

A SURVEY OF ADULT MOSQUITOES ON LOMBOK ISLAND, REPUBLIC OF INDONESIA¹

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ABSTRACT. Mosquito collections were carried out in May 1978 and March 1979 in Lombok Island, Republic of Indonesia, in association with an arboviral survey. Thirty species of mosquitoes in 8 genera were collected in 1978 from East and West Lombok; 18 species in 4 genera were obtained during intensive adult collections in 1979.

The 30 species of mosquitoes identified in these studies compares with 16 species previously reported from Lombok and 31 others presumed to be present based on records from neighboring islands. The possible involvement of certain species in disease relationships is discussed.

INTRODUCTION

Mosquitoes of many of the islands in the Lesser Sundas group of the Indonesian Archipelago have not been well documented in published reports. This is true of Lombok Island as with Bali until recently (Lee et al. 1983b). Lombok lies just east of Bali and is separated from Bali by approximately the 38 km Lombok Straits.

Collecting trips were made to the island on 2 occasions in 1978 and 1979. Adult mosquito populations were sampled in support of serological surveys carried out to determine the prevalence of arthropod-borne viruses. The results of those surveys which included serum samples from humans, domestic and wild animals and birds are reported by Olson et al. (1983).

This report documents the various species of mosquitoes collected during those brief working visits to eastern and western locations of Lombok in May 1978 and in western Lombok during March 1979. A literature search revealed that 16 species were reported from the island and that 31 other species probably occurred on the basis of geographical distribution in neighboring islands (Table 1).

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MATERIALS AND METHODS

Mosquitoes were obtained by light traps (Model CDC-4), resting captures by aspirating and sweeping and human-landing captures during the May 1978 period. These were carried out in both East and West Lombok over a period of 4 days in each area. Light traps enhanced with the use of CO₂ from dry ice were placed at animal shelters and in garden areas of villages for total night operations (1800–0600 hr). Resting collections by use of aspirators and sweep nets were carried out between 2000–2200 hr at several sites sheltering cattle, buffalo and horses. Human-landing collections were made during daylight hours in garden areas, and in-house resting collections were conducted during early morning hours. In March 1979, similar collections were carried out in West Lombok only. Figure 1 indicates major collection sites: Kerongkong and Bagik Payung villages in East Lombok, and Bilekedit in West Lombok. See Olson et al. (1983) for further information about the collection sites.

Most of the mosquitoes were used for viral isolation attempts, but all were identified to species during their field preservation or after return to the Jakarta laboratory. Mosquito larval collections, mainly from natural and artificial containers, were made on several occasions and specimens were reared to adults for identification. Identifications were made with the use of keys and descriptions given by Bonne-Wepster (1954), Huang (1972), Mattingly (1957), Reid (1968) and Sirivanakarn (1976).

RESULTS

MAY 1978. Light trap operations totalling 16 trap nights and 3 resting/sweeping collections were carried out in East Lombok. Ten species of mosquitoes were identified from a collection of 4,483 specimens utilized for virus isolation attempts. Additionally, 11 other less common species were obtained by other means including larval collection (Table 2).

