Review of the anopheline mosquitoes of Myanmar

Thin Thin Oo[1], Volker Storch[2], and Norbert Becker[3*]

[1]*Department of Zoology, University of Yangon, Myanmar*
[2]*Zoological Institute, University of Heidelberg, Im Neuenheimer Feld 230, 69120 Heidelberg, Germany*
[3]*German Mosquito Control Association/KABS, Ludwigstrasse 99, 67165 Waldsee, Germany*
[*]*Corresponding author*

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ABSTRACT: This study examined the species of anopheline mosquitoes in Myanmar. Out of 36 species of anophelines distributed throughout the country, ten species were found to be infected with the malaria parasite. These vectors are presented with particular reference to their distribution and a summary of bionomics and infection rates. ***Journal of Vector Ecology* 29 (1): 21-40. 2004.**

Keyword Index: Anopheline mosquitoes, Myanmar.

INTRODUCTION

In contrast to most of the other countries of Asia, little information has been published on aspects of malaria and anopheline mosquitoes in Myanmar before World War II. Only four references can be found in the literature (Stott 1916, Christophers 1933, Grewal 1937, James 1941). No references are available from Myanmar sources regarding the anopheline mosquitoes and/or malaria situation of the country during the Japanese occupation from 1942 to 1945. It is presumed that malaria investigations were interrupted during that period. However, five references are available from British military sources (to fill the knowledge gap concerning anopheline mosquitoes within Myanmar) during World War II. These are the results of surveys carried out by the British anti-malaria unit in Upper Burma (now Myanmar) and Arakan (now Rakhine) during the Burma Campaign from 1943 to 1945. Of these five references, four are published as articles and one is a Ph.D. thesis. Yofe and Fox (1946) dealt with entomological aspects, and Macan (1948, 1950) included epidemiological data accompanied by spleen surveys and mosquito dissection records in Burma. Tyssul-Jones (1950) furnished indirect epidemiological evidence in incriminating *Anopheles sundaicus* as one of the local vectors of malaria. Fox (1949) listed a total of 27 species of anophelines encountered in Burma up to the end of World War II in 1945 and reviewed all the available data accompanied by distribution maps and dissection records.

A malaria control project assisted by the World Health Organization (WHO) was conducted in Lashio area, Northern Shan State (NSS) from October 1951 to March 1954 and subsequently in Maymyo (now Pyinoolwin) area, NSS from April 1954 to December 1955, during which detailed studies were undertaken on the epidemiology of malaria and bionomics of the local vector *Anopheles minimus* (Weeks 1955, Postiglione and Venkat-Rao 1956, Tun Aung and Mya Maung, personal communication). A total of 24 anopheline species was encountered by national and WHO entomologists in the project area.

During the malaria eradication period (1970-1980), a vast amount of information was accumulated on the biology of anopheline mosquitoes in Burma, with particular reference to their distribution, bionomics, malaria transmission, and susceptibility to insecticides as a result of routine entomological surveys undertaken on country-wide basis by Kyi (1970a, b, 1971, 1972a, b, c, 1975) and Kyi and Winn (1976).

In addition, there are some published and unpublished departmental reports held by the Department of Medical Research (DMR) and Department of Vector Borne Disease Control (VBDC). These materials form the bulk of general background information on malaria incidence and status of anopheline mosquitoes in the country. The main focus of this study is to determine the vector-competence of the various species. It is a critical survey of all available data regarding the species of anopheline mosquitoes so far recorded in Myanmar and their relationships with malaria transmission.

MATERIALS AND METHODS

Brief geographic description of Myanmar

As the western segment of the Indochina Pennisula, the Union of Myanmar lies between southeast Asia and southern Asia. Myanmar extends from 9° 55′ to 28° 30′ north and longitudinally from 92° 10′ to 101° 9′ east.

Approximately one-third of Myanmar lies outside the tropics and the remaining two-thirds belongs to the hot tropical area. Myanmar adjoins the Bay of Bengal in the west and the Andaman Sea in the south, both parts of the Indian Ocean.

It has a long land frontier (6,170.69 km) that it shares with Bangladesh (258 km) and India (1,341 km) on the west, China (2,210 km) on the north and northeast as well as Laos (226 km) and Thailand (2,097 km) on the east. The country's maximum east-west extension is 927 km and the maximum north-south is 1,935 km.

