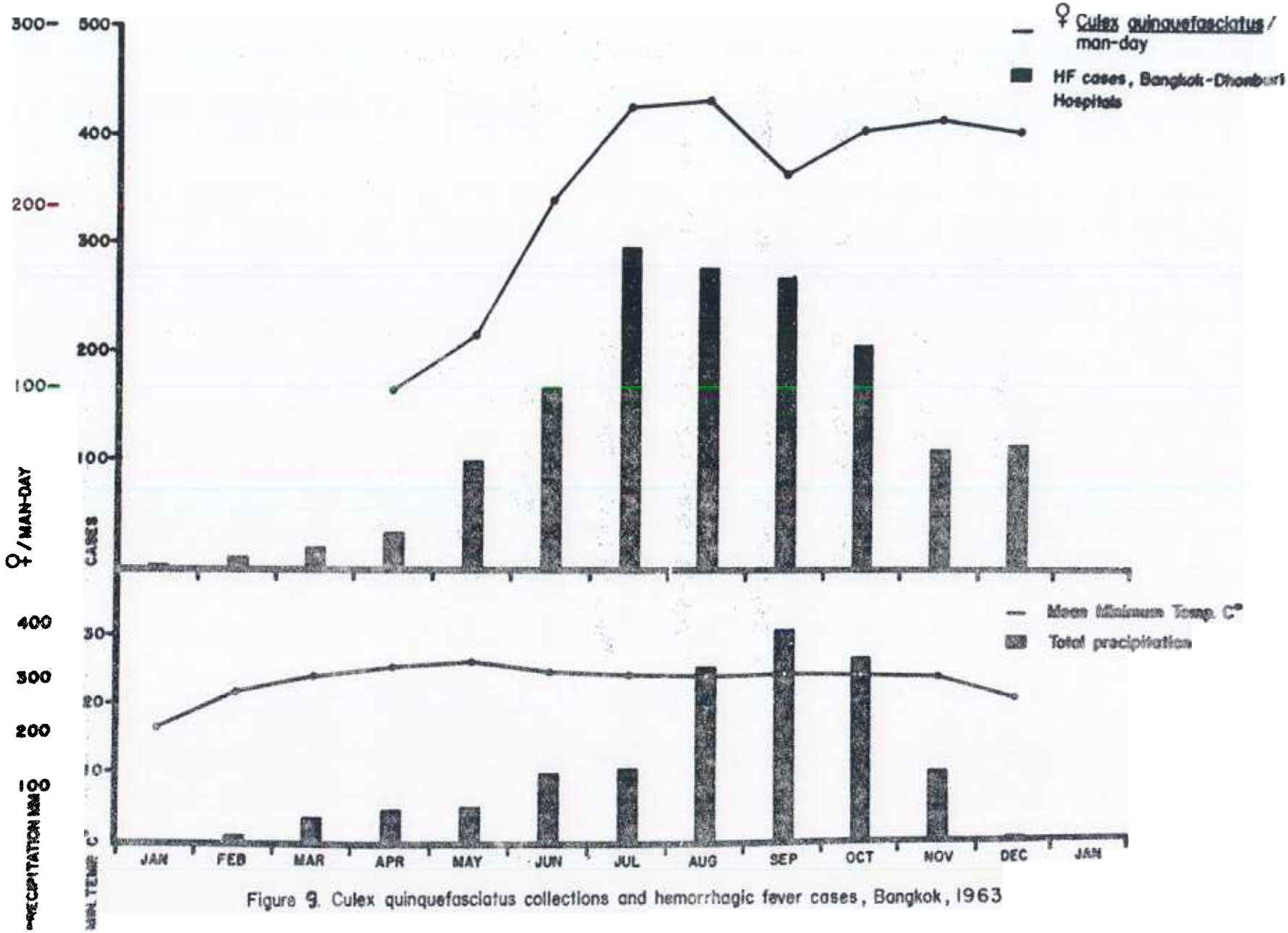

Figure 9. Culex quinquefasciatus collections and hemorrhagic fever cases, Bangkok, 1963

breeding containers moving into and out of Bangkok. In addition, Aedes aegypti is present in the city and breeding all through the year, so that control measures will be required on a continuous basis. Despite these adverse factors, control is possible, although expensive. Some advantage may be expected from immediate control measures applied early in an outbreak of HF, since investigations of the Virus Department in the study areas have indicated that the outbreaks are initially very focal in nature, as might be expected of an aegypti-borne disease.

The situation concerning control of Culex quinquefasciatus is somewhat different. As noted above, no section of the city is free from this mosquito. Its status as a disease vector is somewhat in doubt, but there is no doubt of its effect on the population from the pest viewpoint. Use of insecticides against this species has never been entirely satisfactory, and the more logical approach for its control lie in the field of engineering. The low altitude of Bangkok (some five feet above mean sea level) and the consequent lack of gradient make this difficult. Some of the highest breeding concentrations found in these studies were in the extensive sheets of water, covering many acres, under houses in parts of the city. Additional intensive breeding was found in blocked canals and in drains with an interrupted gradient. For the moment personal protective measures such as the use of screening, bed-nets, and repellent seem to offer the best protection from this species.

Some indication of the habits and abundance of twelve of the more important species is given in table 9.

Summary: From 1961 to 1964 mosquitoes were collected in the Bangkok area, chiefly in connection with investigations on the epidemiology of Thai hemorrhagic fever (HF). This is a disease of viral etiology, striking chiefly children, often with a fatal outcome. Mosquitoes were identified and tabulated by date, place and method of collection. Samples of the females collected were submitted to the Virus Department for isolation of virus strains. A large number of virus strains were isolated, chiefly dengue and chikungunya viruses. It had been reported, and confirmed during this study, that dengue virus is the etiological agent of (HF); while chikungunya virus is the etiological agent of a milder component of the disease spectrum seen during the epidemics. Mosquito populations were plotted against the epidemic curve in 1962 and again in 1963, and the distribution of the mosquitoes in different areas of the city was examined. Of the over sixty species of mosquitoes captured in Bangkok, less than ten fed upon man to any great extent. By virus isolation, feeding habits,

seasonal distribution and distribution within the city, only Aedes aegypti appeared to be of importance in the spread of hemorrhagic fever. While Culex quinquefasciatus is by far the most important pest mosquito species in the city, its seasonal curve of abundance did not match the disease. Furthermore, the proven dengue etiology of HF indicates A. aegypti as the only important vector of the disease.

Conclusions: Hemorrhagic fever, a peculiar clinical manifestation of infection with dengue virus, is transmitted in Bangkok by Aedes aegypti. Culex quinquefasciatus, however, is by far the most abundant and bothersome of the over sixty species of mosquitoes found in the city. C. quinquefasciatus may possibly play a role in the transmission of chikungunya and other viruses in Bangkok, but it is probably not important in this respect. Control of these two urban mosquito species would contribute greatly to the health and well-being of the population of Bangkok. Control of A. aegypti is probably feasible using present methods; but control of C. quinquefasciatus would require extensive and very expensive engineering changes in the city.

Publications:

1. Halstead, S.B., C. Yamarat and J.E. Scanlon. 1963. The Thai hemorrhagic fever epidemic of 1962; A preliminary report. Jour. Med. Assn. Thailand 46 (8): 499-465.

2. Scanlon, J.E. The mosquito fauna of Bangkok. Part I- An annotated species list. Manuscript in preparation for publication in Jour. Med. Entomology.

3. Scanlon, J.E. The mosquito fauna of Bangkok. Part II- Population changes and feeding habits. Manuscript in preparation for publication in Jour. Med. Entomology.