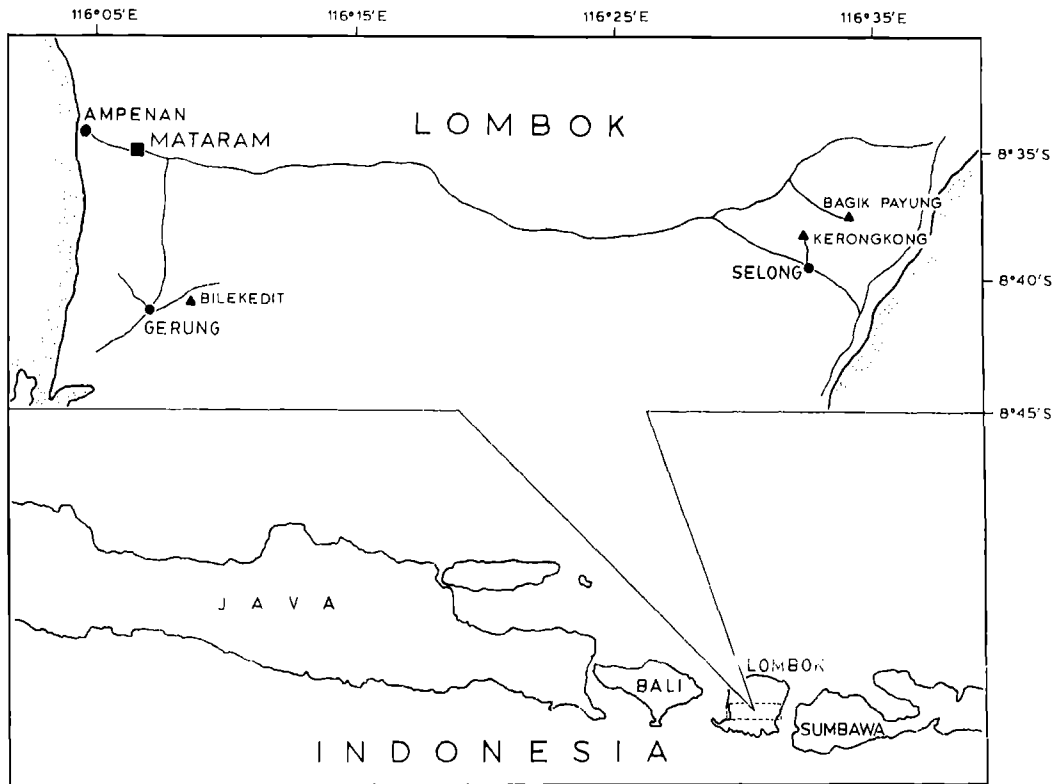


Fig. 1. Map of Indonesia indicating the Island of Lombok and collection sites.

In West Lombok, collections were made from 16 light trap-nights and 1 resting/sweeping collection. Eleven species, totalling 8,649 specimens, were utilized for virus studies. Twenty-two other less common species were retained for reference purposes.

MARCH 1979. Concentration of collection efforts to obtain large numbers of mosquitoes for viral assay resulted in obtaining more than 174,000 mosquitoes, 144,756 of which were assayed in 1,022 pooled groups. A list of mosquitoes and the numbers obtained are given in Table 3. These were collected during 37 light trap-nights with an average of 1,346 specimens per trap-night. Nine night-time resting/sweeping collections resulted in 122,929 specimens, an average of 13,658 per collection period of 1-2 hours by 3-4 collectors.

MOSQUITO SPECIES IDENTIFIED (See Table 1 for species previously reported from Lombok)

Aedes aegypti (Linnaeus): Collected only as larvae from West Lombok in 1978. The habitats were earthen and stone water jars outside of houses. None were found from in-house resting collections or by other means. Although dengue neutralizing (N) antibodies were detected in

the human population, the presumed principal vector was rare at the time of these collections. Zika virus has been isolated from this species in Malaysia (Berge 1975), and Zika Nt antibodies were also detected in human sera in Lombok (Olson et al. 1983).

Aedes albopictus (Skuse): Collected as larvae in both East and West Lombok, inhabiting earthen and stone water containers outside of houses, in bamboo stumps and fences made of bamboo poles. Adults were found in resting collections in gardens and at a cow shed in 1978. A few specimens were again captured in West Lombok in 1979.

Aedes annandalei (Theobald): Collected only in West Lombok in 1978. Only 1 female specimen was captured in a garden area in a human-landing collection. It has not been previously reported from Lombok but was reported from nearby Bali.

Aedes lineatopennis (Ludlow): Adults of this species were collected in both years. The numbers were low, only 63 specimens obtained in 1978, and 524 in 1979. More specimens were captured in light traps than in resting/sweeping collections and its presence was presumed on

the basis of reported geographical distribution in the Lesser Sundas Islands. This species has been associated with Tembusu virus in Malaysia. One viral isolate obtained in these studies remains unidentified.