Myanmar, with a total area of 676,577 square kilometers, is the second largest country in the Association of Southeast Asian Nations (ASEAN), after Indonesia. It is about the same size as France and Britain together.

The Union of Myanmar lies within the most distinctive physical environment in Asia with single core areas placed within a bounding framework of mountains. The country consists of a group of lowland alluvial valleys ending in a broad delta opening to the Andaman Sea. The lowland is surrounded by a series of mountainous uplands with few suitable passes. In the north, the landscape is high and rugged with very narrow valleys. To the south the mountain frame is open towards the Ayeyarwady-Sittoung delta and the Gulf of Martaban. It is an elongated region in which all essential units have a chiefly north-south axis.

Collection areas

Sampling sites were chosen throughout the country (Table 1 and Figure 1). All catches were conducted by field techniques of WHO (1992) from May 1998 to March 2000.

Night collections: Human bait catches (both indoors and outdoors) with glass tubes and aspirators or sucking tubes were conducted from 6:00 p.m. to 6:00 a.m. on the next day once a week.

Indoors: A house was selected in the area of the village with the greatest number of cases of malaria. A house with more than one room was preferred, allowing the usual residents to sleep in one room while another was used by the collector.

Outdoors: The collection of mosquitoes from the body was a common way of obtaining biting specimens, especially of *Anopheles*. Outdoor collecting from human bait was conducted to fit in with the normal resting and sleeping habits of the local people. The collections were often made during the entire period from dusk to dawn.

The paper cups containing the hourly collections were labelled with location, date, whether and when the location was last sprayed, type of bait, site of collection (indoors or outdoors), hour of collection (e.g., 6:00 p.m. to 7:00 p.m.), and the collector's name.

Animal-baited trap net catches were conducted with aspirators starting from 6:00 p.m. to 6:00 a.m. on the next day. A tame animal was selected from the village, usually a cow or water buffalo. An animal-baited trap net was set close to where the animal was customarily kept overnight. Before sunset, the animal was tied securely using a short tether attached to wooden or metal pegs driven firmly into the ground. At sunset, the mosquitoes were collected using a flashlight and sucking tube in a three-h interval, for instance at 6:00 p.m., 9:00 p.m., midnight, 3:00 a.m., and sunrise. Each hour's collection was kept in a separate paper cup. The animal bait collection was carried out in the same location and at the same time.

Daytime collections: In each village, about 10 houses were normally examined in order to provide a representative sample. The selection of houses for routine collecting was a complex statistical procedure. In the case of a single visit, the houses selected were scattered throughout the village. It was often advantageous to select the poorest and worst-ventilated houses because they usually contained the largest numbers of mosquitoes. Houses on the fringe of a village or near known breeding sites would often yield more day-resting mosquitoes.

The collection of mosquitoes in a house took place early in the morning. The whole house was examined, but if it was too large, a maximum 15-min search in each room was done. Special attention was paid to those parts of the house most likely to yield vector mosquitoes, including sleeping and washing rooms. Selected rooms had few external openings.

The search for mosquitoes on walls, ceilings, or the roof was aided by a flashlight. The systematic search started from the door and moved clockwise around the inside of the house. Specimens were looked for on wall hangings and curtains, behind and under furniture, and inside large pots and jars. No more than five mosquitoes were collected in the sucking tube before being transferred to a paper cup.

During hand collecting, a separate paper cup was used for each house. The cup was clearly labelled with at least the following essential information: location, date and time of collection, duration of collecting (minutes), house number or householder's name, type of structure (house, animal shelter, store, etc.), whether sprayed, and

