5. Title: Ecology and Control of dengue vectors

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INTRODUCTION

The studies described bolow were part of a collaborative investigation into the epidemiology of dengue hemorrhagic fever in Southeast Asia carried out together with the departments of Virology and Epidemiology. Recurrence of epidemic dengue fever on the island of Koh Samui in the Gulf of Thailand provided the opportunity to study the ecology of the vector species in a relatively isolated situation. The companion studies on the epidemiologic and virologic aspects of dengue transmission on the island are reported under the SEATO Medical Research Study on Arboviruses.

DESCRIPTION

During the 1966 and 1967 epidemics of dengue hemorrhagic fever on Koh Samui, both Aedes aegypti and Aedes albopictus were implicated as vectors. In the fall of 1967 a field trial for the control of Aedes aegypti was conducted in the village of Baw Phut on Koh Samui. The method of control was directed primarily towards the larval stages of this mosquito which are found almost exclusively in the water storage receptacles in and around the houses. Since varying levels of resistance to DDT had been detected in the Koh Samui populations of both A. aegypti and A. albopictus, water containers were treated with an organophosphate, Abate, to give a final insecticide concentration of 0.25 to 1.0 ppm. Concurrently with the Abate treatments, 2 per cent Malathion in diesel oil was dispersed in a fog through out the village for the destruction of adult mosquitoes. As a result of these control efforts there was an immediate and dramatic reduction in the A. aegypti population in Baw Phut. No adults were collected in the village for a period of 4 weeks, and the water containers were free of A. aegypti larvae for from 5 to 9 weeks following the application of Abate.

During the present report period an island–wide Aedes aegypti control program was undertaken using the techniques employed at Baw Phut in 1967. It was not known whether control of A. aegypti alone would be sufficient to significantly reduce or interrupt dengue transmission on Koh Samui; therefore, the objectives of this control program were to measure the effects of an A. aegypti population reduction on dengue transmission in terms of 1) rates of dengue virus infections in vector mosquito populations, 2) incidence of clinically–recognized dengue and dengue hemorrhagic fever and 3) monthly sero–conversion rates in the island's pediatric population.

Weekly mosquito collections were begun in five villages, Mae Nam, Ban Mak Kam, Ban Saket, Ban Talingnam and Ban Le, during May 1968 to establish baseline population indices for the two vector species. Adults were collected by means of human–biting collections conducted indoors and outdoors in randomly selected houses and sites, respectively, in the five surveillance sites. Larvae were collected from domestic water containers inside and outside of houses and from bamboo cups set in grid patterns in each of the five villages. Between 29 July and 14 August domestic water containers throughout the island were treated with Abate applied so as to yield a concentration of 1.0 ppm. In addition, the houses in all of the principal villages on the island were treated with a 4 per cent malathion fog at least twice during the above–mentioned period. These fogs were applied either by means of truck mounted cold–fog generators or by Swingfog thermal generators. A total of 4640 households were treated out of 4905 visited during this program or more than 90 per cent of the island's houses.

