

ANOPHELINE MOSQUITOS OF NORTHWEST COASTAL MALAYSIA

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Abstract. Collections of adult anopheline mosquitos were made from a cow-baited trap in nine coastal villages located along nearly 160km of northwest peninsular Malaysia. Two collections, separated by 1.5 to 6 months, were made at each site. Nearly 6,000 anophelines of 19 species were collected. The dominant species were *Anopheles peditaeniatus*, *An. sinensis*, *An. subpictus* and *An. lesteri paraliae*. Small numbers of the malaria vectors *An. maculatus* (at one site) and *An. campestris* (at four sites) were collected, but no *An. sudaicus* were recorded.

INTRODUCTION

In peninsular Malaysia most previous studies on anopheline mosquitos have concentrated on those species, especially malaria vectors, which occur in the central and southern regions. The present study was concerned with the species composition, and their relative abundance, in the northwest region, and specifically with the adult fauna of the brackish water fringe and the flat coastal plains. These zones form two of the seven topographical regions into which Hodgkin (1956) divided the country in his review of malaria transmission in peninsular Malaysia.

The brackish water zone is a narrow strip where the land is liable to be flooded by sea water. However, along much of the northwest coastline, bunds and tide-gates have been constructed to exclude sea water, thus making most of the coastal strip suitable for the cultivation of such crops as rice, coconut, rubber and oil palm. The coastal plain has become largely devoted to rice cultivation, and rice fields extend along the coast for nearly 170km, with inland incursions stretching up to 32km.

To determine the distribution and species composition of the anopheline fauna, sites were selected at intervals of 20-40km, and two night collections, separated by 1.5 to 6 months, were made at each site.

MATERIALS AND METHODS

Collection sites

Adult collections were made at Kampung Tekuh and Pantai Chenang on Pulau Langkawi, Kampung Sungai Berembang, Kampung Alur Ibus; Kampung Singkir Laut, Kampung Permatang Rawa, Kampung Permatang Pasir, Sungai Udang Kecil and Kuala Gula (Fig 1).

Pulan Langkawi : Kampung Tekuh: Pulau Langkawi is an island resort which lies about 12km from the mainland. It has a brackish-water zone and a coastal plain that extends about 3.2km inland. Kampung Tekuh is a small village about 6km west of the main town of Kuah. Most of the population are involved in rice growing at a subsistence level. The ricefields are close to the coast which is fringed by mangrove trees and swamp trees. Buffalos are more commonly kept than cattle as they are used for ploughing the ricefields.

Pulan Langkawi : Pantai Chenang: Pantai Chenang is situated on the southwest corner of Pulau Langkawi about 14km from Kuah. It is located very close to the sea with a wide strip of sandy beach. Rice is also grown on a subsistence level, but more extensively than in Kampung Tekuh. The income of the population is supplemented by a small fishing industry.

Kampung Sungai Berembang: Kampung Sungai

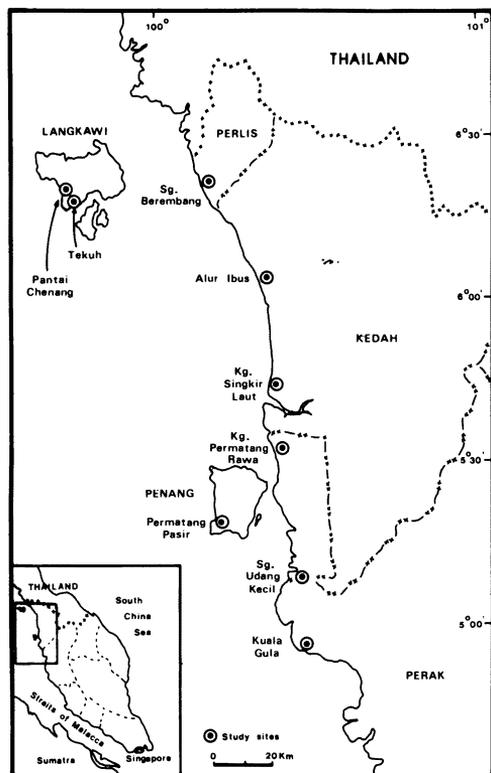


Fig 1—Map of northwest Malaysia showing the location of collection sites.