Aedes poicilius (Theobald): Observed as larvae and adults in East and West Lombok in both

years. Larval habitats were leaf axils of banana plants. Four hundred twenty-six adult specimens were collected in 1978 and 40 in 1979. The largest numbers were taken in light traps at animal shelters. A few were collected in resting and human-landing collections. This species is the major vector of *Wuchereria ban-*

Table 1. Mosquito species recorded in Lombok and neighboring islands from literature citations.¹

Species	Reported presence	
	Lombok	Neighboring Islands ²
<i>Aedes aegypti</i> (Linnaeus)	+ (c)	+ (a)
<i>albopictus</i> (Skuse)	+ (c)	+ (a, d)
<i>annandalei</i> (Theobald)		+ (c, g)
<i>aureostriatus</i> (Doleschall)		+ (a)
<i>desmotes</i> (Giles)		+ (a)
<i>formosensis</i> Yamada		+ (c, e)
<i>harveyi</i> (Barraud)		+ (e)
<i>iyengari</i> Edwards		+ (a)
<i>lineatopennis</i> (Ludlow)		+ (a)
<i>lineatus</i> (Taylor)		+ (a)
<i>niveus</i> group		+ (a, c)
<i>poicilius</i> (Theobald)	+ (c)	
<i>scutellaris</i> (Walker)		+ (a)
<i>vexans</i> (Meigen)	+ (c)	+ (a)
<i>vigilax</i> (Skuse)		+ (a)
<i>Anopheles aconitus</i> (Dönitz)	+ (b, c)	
<i>annularis</i> Van der Wulp		+ (b, c)
<i>baezi</i> (Gater)		+ (b, c)
<i>barbirostris</i> Van der Wulp	+ (c)	
<i>barbumbrosus</i> Strickland & Choudhury	+ (c)	
<i>kochi</i> Dönitz	+ (b, c)	
<i>minimus flavirostris</i> Theobald		+ (b, c)
<i>subpictus</i> Grassi	+ (b, c)	
<i>sundaicus</i> (Rodenwaldt)	+ (c)	+ (b)
<i>tessellatus</i> Theobald	+ (b, c)	
<i>vagus</i> Dönitz	+ (c)	+ (b)
<i>Culex annulirostris</i> Skuse		+ (a)
<i>castrensis</i> Edwards		+ (a, c)
<i>fuscocephala</i> Theobald		+ (a)
<i>geiidus</i> Theobald	+ (c)	+ (a)
<i>malayi</i> (Leicester)		+ (a)
<i>quinquefasciatus</i> Say		+ (a, c)
<i>sinensis</i> Theobald		+ (a)
<i>sithens</i> Wiedemann		+ (a)
<i>tritaeniorhynchus</i> Giles	+ (a, c)	
<i>vishnui</i> Theobald		+ (a)
<i>whitei</i> Barraud	+ (i)	
<i>Armigeres annulipalpis</i> (Theobald)		+ (a)
<i>obturans</i> (Walker)		+ (a)
<i>Ficalbia minima</i> (Theobald)		+ (f)
<i>Mansonia indiana</i> Edwards		+ (a)
<i>Topomyia gracilis</i> Leicester		+ (a, c)
<i>nigra</i> Leicester		+ (c)
<i>Toxorhynchites splendens</i> (Wiedemann)		+ (a)
<i>Tripteroides arvanoides</i> (Theobald)		+ (a, c)
<i>plumosus</i> (Brug)		+ (c)
<i>Uranotaenia bicolor</i> sp.	+ (h)	

¹ a—Bonne-Wepster 1954; b—Bonne-Wepster and Swellengrebel 1953; c—Brug and Bonne-Wepster 1947; d—Huang 1972; e—Knight 1968; f—Mattingly 1957; g—Mattingly 1965; h—Peyton 1977; i—Sirivanakarn 1976.