RESULTS

By the last week in August A. aegypti adults had largely disappeared from the houses in all surveillance sites and none were collected during September; biting collections made outdoors in these villages continued to yield appreciable numbers of A. albopictus during this same period (Fig 1). The rate of infestation household water containers with Stegomyia larvae in the five villages varied from 42 to 70 per cent in the week prior to the Abate treatments (Fig. 2). These rates dropped below 10 per cent following completion of the insecticide treatments and remained below that level in all of the sites for three weeks and for up to 7 weeks in Talingnam and for 9 weeks in Ban Le. By November the receptacle indices were 20 per cent or higher in all sites, but by the end of this report period they had risen to pretreatment levels only at Mak Kam (Fig 2). On the other hend, the A. aegypti house indices (percentage of inspected houses infested) which varied from 54 to 80 prior to treatment dropped to below 10 for from two to six weeks only and began a steady rise thereafter (Fig 3). After 16 weeks the house indices had reached pretreatment levels in all five surveillance sites. The numbers of A. aegypti larvae in bamboo cups steadily declined following the insecticide treatments; none were collected in bamboo cups during September although A. albopictus larvae were present throughout (Fig 4). The numbers of A. albopictus collected in outdoor biting collections continued to rise from August on and reached a peak in November following the period of greatest rainfall on Koh Samui (Figs 5, 6). The number of A. albopictus adults collected indoors was small in proportion to those collected outdoors and was apparently directly related to the density of the outdoor population (Fig 5). Between 27 May 1968 and 29 March 1969 a total of 9698 A. albopictus adults were collected outdoors at the surveillance sites, but only 36 (0.4%) were collected inside houses. During the same period at these sites a total of 2050 A. aegypti adults were collected indoors, but none were collected outdoors. Outdoor biting collections at the surveillance sites were made at a distance of at least 100 meters from the nearest house. Collections of both A. aegypti and A. albopictus for virus isolation attempts during this period were made only from in and around the houses of suspect dengue cases and were not related in place or time to the collections at the surveillance sites. Between May and November 1968 a total of 22570 A. albopictus females were collected for virus isolation attempts, but only 126 (0.5%) of these were collected indoors. During the same period 513 A. aegypti females were collected for virus pools, and 37 (7.0%) of these were caught outdoors. The presence of A. aegypti in these outdoor–biting collections is probably due to the fact that the collections for virus pools were made close (within 10 meters) to the patients house, while outdoor collections at the surveillance sites, which failed to yield any A. aegypti, were made at greater distances from houses. These observations, together with the bamboo cup data, suggest that the utilization of outdoor oviposition sites by Aedes aegypti is primarily by emigrants from the domestic population, and that a completely feral population of that species does not exist on Koh Samui.

Between 16 August and 3 October only 10 pools of A. aegypti, comprising 31 mosquitoes, were collected for virus isolation attempts, from patients homes, although 4988 Aedes albopictus were collected during the same period from outside these same homes. Dengue virus was isolated from a pool of

Aedes aegypti collected in the first week of September, while 6 pools of A. albopictus collected between 16 August and 3 September yielded dengue isolates. No dengue isolations were obtained from pools of A. aegypti collected after the first week in September, but a pool of A. albopictus collected on 13 November yielded a strain of dengue type–4 virus. No cases of dengue or dengue hemorrhagic fever were reported on Koh Samui after the last week in August.

While both Aedes aegypti and A. albopictus were implicated in the transmission of dengue virus on Koh Samui during 1966 and 1967, the rate of isolations of dengue virus was significantly higher from the former species. A. aegypti is known to feed almost exclusively on man, but it was not known whether A. albopictus is equally dependent upon human blood–meal sources. Any significant degree of diversion to non–human hosts by A. albopictus would almost certainly affect its efficiency as a dengue vector.

During this period diurnal biting collections were made on Koh Samui from buffalo, cattle, pigs, dogs, a pig–tailed macaque (Macaca nemestrina) and a palm civet (Paradoxurus hermaphroditis). Engorged A. albopictus were taken from all these hosts except the macaque and civet. A comparison of capture–rates suggested that man was more attractive than either buffalo, cow or pig, but it was apparent that these latter hosts are probably important sources of blood for A. albopictus on Koh Samui (Table 12). Feeding by A. albopictus on dogs was also observed, but these animals proved too excitable for use in estimating biting rates.

Diurnal bait–trap collections were also made during this period using a variety of small animals as bait. Small numbers of engorged A. albopictus were collected from lard–can traps baited with each of the following hosts:

Callosciurus caniceps samuiensis (grey tree squirrel)
Rattus rattus robinsoni (roof rat)
R. rajah spurcus (rajah rat)
R. norvegicus (Norway rat)
R. germaini remotus (island rat)
Tupaia glis (tree shrew)
Cynopterus brachyotis (dog–faced fruit bat)
Domestic dog
Domestic cat

The fact that engorged mosquitoes from these trap collections had actually fed on the respective bait animals was confirmed by agar–gel diffusion tests. The placing of dry ice in these traps, in addition to the animal bait, served in some, but not all cases, to increase the number of A. albopictus collected. No mosquitoes were attracted to either Rattus exulans or to the domestic chicken alone, but A. albopictus were collected from traps baited with each of these two hosts when CO_2 was added to the traps. There is no evidence that the mosquitoes collected fed on either of these hosts. Small numbers of A. albopictus were also taken in a lard–can trap baited with CO_2 alone. Magoon–type traps containing a pig, dog and a pig–tailed macaque, respectively, also attracted small numbers of A. albopictus.