Berembang is located in the state of Perlis, and forms part of the northern rice bowl of Malaysia. It is situated right on the coast where it is sandwiched between the sea and extensive ricefields. The terrain is flat, only a few meters above sea level, and sea water is prevented from flooding the village and the ricefields by a bund on which the main road leading into the village has been constructed. The majority of the population are rice growers, but a few obtain their livelihood from the sea.

Kampung Alur Ibus: Kampung Alur Ibus is situated on the coast of Kedah, about 1.6km from the sea. It is flat and low lying, being only a few meters above sea level. As with Kampung Sungai Berembang, the village lies within the main rice-growing area of Malaysia, and the income of the population is derived mainly from this source. Houses are scattered, and built on dry, slightly raised ground in the middle of the ricefields. Most of the settled and cultivated areas are protected by

bunds and tide-gates and they are not liable to inundation by salt water. In both Kampung Sungai Berembang and Kampung Alur Ibus, large domestic animals such as cattle and goats were scarce.

Kampung Singkir Laut: Kampung Singkir Laut is a small fishing village located near the tip of the southern coastline of the state of Kedah. The surrounding area generally is hilly and covered with secondary forest. The village is situated at the base of a cliff below the level of the main road and close to the sea, with the immediate surroundings covered by coconut trees, amongst which the houses are built close to one another. The beach is lined with mangrove trees. Small domestic animals were common, and cattle were kept in a shed about 2.5km away from the village.

Kampung Permatang Rawa: Kampung Permatang Rawa is a coastal village situated about 30km north of the island of Penang. The principal crop grown within this coastal strip is rice, interspersed with coconut palms, especially around the houses. The village in general is sandwiched between the sea and the ricefields. Inundation with sea water is never extensive, and consequently collections of brackish water, exposed or partially shaded, were scarce; bunds and tide gates protect the settled and cultivated areas from the sea water. There was one very large enclosed field within the village where about 60 cattle were kept at night. This cattle enclosure was located close to the collection site. Around the site were chicken coops which housed 500-700 chickens during part of the year.

Kampung Permatang Pasir: On Penang island, sampling was carried out at Kampung Permatang Pasir, which lies on the southwest coast of the island, about 1.5km from the sea. Much of the area was formerly under rice cultivation, but the fields are now barren and overgrown with tall grasses and sedges where large numbers of cattle and goats graze. However, the ditches and former irrigation canals were still filled with water. Other vegetation in the village included patches of nipah palm. Coconut palms and rubber trees were also abundant. There was only one house close to the sampling site.

Sungai Udang Kecil: Sungai Udang Kecil, also a coastal village, is situated about 60km by road south of the island of Penang. It is approximately 2km from the sea front, adjoining the mouth of the Aceh and Kerian rivers on the border between

Penang and Perak. Rice is again the main crop and, typical of the coastal areas here, coconut palms are abundant. A small area of the village is cultivated with oil palm. The coastline is fringed by mangrove swamps and their limits are the bunds that protect the cultivated areas from being inundated by the sea. The livelihood of the people is farming and fishing. In addition, many of the

villagers keep livestock such as chickens, ducks, goats and cattle for additional income. There are two cattle sheds, about 0.5km apart, each housing about 20 cattle.

Kuala Gula: The last sampling station, designated as the southern tip of the northwest coast of peninsular Malaysia, is Kuala Gula. It is a small fishing village situated right at the mouth of the Gula

Table 1

Species composition of the anopheline populations in northwest peninsular Malaysia.