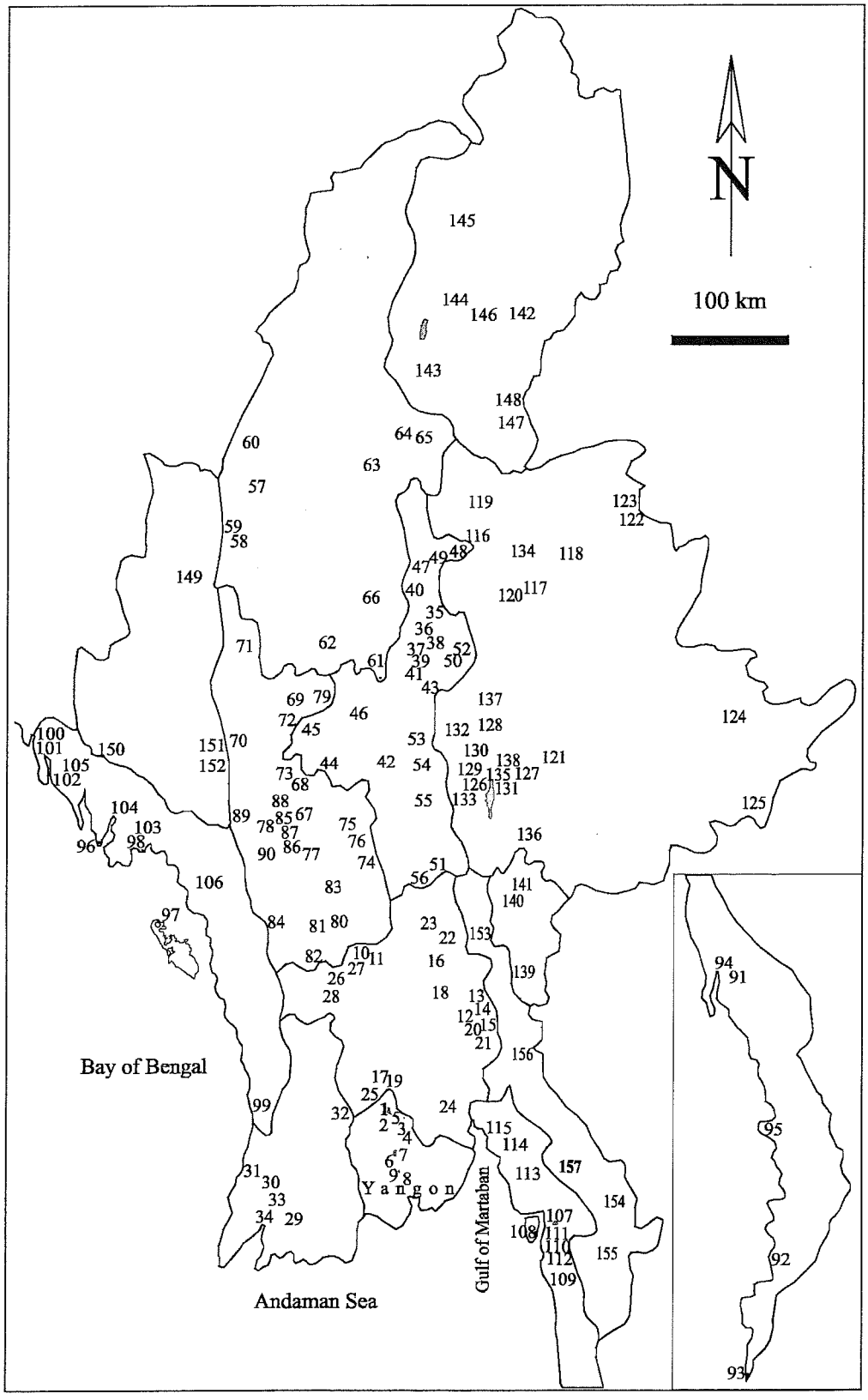

Figure 1. Sampling sites where anophelines were collected (1-157).

if so, when.

The collected specimens were identified morphologically as far as possible using keys of "identifications of anopheline larvae" and "identifications of female anopheline mosquitoes" which were modified by Thin Thin Oo, after Delphin and Rao (1957).

Dissection of mosquitoes (Incrimination of vector)

The choice of which organ was to be dissected depended on the type of data required. The stomach was dissected to investigate the presence of oocysts, their number, stage of development, and positioning on the midgut. If oocysts were observed, the mosquito was considered "infected." However, in order to determine whether a mosquito was infective, the salivary glands were dissected and examined for the presence of sporozoites. This was carried out routinely for establishing the parity, sporozoite, and oocyst rates.

Research on the malaria vector

Classification has been made of all recorded species and their relation to malaria transmission in Myanmar. The decision as to whether or not a particular species is a vector of malaria was done taking the following into account:

Dissection records: The evidence that can incriminate a species as a vector is the finding of sporozoites in the salivary glands on numerous occasions. The occasional finding of gut infection without corresponding salivary gland infection cannot be considered as evidence that the species is transmitting malaria.