New Jersey light traps were operated in coconut plantations a total of 18 trap nights. Seven male and eight female A. albopictus were captured; one of these females was blooded, and agar gel-diffusion tests indicated that this mosquito had fed on a bat. New Jersey traps, with light bulbs removed, and baited with CO_2 were operated during daylight hours on 33 occasions, yielding one male and eight female A. albopictus, two of which were blooded. The agar gel–test indicated these two specimens had fed on either man or monkey. Resting traps were unsuccessful in the collection of Aedes albopictus.

The above results indicate that A. albopictus probably feed on a variety of hosts other than man, and commonly feeds on buffalo, cattle and pigs, hosts which are readily available throughout Southeast Asia. The small numbers of A. albopictus collected from bait traps may reflect a reluctance on the part of that mosquito to enter enclosures rather than lack of attraction to the respective bait animals.

Table 12

Rates of Capture of Female Aedes albopictus attracted to various hosts.

Host*	Total number collected	Total collection time (min.)	Rate of capture
Man	125	40	188/hr.
Buffalo	36	90	24/hr.
Cow	19	30	38/hr.
Pig	40	130	19/hr.

* — Two different animals of each species were used.

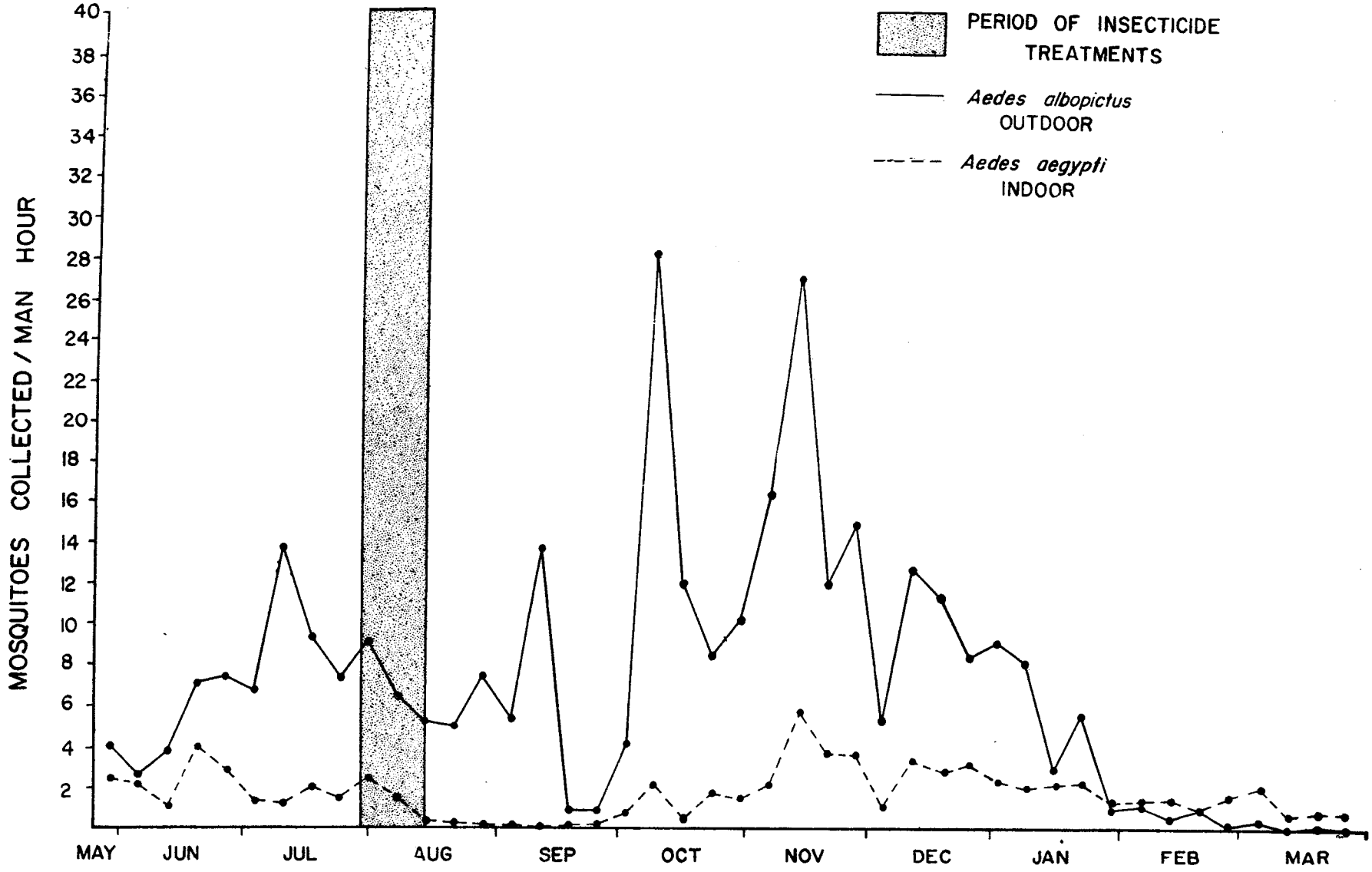

Fig 1. Result of weekly collections of Aedes aegypti and Aedes albopictus biting man on Koh Samui, 1968–69.