² Lesser Sundas Islands, including Bali, Flores, Sumba, Sumbawa and Timor

Table 2. Mosquitoes collected in East and West Lombok, May 1978; collections made with light traps, resting/sweeping methods and by larval sampling.

Species	East Lombok		West Lombok	
	Adult coll.	Larval coll.	Adult coll.	Larval coll.
<i>Aedes aegypti</i>	0		0	+
<i>albopictus</i>	8	+	5	+
<i>annandalei</i>	0		1	
<i>lineatopennis</i>	0		63*	
<i>poicilius</i>	331*	+	95*	+
<i>vexans</i>	47*		213*	
spp.	0		49	
<i>Anopheles aconitus</i>	0		18	
<i>annularis</i>	178*		527*	
<i>barbirostris</i>	45*		109*	
<i>kochi</i>	0		3	
<i>maculatus</i>	2		1	
<i>peditaeniatus</i>	0		3	
<i>subpictus</i>	3		0	
<i>tessellatus</i>	146*		78*	
<i>vagus</i>	463*		197*	
spp.	0		144	
<i>Armigeres kuchingensis</i>	4	+	2	
<i>subalbatus</i>	0	+	2	
<i>Culex bitaeniorhynchus</i>	47*		4	
<i>fusccephala</i>	3		19	
<i>gelidus</i>	51		390*	
<i>pseudovishnui</i>	0		2	
<i>quinquefasciatus</i>	37*	+	18*	
<i>sinensis</i>	0		2	
<i>tritaeniorhynchus</i>	276*		2480*	
<i>vishnui</i>	2913*		4479*	
<i>whitmorei</i>	15		16	
spp.	0		798	
<i>Malaya genurostris</i>	2	+	0	+
<i>Mansonia uniformis</i>	13		1	
<i>Mimomyia luzonensis</i>	2		2	
<i>Uranotaenia</i> sp.	0		1	
			8649	

* Specimens assayed for viruses = 4483

crofti in the Philippines (Foote and Cook 1959). Whether or not this taxon is conspecific in Lombok and the Philippines remains to be resolved.

Aedes vexans (Meigen): This species was collected only as adults in East and West Lombok in both years. In 1978, many more specimens were captured in West Lombok than East Lombok (213 vs 47). In 1979, 220 specimens were collected, the majority by light traps. One strain of unidentified virus was isolated from this species in the present study and it is known to be related with Batai virus from Thailand (Berge 1975).

Aedes (Finlaya) sp., unidentified: One specimen was obtained from East Lombok in 1978 and was among *Ae. poicilius* collected in light traps. It is differentiated by the lack of white wing scales.

Anopheles aconitus (Dönitz): Collected in West Lombok in 1978. Only 18 specimens were collected by light traps and by resting captures at

cow shelters. The importance of this species as a vector of malaria in Java is well known (Sundararaman et al. 1957, Reid 1968).

Anopheles annularis Van der Wulp: Collected in both years in East and West Lombok, primarily in light traps. Seven hundred and five specimens were obtained in 1978 but only 298 in 1979. Its presence in Lombok was presumed on the basis of reported geographical distribution. One strain of Japanese encephalitis virus (JE) was isolated during these studies. It may be a minor vector of malaria in Indonesia (Swelengrebel and Swelengrebel de Graff 1920, Reid 1968).

Anopheles barbirostris Van der Wulp: This species was collected during both years in both East and West Lombok, mainly in light traps. One hundred fifty-four specimens were obtained in 1978 and 205 in 1979. It is the vector of *Brugia malayi*, *B. timori* and of malaria in other regions of Indonesia (Reid et al. 1979, Reid 1968).

Anopheles kochi Dönitz: Collected in West

Table 3. Mosquitoes collected at Bilekedit, West Lombok, March 20–25, 1979.