Feeding habits: If it can be shown, either by night collections or by an extensive series of precipitation tests (WHO 1975), that a particular species is feeding mainly on human blood rather than on animal blood, then that species must be considered a potential vector.

Distribution: Usually there is a correlation between the distribution of a suspected species and the distribution of malaria.

Seasonal prevalence: A species that is transmitting malaria in any area must be abundant in that area at the time when most malaria cases are occurring. This fact can sometimes be used as circumstantial evidence against a species when the direct evidence of positive dissections cannot be obtained. Conversely, a species that is never found in any abundance is not likely to be of any importance as a vector.

RESULTS

Out of 36 species of anophelines distributed throughout the country, ten species have been found to be infected with the malaria parasite (Table 2) based on the entomological and parasitological studies. The species can be classified according to their vector competence as follows:

Primary vectors: *Anopheles dirus* and *Anopheles minimus*.

Secondary vectors: *Anopheles aconitus, Anopheles annularis, Anopheles culicifacies, Anopheles sinensis, Anopheles jeyporensis, Anopheles maculatus, Anopheles philippinensis,* and *Anopheles sundaicus.*

Non-vectors (Either entirely cattle-feeders or too scarce to be of any importance): *Anopheles aitkenii, Anopheles argyropus, Anopheles barbirostris, Anopheles bengalensis, Anopheles fluviatilis, Anopheles gigas, Anopheles nitidus, Anopheles insulaeflorum, Anopheles jamesii, Anopheles karwari,* Anopheles *kochi, Anopheles kyondawensis, Anopheles lindesayi, Anopheles willmori, Anopheles majidi, Anopheles nigerrimus, Anopheles pallidus, Anopheles peditaeniatus, Anopheles pseudojamesii, Anopheles splendidus, Anopheles stephensi, Anopheles subpictus, Anopheles tessellatus, Anopheles theobaldi, Anopheles vagus,* and *Anopheles varuna.*

Primary vectors

Anopheles dirus: *Anopheles dirus* is the major vector of malaria in Myanmar and is mostly associated with forested foothills, deep forests, and domestic wells (Oo et al. 2002). This species can be found in certain regions breeding in bamboo stumps with water collection. There is a well marked post-monsoon transmission season with a peak in October.

Anopheles minimus: *Anopheles minimus* is essentially a mosquito of hilly regions, either low or rolling foothills or narrow river valleys in mountain ranges. When found in the plains, it is always associated with extensive irrigation systems. The topographical conditions where *Anopheles minimus* is recorded range from coastal plains through narrow river valleys to foothills and plateaus. *Anopheles minimus* has not been recorded in locations over 915 meters above sea level. It is the most dangerous vector responsible for hyperendemic and stable malaria in the foothill and sub-mountain regions (Fox 1949, Kyi 1970a, Kyi and Winn 1976, Paing et al. 1988, Paing 1989, VBDC 2000). In areas under the influence of this species, there is a well marked pre-monsoon transmission season with a peak in May and June and a post-monsoon incidence with a peak in November and December.

Secondary vectors

Anopheles aconitus: *Anopheles aconitus* is widely distributed and recorded in various localities especially hilly tracts, foothill areas, and the plains of central and southern Myanmar (Kyi 1971, Paing 1990a). This species mainly feeds on bovines (cattle-feeder), therefore it cannot be considered as a main vector of any importance in Myanmar. However, when cattle are not available, it will feed on humans and could be considered as a secondary vector in some isolated localities.

Anopheles annularis: *Anopheles annularis* is a common anopheline mosquito in all areas of Myanmar. Though it is not important as a major vector in Myanmar as a whole, it has considerable local importance in the Rakhine coastal region where it is responsible for severe epidemic outbreaks (Kyi 1972a, Paing 1990a). The villages along this coastal region are subjected to periodic cyclones. Following the cyclones, an outbreak of malaria usually occurs in cyclone-devastated areas. Pools and ditches in and around the village are filled with water and *Anopheles annularis* breed in profusion. There is a well-marked transmission season from October to March.