Species	Collection sites							
	PL	KSB	KAI	KSL	KPR	KPP	SUK	KG
<i>Anopheles (Anopheles)</i>								
<i>argyropus</i>	-	-	-	-	-	1	-	-
<i>barbirostris</i>	131	6	-	2	-	-	-	-
<i>campestris</i>	2	-	-	-	6	11	12	-
<i>lesteri paraliae</i>	-	-	-	-	13	135	211	12
<i>nigerrimus</i>	1	14	14	-	52	1	41	-
<i>nitidus</i>	8	-	-	-	-	-	1	-
<i>peditaeniatus</i>	59	1,203	985	7	509	21	4	-
<i>pursati</i>	-	-	-	-	-	2	-	-
<i>sinensis</i>	3	719	26	-	300	2	56	3
<i>Anopheles (Cellia)</i>								
<i>aconitus</i>	98	-	-	-	-	-	-	-
<i>indefinitus</i>	6	4	2	17	17	-	96	32
<i>jamesii</i>	34	-	-	-	-	-	-	-
<i>karwari</i>	1	-	-	9	-	-	-	-
<i>kochi</i>	67	-	-	-	-	1	-	-
<i>maculatus</i>	-	-	-	3	-	-	-	-
<i>philippinensis</i>	51	-	-	2	-	-	1	-
<i>subpictus</i>	126	-	2	400	32	-	65	36
<i>tessellatus</i>	3	-	-	6	-	31	-	-
<i>vagus</i>	60	-	-	9	153	8	11	19
Totals	650	1,946	1,029	455	1,082	213	498	102

- PL = Pulau Langkawi
 KSB = Kampung Sungai Berembang
 KAI = Kampung Alur Ibus
 KSL = Kampung Singkir Laut
 KPR = Kampung Permatang Rawa
 KPP = Kampung Permatang Pasir
 SUK = Sungai Udang Kecil
 KG = Kuala Gula

river which thrives on a considerable fishing industry. The houses are built very close together on raised ground along the water front. Bunds exclude the sea water from the lowlying land, and inundation with salt water is not a major problem. The village is bordered by mangrove swamps along the river mouth, and inland it is surrounded by a large oil palm estate. Domestic animals such as chickens, ducks, geese, goats and cattle were common.

Collection methods

In Malaysia, the routine collecting of anophelines in houses during the day has been found to be unsatisfactory. This is because the majority rest outdoors during the day (Wharton, 1950, 1951). The mosquitos are normally collected at night, and various methods have been employed for this purpose. They may be caught biting man, resting on sides of net traps, in light-traps or in animal sheds. In the present study, the method that was found to be the most satisfactory was the cow-baited trap.

The cow-baited trap was based on the technique employed by Reid (1961) in his comparative studies on the attraction of mosquitos to human and animal baits. The trap consisted of a large mosquito net which measured 2.4m by 2.4m and 1.6m high, with a 1.2m door on one side which could be closed by zip fasteners. The net was hung 0.3m above the ground to allow the entry of mosquitos, and a cow was tethered inside it. A tarpaulin was placed over the net for shelter from rain. The trap was in operation for six hours beginning at sunset, and at the end of each hour three collectors entered the net and for 15 minutes collected the anopheline mosquitos resting on the sides of the net. The collections were held in ice chests to reduce mosquito movement and damage and transported to the Universiti Sains Malaysia for identification.

RESULTS

A total of 68 *Anopheles* species have been recorded in Malaysia and, of these, 18 were reported by Reid (1968) to occur in the brackish water zone and the coastal plain. In the present survey of the nine coastal villages, a total of 5,975 anophelines comprising 19 species were collected. However, only seven of the 18 species reported by Reid

(1968) were found. *An. sundaicus*, formerly a common species in the brackish water fringe, was not encountered. The most dominant species in the survey was *An. peditaeniatus*, which accounted for 46.7% of the total catch. Other species commonly collected were *An. sinensis* (18.6%), *An. subpictus* (11.1%), *An. lesteri paraliae* (6.2%), *An. vagus* (4.4%), *An. barbirostris* (2.3%), *An. nigerrimus*, (2.1%) and *An. aconitus* (1.6%). Table 1 shows the species composition of the collections from each of the villages, but since the two villages on Pulau Langkawi are relatively close together, their collections have been pooled.

An. argyropus was the least collected mosquito along the coast. Only one specimen was collected in Kampung Permatang Pasir. In India and Thailand this species has been found breeding in rice-fields and swamps (Ramachandra Rao, 1984; Harrison and Scanlon, 1975), but Reid (1968) reported immatures collected in Malaysia from large deep swamps. Deep swamps were uncommon in the study areas, which may explain the virtual absence of *An. argyropus*.