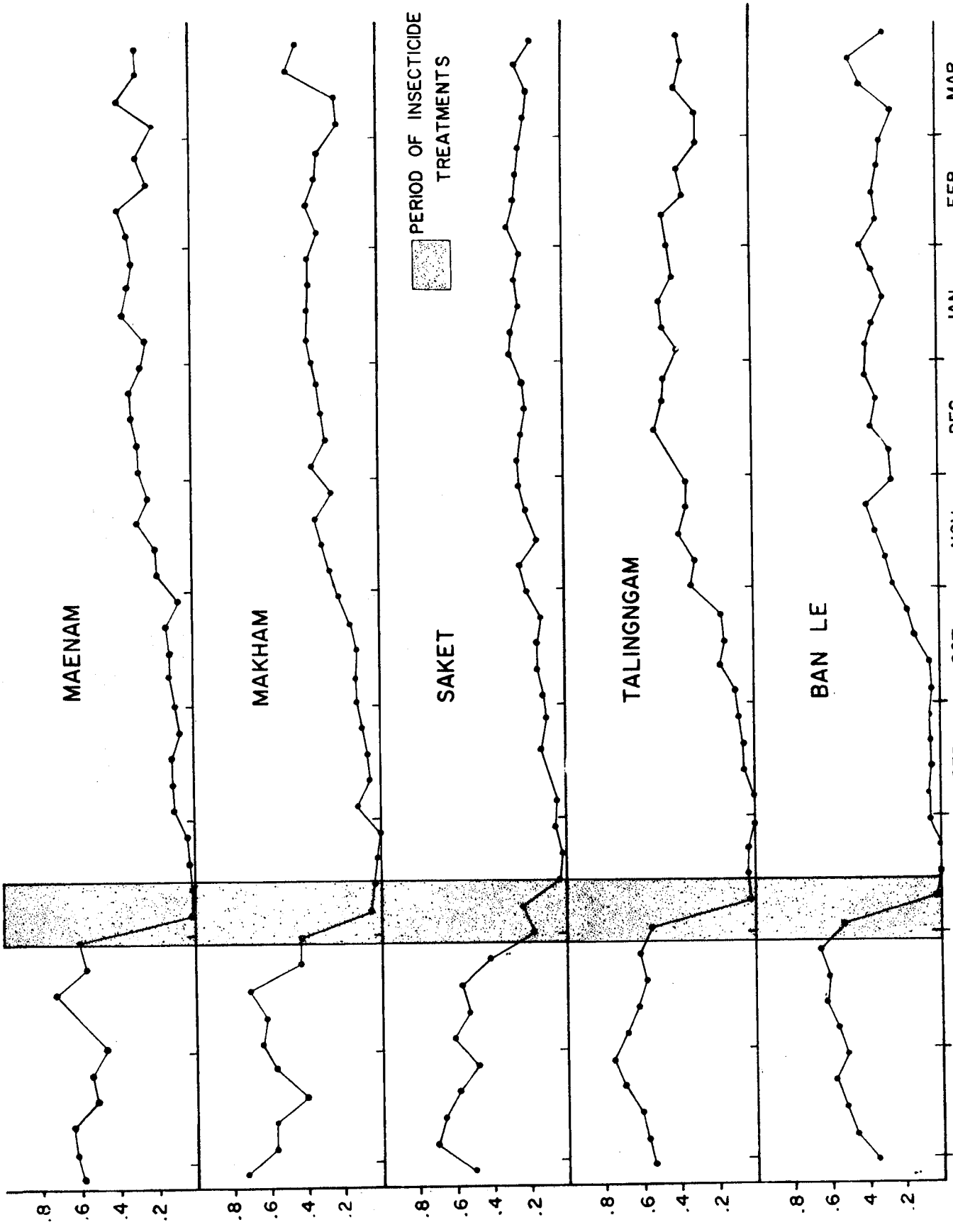

Fig 2. Results of weekly collections of Stegomyia larvae from domestic water containers—Koh Samui. 1968—69.