Species	Collection method ^a		Total	% of ^b total
	Light trap (av. no. per trap night)	Resting/ sweeping (av. no. per man-hr)		
<i>Culex tritaeniorhynchus</i> ****	14,512 (392)	95,271 (1985)	109,783	(77.1)
<i>vishnui</i> **	8,345 (226)	6,626 (135)	14,971	(10.5)
<i>whitmorei</i> *	3,723 (101)	4,388 (90)	8,111	(5.7)
<i>fuscocephala</i>	1,647 (45)	2,256 (46)	3,903	(2.7)
<i>bitaeniorhynchus</i>	438 (12)	29 (<1)	467	(0.3)
<i>pseudovishnui</i>	109 (3)	29 (<1)	138	(0.1)
<i>gelidus</i>	2 (<1)	2 (<1)	4	(0.1)
<i>quinquefasciatus</i>	0 (0)	4 (<1)	4	(0.1)
<i>sitiens</i> grp (mixed spp.)	19,480 (526)	11,830 (241)	31,310	
<i>Anopheles vagus</i> **	1,359 (37)	1,742 (36)	3,101	(2.2)
<i>tessellatus</i> *	459 (12)	124 (<3)	583	(0.4)
<i>annularis</i> *	155 (4)	143 (3)	298	(0.2)
<i>barbirostris</i>	122 (3)	83 (<2)	205	(0.1)
<i>kochi</i>	55 (<2)	67 (<2)	122	(0.1)
spp. (mixed)	472 (13)	89 (<2)	561	
<i>Aedes lineatopennis</i> *	355 (10)	169 (3)	524	(0.4)
<i>vexans</i> *	154 (4)	66 (<2)	220	(0.2)
<i>poicilius</i>	37 (1)	3 (<1)	40	(0.1)
<i>albopictus</i>	1 (<1)	1 (<1)	2	(0.1)
spp. (mixed)	239 (6)	8 (<1)	247	
<i>Armigeres subalbatus</i>	1 (<1)	0 (0)	1	(0.1)
			174,595	(99.7)

* Positive for virus, and number of isolates.

^a Light traps operated for a total of 37 trap-nights during 7 nights (1800–0600 hr). Resting/sweeping collections at animal stables during 7 nights (2000–2200 hr) by 3–4 collectors for a total of 49 man-hr collecting.

^b % of total numbers of mosquitoes identified to species (does not include mixed spp of *Culex*, *Anopheles* and *Aedes*).

Lombok in both years but only 3 specimens were obtained with light traps in 1978 and 122 by light traps and resting collections in 1979.

Anopheles maculatus Theobald: Collected in East and West Lombok in 1978 but not in 1979; only 3 specimens were obtained in light traps. It was not previously recorded from Lombok.

Anopheles peditaeniatus (Leicester): Three specimens were identified from West Lombok in 1978. The species has not previously been reported from Lombok.

Anopheles subpictus Grassi: Three specimens were collected in East Lombok in 1978. It is associated with Batai virus in India (Berge 1975) and is a vector of *W. bancrofti* and malaria in Flores (Lee et al. 1983a).

Anopheles tessellatus Theobald: Collected in both years in East and West Lombok. Two hundred twenty-four were obtained in 1978 and 583 in 1979, mainly by light traps. It was associated with Batai virus in India (Berge 1975). One unidentified virus was isolated in the present studies.

Anopheles vagus Dönitz: Collected in both years in East and West Lombok. Six hundred and sixty specimens were obtained in 1978 and

3,101 in 1979, representing the most abundant species of *Anopheles* found. Greatest numbers were obtained in resting collections at animal stables. Two viral strains (1 of JE and 1 unidentified) were isolated from this species.

Armigeres kuchingensis Edwards: Six specimens were collected in East and West Lombok in 1978 from light traps and in resting collections. Larvae were also obtained from coconut shells. This species has not previously been reported from Lombok.

Armigeres subalbatus (Coquillett): Three specimens were collected in West Lombok in both years from light traps. This species has not previously been reported from Lombok.