An. barbirostris was collected only in the northern half of the coast surveyed, and it was most abundant on Pulau Langkawi. Hodgkin (1956) reported it to be common in inland rice-fields, whereas Reid (1962) reported it on the coast where the soil is sandy.

An. campestris on the other hand was collected mostly in the southern half of the coast surveyed. This species is typically found in flat coastal or rice plain areas (Reid, 1962). A greater part of the northwestern coast is broad alluvial plain given over to rice cultivation, and no explanation can be suggested for the abundance of *An. barbirostris* in the north and the relative scarcity of *An. campestris* in the region. More research is needed to confirm the distribution of these species in the northwest.

An. lesteri paraliae was only collected in the southern group of study sites. The subspecies is largely confined to the coast where it breeds in shady pools containing fresh or slightly brackish water (Sandosham, 1959). Its southern distribution may be explained by the fact that the northern region is a more open ricefield ecotype, with the exception of Kampung Singkir Laut, where the terrain is hilly.

An. nigerrimus was collected in all the study sites except in Kampung Singkir Laut and Kuala Gula. This species breeds in stagnant or slow-moving water covered with aquatic vegetation, and has been particularly associated with deep ponds, open swamps and ricefields (Reid, 1953, 1968; Sandosham, 1959). Kampung Singkir Laut is surrounded by hilly areas covered with secondary forest, whereas Kuala Gula is surrounded by mangrove swamps and an oil palm estate. In both localities the preferred habitats of *An. nigerrimus* were uncommon.

An. nitidus, which Reid (1953) reported as being numerous in ricefields, was rather scarce along the northwest coast. Only eight mosquitos were collected on Pulau Langkawi and one in Sungai Udang Kecil. It is a comparatively uncommon species and knowledge of its ecology is meagre.

An. peditaeniatus was the most common of the species collected along the northwest coast. It is one of the dominant members of the *An. hyrcanus* species group found in ricefields; besides being numerous in ricefields, larvae are found in swamps and grassy ponds (Reid, 1953; Harrison and Scanlon, 1975). Since much of the region surveyed is under extensive rice cultivation, the high prevalence of ricefield breeders such as *An. peditaeniatus* is not unexpected. On the other hand, the low numbers of *An. peditaeniatus* at Sungai Udang Kecil, where rice is grown on a large scale, is very difficult to explain. A more extensive series of collections throughout the year at this site confirmed that *An. peditaeniatus* is relatively uncommon.

An. porsati was only collected at one site. It is a rare species, of which little is known. It has been recorded in Kedah and Penang, but does not extend further south (Reid, 1968). In Thailand it has been collected in low numbers from widely scattered collection sites (Harrison and Scanlon, 1975).

Except at Kampung Singkir Laut, *An. sinensis* was collected in all the study sites. It is a predominantly ricefield mosquito, and it is strongly influenced by the water level in the fields (Chiang *et al.*, 1986). The low catches on Pulau Langkawi, Kampung Alur Ibus and Sungai Udang Kecil, all with large areas of ricefields, may be because the collecting periods were at times when most of the

fields were being prepared for planting, when there was little standing water. Collections during other periods at Sungai Udang Kecil provided good numbers of the species.

An. aconitus was surprisingly collected only on Pulau Langkawi. It is reported as a fairly common mosquito throughout peninsular Malaysia, breeding in the grassy edges of ricefields, grassy ponds and swamps that are exposed to sunlight (Hodgkin, 1956). It is apparently absent from parts of the coastal plains where there are no ricefields or other suitable breeding places (Sandosham and Thomas, 1983), but its absence from most of the present collection sites is difficult to explain.

Though not very common, *An. indefinitus* was collected in all the study sites except in Kampung Permatang Pasir. This species has been reported by Reid (1968) as a common coastal anopheline, breeding in grassy pools, ponds and ditches with freshwater.

An. jamesii was another anopheline species that was collected only on Pulau Langkawi. In general its distribution is confined to the north-western part of the peninsula (Reid, 1968), having been reported only on Pulau Langkawi and in mainland Kedah, where females were caught around buffalos (Sandosham and Thomas, 1983).