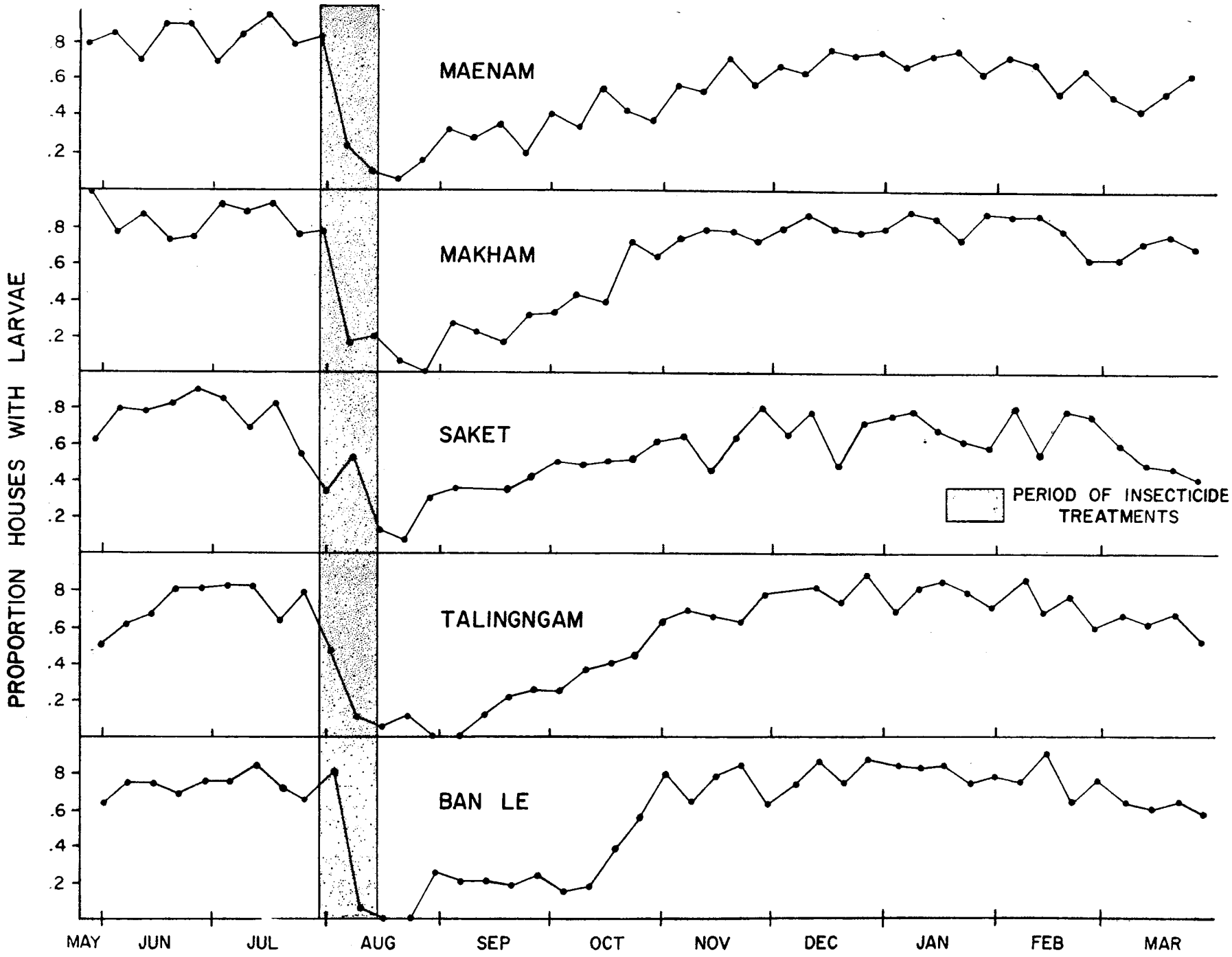

Fig 3. Weekly house indices for Stegomyia infestations on Koh Samui, 1968 – 69.