Culex bitaeniorhynchus Giles: Collected as adults in both years in East and West Lombok. In 1978, only 51 specimens were obtained and in 1979, 467 were collected from light traps and in resting collections, the majority by the former method. It has not previously been reported from Lombok or from nearby islands. The species has been associated with Murray Valley encephalitis (MVE) in Australia and with Batai in India (Berge 1975).

Culex fuscocephala Theobald: Collected in East

Lombok in 1978 (22 specimens) and in West Lombok in 1979 (3,903 specimens); the majority in resting collections in 1979. Japanese encephalitis virus was recently isolated from this species collected near Jakarta in 1979 (J. G. Olson, personal communication).

Culex gelidus Theobald: Four hundred forty-one specimens were collected in 1978 by light traps and in resting collections in East and West Lombok, and only 4 specimens in 1979. No viral agents were obtained in these studies but JE virus was isolated from this species elsewhere in Indonesia (Van Peenen et al. 1975). It has been associated with Tembusu and Batai viruses in Malaysia and India, respectively (Berge 1975).

Culex pseudovishnui Colless: Only 2 specimens collected in West Lombok in 1978, and 138 in 1979, mostly in light traps. It was not previously reported from Lombok. It has been associated with Kunjin and Tembusu viruses in other areas (Berge 1975).

Culex quinquefasciatus Say: The least commonly collected *Culex* in our studies. In 1978, 55 specimens were collected from East and West Lombok, the majority in resting collections. In 1979 only 4 specimens were obtained in resting collections. It was not previously reported from Lombok. *Culex fatigans* (= *quinquefasciatus*) was shown capable of transmitting Murray Valley encephalitis in Australia (Berge 1975).

Culex sinensis Theobald: Represented by only 2 specimens collected from light traps in West Lombok in 1978. None were identified in 1979 but possibly were included in the unsorted group under *Cx. sitiens* group.

Culex tritaeniorhynchus Giles: The most abundant mosquito species collected in these studies. It was collected in 1978 in East and West Lombok (2,756 specimens) and 1979 (109,783 specimens) in light traps and by resting collections, with greatest numbers taken in resting collections in 1979. Four viral isolates (1 of JE, 3 unidentified) were obtained in these studies and JE virus has been isolated from the species elsewhere in Indonesia (Van Peenen et al. 1975). It has also been associated with 2 other viruses used in our tests, dengue-3 and Tembusu (Berge 1975).

Culex vishnui Theobald: Collected as adults in both years in East and West Lombok, from light traps and in resting collections. Seven thousand ninety-two specimens were obtained in 1978 and 14,971 in 1979; the majority in light traps. It was the second most abundant *Culex* sp. collected. Two unidentified viral isolates were obtained from this material. The species (reported as *annulus*) was associated with Tembusu in Thailand and JE in Taiwan (Berge 1975, J. G. Olson, personal communication).

Culex whitmorei (Giles): Collected in 1978 (31 specimens) and 1979 (8,111 specimens) in East and West Lombok; the majority in resting collections in 1979. It was the third most abundant *Culex* collected. It was not previously reported from Lombok or neighboring islands. One unidentified viral isolate was obtained from this species collected from West Lombok in 1979.

Culex spp., *Sitiens* Group: Mixed species collected in both 1978 (798 specimens) and 1979 (31,310 specimens) by light traps and by resting collections. It is thought that these consisted of *Cx. tritaeniorhynchus*, *pseudovishnui* and *vishnui*.

Malaya sp.: Tentatively determined as *genurostris* Leicester; collected only as larvae from banana leaf axils in East Lombok and from bamboo stumps in West Lombok in 1978. This genus was not listed in references as occurring in Lombok or nearby islands.

Mansonia uniformis (Theobald): Collected in 1978 but numbers were few (10 in light trap collections and 3 in resting collections in East Lombok; only 1 specimen was collected in West Lombok) and none were collected in West Lombok in 1979. The species was presumed present in Lombok from records for nearby islands.