Anopheles culicifacies: The distribution of *Anopheles culicifacies* is mainly confined to the plains and irrigated areas, especially in the central dry zone. It is a highly domestic and zoophilic mosquito in Myanmar. Although it is a plains species, it is found at moderate altitudes like the Shan Plateau (Shan State) in the eastern part of Myanmar. It breeds in fresh and clear water with vegetation and also in sandy pools and rock pools. Though not a major vector of malaria in Myanmar, *Anopheles culicifacies* has a considerable secondary importance wherever present in hyperendemic foothill areas (Kyi 1972b, Paing 1990b). In the plains of Central Myanmar where it is the only vector species, it has been known to be responsible for sporadic epidemic outbreaks.

Anopheles sinensis: This mosquito shows a fairly limited distribution in Myanmar. According to observations, it might be concluded that the seasonal incidence of this species in Myanmar appears to be at the end of the monsoon months of August and September. *Anopheles sinensis* is mainly a cattle-feeder but will attack man if cattle are not available. *Anopheles sinensis* is an important malaria vector only at the Myanmar-China border in NSS when it occurs in high densities (Kyi 1971, VBDC 2000).

Anopheles jeyporensis: *Anopheles jeyporensis* can be found in hilly tracts, foothill areas, and coastal plains. *Anopheles jeyporensis* has a very limited distribution. It is abundant only in two localities: Rakhine State (Myanmar-Bangladesh border area) and Sagaing Division (Kabaw valley area). It is a secondary vector on the Myanmar-Bangladesh border area and on the Myanmar-China border area, NSS when it occurs in great numbers (VBDC 2000). Elsewhere it is found in very small numbers.

Anopheles maculatus: *Anopheles maculatus* is primarly recorded from forested foothills, deep forest camps, and in rocky mountainous areas about 1,220 meters above sea level. It is not found in plains areas far away from the foothills. This species could be regarded as a secondary vector especially in Tanintharyi Division, southern part of Myanmar (Paing 1990c, VBDC 2000).

Anopheles philippinensis: *Anopheles philippinensis* has been recorded in all parts of the country and all types of terrain except Tanintharyi Division, southern part of Myanmar. It has been incriminated as a vector in valley regions (Bahmor and Kabaw valley, Sagaing Division) and is a local vector of minor importance in the Myanmar-Bangladesh border area. Elsewhere it is not proven to be an efficient vector (Fox 1949, Kyi 1972c, VBDC 2000). There is a well-marked transmission season during monsoon periods (June to September).

Anopheles sundaicus: This species is confined only to the coastal areas such as Rakhine State, Tanintharyi Division, and the lower reaches of the Ayeyarwady Division (delta area) where the creeks are subject to tidal influence. *Anopheles sundaicus* is responsible for regular annual malaria transmission in certain areas where it occurs in great numbers. Irregular local outbreaks of malaria vary from year to year in some localities. The bionomics of *Anopheles sundaicus* in Rakhine are identical with those of this species elsewhere (VBDC 1979). Even though this species has not been found to be infected with *Plasmodium*, it is likely that in Myanmar this species is involved as a vector during local outbreaks of malaria in the coastal areas of the country, especially in Rakhine State and Chaungtha area, Pathein Township, Ayeyarwady Division. Transmission season is the post-monsoon period (Kyi 1971, VBDC 2000).

DISCUSSION

The above classification is provisional only, having been drawn up solely from the material that has been submitted in this paper. Further evidence may well alter the status of some of the species. *Anopheles jeyporensis*, for instance, has yet to be studied in Myanmar under normal conditions. The exact role played by *Anopheles aconitus* in Myanmar has yet to be defined, as much more research is required into the behavior of the species listed as secondary vectors.

It is quite evident that are many gaps in our knowledge and that many problems of anopheline behaviour will require solution before any successful

Table 1. Occurrence of anopheline fauna during the study period and their locations (see Figure 1).