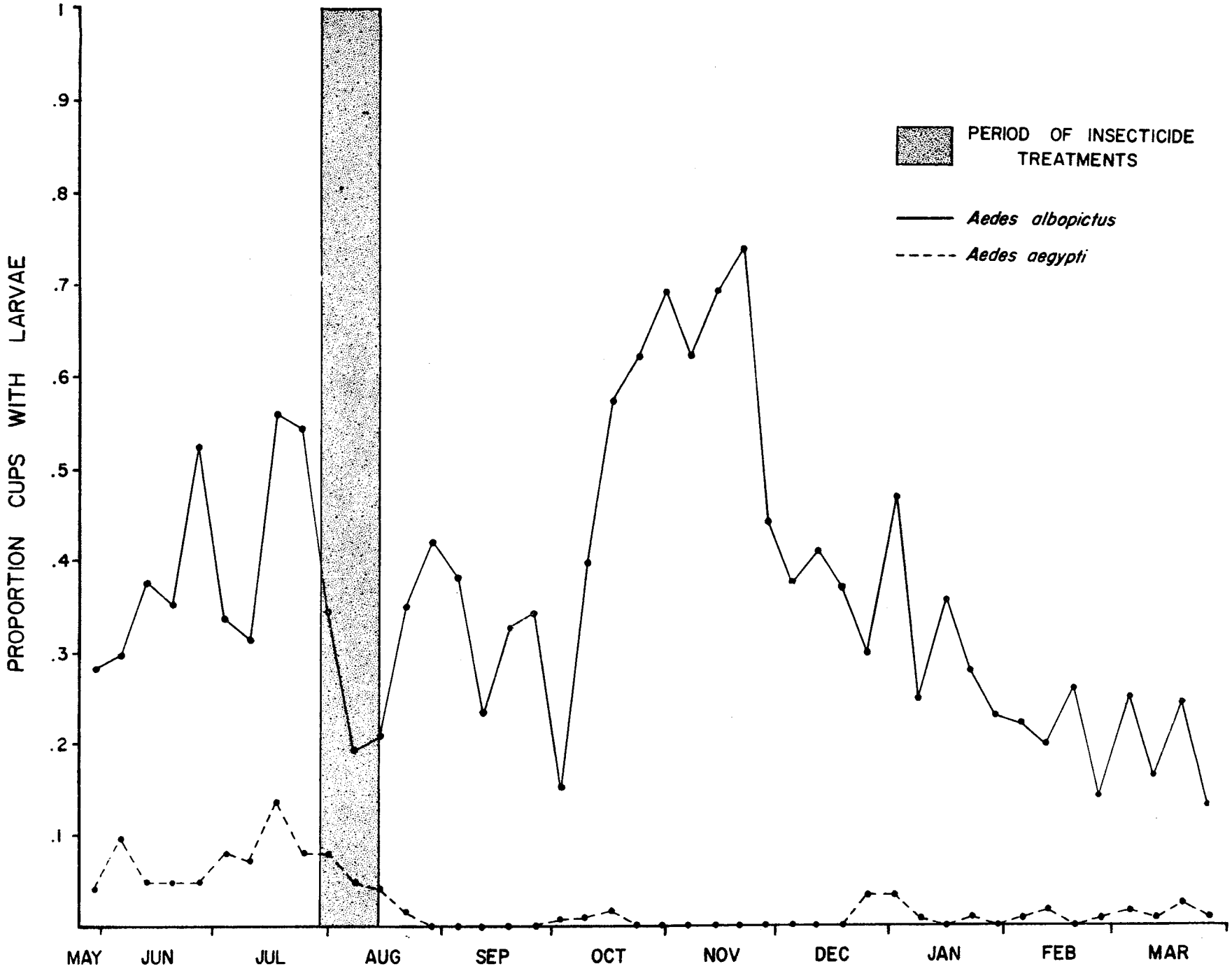

Fig 4. Results of weekly collections of Stegomyia larvae from Bamboo cups on Koh Samui, 1968–69.