Mimomyia luzonensis (Ludlow): Collected as adults in East and West Lombok in 1978; only 4 specimens were taken in light traps. The species has not been previously recorded from Lombok and has not been associated with arboviruses.

Uranotaenia sp.: Only 1 male specimen was obtained in resting collections in West Lombok in 1978.

DISCUSSION

The major purpose of this study was to collect and preserve large numbers of mosquito species for assay of arthropod-borne viruses. Our collecting methods were thus directed to obtain abundant adult mosquitoes, rather than to make a general survey. Nevertheless, 30 species were identified from collections carried out in May 1978 and March 1979. Previous records referring specifically to Lombok included 16 species. A further 31 species were presumed present based on records listing species distribution in Lombok or neighboring islands.

The list of species obtained by concentrated collecting in March 1979 shows the relative abundance of species and of those harboring viral agents (Table 3).

As throughout most regions of Indonesia under rice cultivation, *Cx. tritaeniorhynchus* is the dominant species of *Culex*. In these studies, *Cx. tritaeniorhynchus* comprised 80% of all *Culex* identified to species and 77% of all mosquitoes collected in West Lombok in March 1979.

Elsewhere in Indonesia, the species was shown to be the major mosquito host of JE virus (Van Peenen et al. 1975, Olson et al. 1983). In 1978, 1 isolate of JE was obtained from 2,758 specimens of *Cx. tritaeniorhynchus* processed for viruses from East and West Lombok. In 1979, the species provided 3 viral agents, not yet identified and 1 JE isolate, from 108,203 specimens processed. The species was always abundant at cattle and buffalo stables located in the villages and apparently fed to a great extent on those animals.

Culex vishnui and *Cx. whitmorei*, fewer in total numbers than *Cx. tritaeniorhynchus*, however, provided proportionately more viral isolates in 1979. The remaining *Culex* spp., except *Cx. fuscocephala* were few in numbers by our collecting methods, comprising less than 3% of all the mosquitoes specifically identified, and no viral agents were isolated from them. Japanese encephalitis virus was isolated from *Cx. fuscocephala* collected near Jakarta in January 1979 (J. G. Olson, personal communication).

Anopheles vagus was dominant among the *Anopheles*, comprising 72% of all the anophelines identified to species, but only 2.2% of all the mosquitoes collected in 1979. The species provided 2 viral agents (1 of JE and 1 unidentified). *Anopheles tessellatus* and *An. annularis* each provided 1 unidentified viral agent. The other *Anopheles*, *barbirostris* and *kochi*, comprised less than 8% of the genus identified to species and no viral agents were isolated from them. These species have not previously been shown to be associated with arboviruses in Indonesia.

Anopheles peditaeniatus was identified from but 3 adult specimens collected in West Lombok in 1978. Its presence here is unusual as the *hyrcanus* group was not recorded in the literature from the Lesser Sundas islands east of Java, where it is widely dispersed.

Aedes lineatopennis and *Ae. vexans* comprised 67% and 28% of the *Aedes* collected in 1979, but only 0.4% and 0.2%, respectively, of all the mosquitoes collected. Each provided 1 unidentified viral agent; neither had previously been shown to be involved with arboviruses in Indonesia. The other 2 species of *Aedes*, *poicilius* and *albopictus*, comprised only 5% of the genus and less than 0.2% of all mosquitoes identified.

No mosquitoes in the other genera collected were processed for viruses as numbers were too few and some were known only from larval collections. Few *Ma. uniformis* were collected in these studies. We have also noted the low populations of this species in Bali and further east in Flores where regular, long-term collections were carried out. The low numbers suggest

that the species may have little medical importance in the areas of our studies.

The remaining genera are of minor concern in these studies as they are not known to be of medical importance or were represented in low numbers. The genus *Malaya* is now reported for the first time from Lombok, having been reared from larval collections. *Mimomyia luzonensis* and *Uranotaenia* sp. were very rare in adult collections.

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