An. karwari was collected from only two study sites, one on Pulau Langkawi, the other at Kampung Singkir Laut. It is predominantly a hill mosquito, occupying breeding habitats very similar to those of *An. maculatus*, ie hill seepages and small streams in the open or under light shade. Such habitats may often have only *An. karwari* or *An. maculatus* (Hodgkin, 1956).

An. kochi was collected almost entirely on Pulau Langkawi. Except for a single specimen in Kampung Permatang Pasir, this species was not collected at any of the other study sites on the mainland. Reid (1968) reported it as a common species which is widely distributed in the open, in habitats such as muddy collections of water, hoof marks, and buffalo wallows. Its absence from most collection sites is difficult to explain.

In the present study, Kampung Singkir Laut was the only study site where *An. maculatus*, the main malaria vector in peninsular Malaysia, was collected. It is a common species found predominantly in open hilly areas where it breeds in

water courses and seepages (Sandosham 1959, 1962). However, the coastal areas of the west coast of peninsular Malaysia are mostly flat alluvial plains which explains its scarcity.

The majority of *An. philippinensis* were collected on Pulau Langkawi. It was quite rare in the mainland study sites, only two specimens being collected in Kampung Singkir Laut and one in Sungai Udang Kecil. Reid (1968) was uncertain as to its distribution in Malaysia because some of the records available may refer to *An. nivipes*, but Sandosham and Thomas (1983) stated that it is common throughout the country, especially in rice-growing areas.

Except in Kampung Sungai Berembang and Kampung Permatang Pasir, *An. subpictus* was collected commonly in the study sites. It is a species confined to the coast and its distribution is possibly restricted to the northern half of peninsular Malaysia (Reid, 1968). It is generally a brackish-water species (Reid, 1966), and in areas where regular inundation by sea-water occurs *An. subpictus* is very common, especially where there are large numbers of cattle.

An. tessellatus was collected in low numbers on Pulau Langkawi, in Kampung Singkir Laut and Kampung Permatang Pasir. It is quite widely distributed throughout Malaysia, except in forest, but is seldom encountered in large numbers (Reid, 1968).

An. vagus is another species that is widely distributed except in forest, and it is considered by Sandosham and Thomas (1983) to be one of the most common Malaysian mosquitos. It was collected in nearly all the study sites.

DISCUSSION

Although the reported surveys were limited to two adult collections at each of the nine study sites along an approximately 160km stretch of the coast, a reasonable picture was gained of the species composition of the anopheline population. Initially the two collections were planned to be made once during the period of greater rainfall and the other during the period of lesser rainfall, but owing to the shortage of time and the distances to be travelled the surveys were made 1.5 to 2 months apart, except on Pulau Langkawi where they were made

6 months apart. However, subsequent two-weekly collections at two of the sites revealed wide monthly fluctuations in the anopheline population, which were the result of rainfall and/or rice cultivation practices. Similar fluctuations probably occurred at the other study sites and no great emphasis can be placed on the relative numbers of the species collected.

Of the nineteen species collected, only two were recognized vector species. *An. maculatus*, the country's main malaria vector, was uncommon since it is a predominantly hill species. The other, *An. campestris*, is a vector in the coastal plain (Reid, 1962), and this was more commonly collected than *An. maculatus*. *An. sundaicus*, an important vector in the past in the coastal belt of Malaysia, is a brackish-water species confined to the intertidal zone along the coast (Hodgkin, 1956; Sandosham, 1962). However, in the surveys no specimens were collected. The explanation for its absence is that most of the preferred breeding habitats have been removed by the extensive bunds built to prevent sea water from inundating the agriculture holdings along most of the coast. Since much of the area sampled is under extensive rice cultivation, the most dominant anophelines were, not surprisingly, ricefield breeders, especially *An. peditaeniatus* and *An. sinensis*.

ACKNOWLEDGEMENTS

We are grateful to the technicians of the School of Biological Sciences, Universiti Sains Malaysia, who assisted with the mosquito collections. The investigation received support from the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases.

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