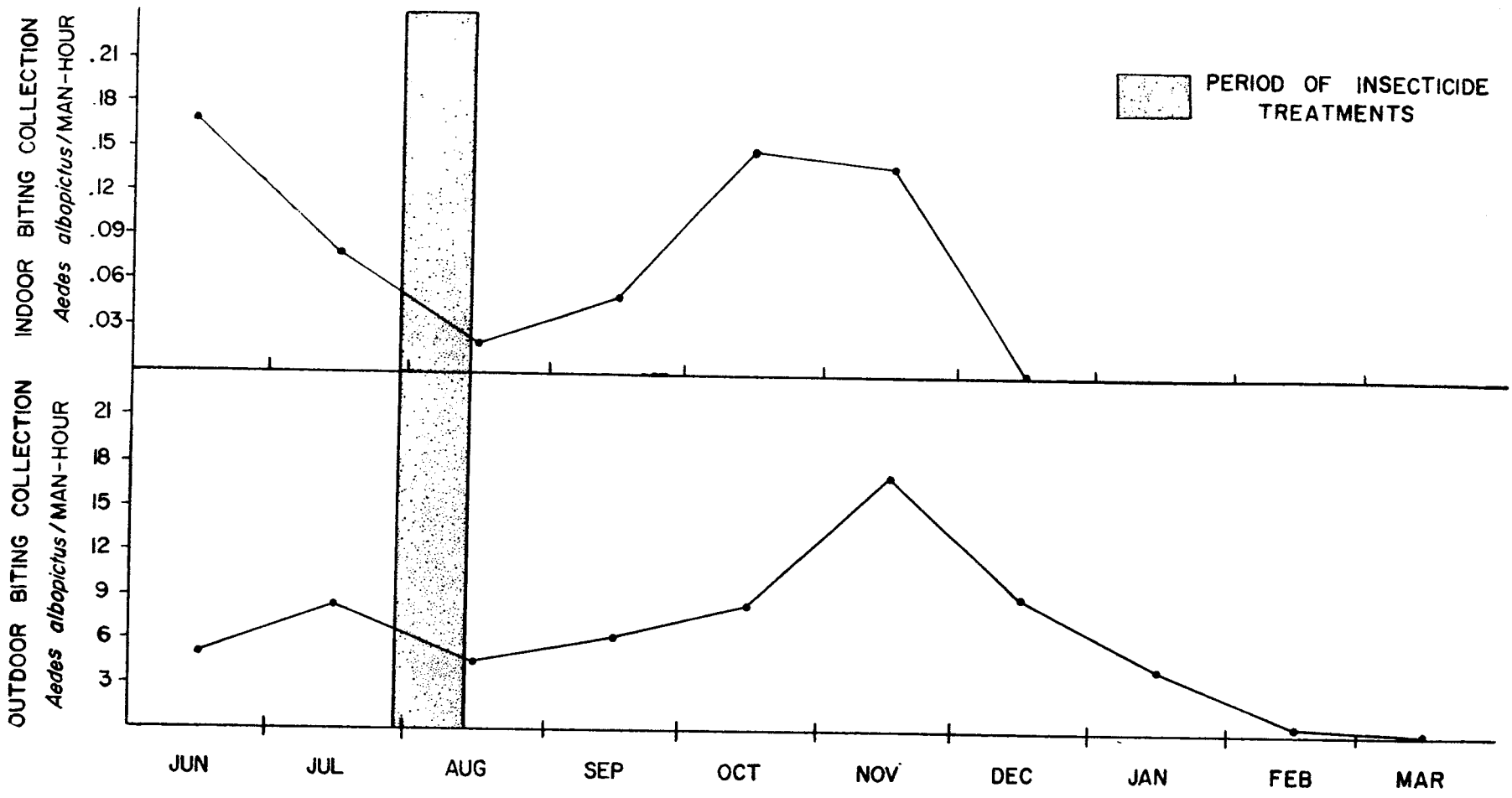

Fig 5. Comparison of indoor and outdoor biting collections of Aedes albopictus on Koh Samui, 1968–69. (total for five surveillance sites)

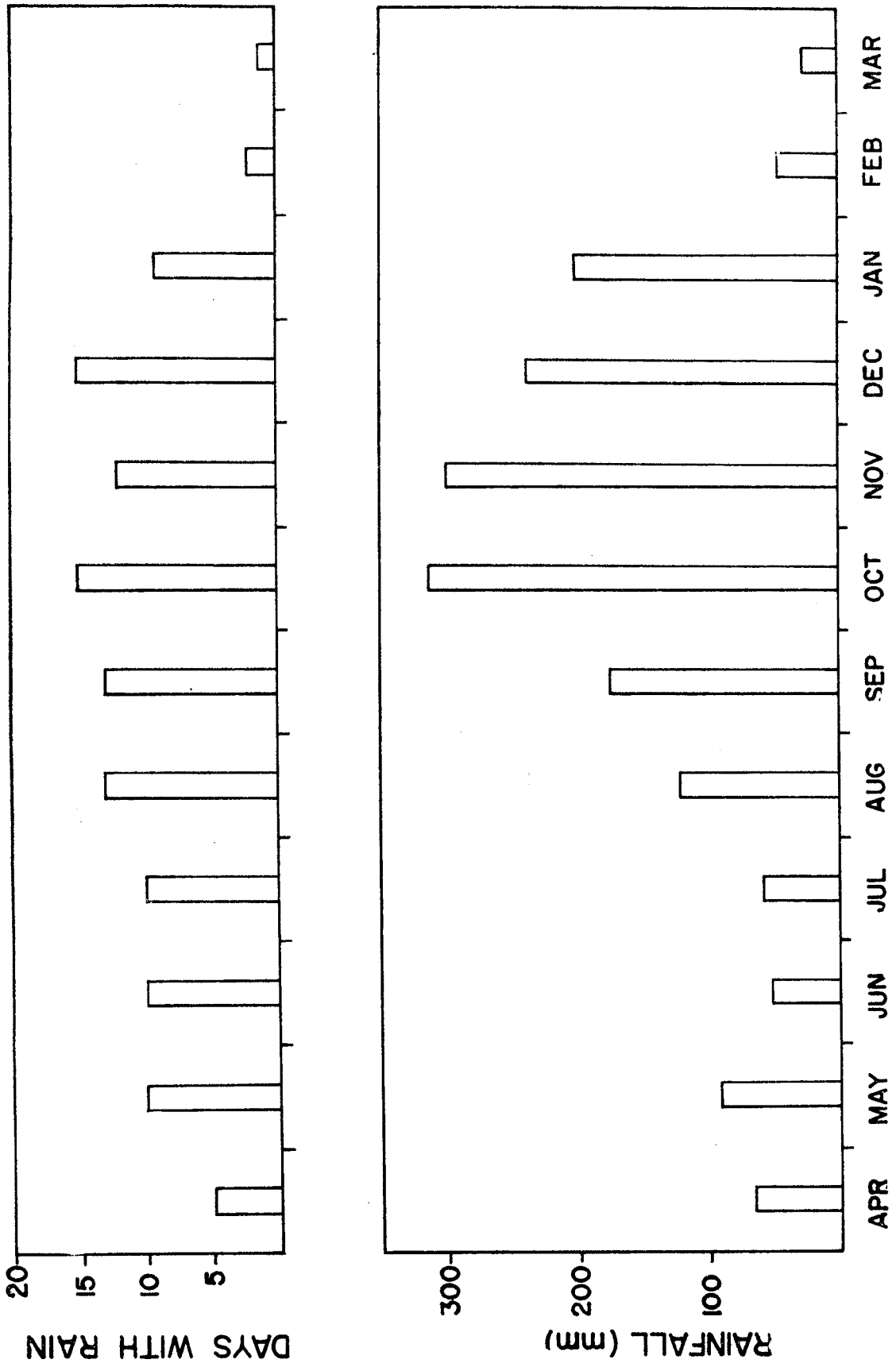

Fig 6. Rainfall recorded at Ang Thong, Koh Samui, 1968–69.