N.B.
p.v. = primary vector
(+) = seldom
\+ = few
++ = common
* = abundant

1.Yangon Division

			p.v.		secondary vector								non-vector																									
No. of study areas	Township	Sampling sites	*An. dirus*	*An. minimus*	*An. aconitus*	*An. annularis*	*An. culicifacies*	*An. sinensis*	*An. jeyporiensis*	*An. maculatus*	*An. philippinensis*	*An. sundaicus*	*An. aitkenii*	*An. argyropus*	*An. barbirostris*	*An. bengalensis*	*An. fluviatilis*	*An. gigas*	*An. nitidus*	*An. insulaeflorum*	*An. Jamesii*	*An. karwari*	*An. kochi*	*An. kyondawensis*	*An. lindesayi*	*An. willmori*	*An. majidi*	*An. nigerrimus*	*An. pallidus*	*An. peditaeniatus*	*An. pseudojamesi*	*An. splendidus*	*An. stephensi*	*An. subpictus*	*An. tesselatus*	*An. theobaldi*	*An. vagus*	*An. varuna*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
1	Taikkyi	Yesitkan village	(+)	(+)	+	*	+	++	(+)	*	++				*		(+)		++		*	(+)	(+)			(+)		*	(+)				+	+	++		*	+
2	Taikkyi	Leinmawchan village	(+)	(+)	+	*	+	++	(+)	*	++				*		(+)		++		*	(+)	(+)			(+)		*	(+)				+	+	++		*	+
3	Hlegu	Yenetgyi village	(+)	(+)	+	++	+	++		*	+				*		(+)				*							*						(+)	+		*	+
4	Hlegu	Paunggyi village	(+)		+	++	+	++	(+)		+				*						*													(+)			*	(+)
5	Hlegu	Kyaukain village			+	++	+	++			+				*						*																*	(+)
6	Insein	Strand road area			+	+		+		++					*						*							+		+							*	(+)
7	N.Okkalapa	Ayeyar 15th street				+		+	(+)																												*	(+)
8	Bahan	Ngadatkyi area				+	(+)	+																														
9	Mayangon	Thiri Avenue				+	(+)	+	(+)												*																	

2. Bago Division

			p.v.		secondary vector									non-vector																								
No. of study areas	Township	Sampling sites	*An. dirus*	*An. minimus*	*An. aconitus*	*An. annularis*	*An. culicifacies*	*An. sinensis*	*An. jeyporiensis*	*An. maculatus*	*An. philippinensis*	*An. sundaicus*	*An. aitkenii*	*An. argyropus*	*An. barbirostris*	*An. bengalensis*	*An. fluviatilis*	*An. gigas*	*An. nitidus*	*An. insulaeflorum*	*An. Jamesii*	*An. karwari*	*An. kochi*	*An. kyondawensis*	*An. lindesayi*	*An. willmori*	*An. majidi*	*An. nigerrimus*	*An. pallidus*	*An. peditaeniatus*	*An. pseudojamesi*	*An. splendidus*	*An. stephensi*	*An. subpictus*	*An. tesselatus*	*An. theobaldi*	*An. vagus*	*An. varuna*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
10	Okpo	Kaingdawsu village	++			+				++																												
11	Okpo	Yebya camp	++	+		+				*																												
12	Kyauktagar	Myochaung village				+																																
13	Kyauktagar	Htiphado village	*	++						*	++						(+)																					
14	Kyauktagar	Kyarkyaungthaik	*	++					(+)																													
		Phado village	*	++				++																					(+)									
15	Kyauktagar	Katsene camp	*																																			
16	Oktwin	Thabyewa village	*	++		+				*	++																											
17	Letpadan	Hsachaung village				+																										+						
18	Pyu	Khintan village			+	+	+	++		++					++						+														+		++	(+)
19	Thayawady	Hlelangu village									++																											
20	Kyauktagar	Ngokto village	*			+																																
		Gwegone village	*			+																																
21	Kyauktagar	Bwechin village				+					++																											
22	Taungoo	Taungoo Town			+	+	++		(+)		*				++		(+)		++		++							*	(+)			+	+	+	++		*	(+)
23	Yedashe	Sezongone village				+	+			++											++											+	+	+			++	
24	Bago	Bago Town			+	+	++		(+)						+		(+)				+							*						+	++		++	
25	Thayawady	Thayawady Town			+	+																													+		++	
26	Pyay	Shwekuyad			+	+																						++		++		(+)			+			
		Htanpauk village			+			*							++						+											+		*			++	
		Kyauklongyi			+	+	+	*	(+)	+	+				+		++		++		+		(+)						(+)			+	++	*			++	
27	Paukhaung	Gonemingone	+	+	+					++	++																							++	+			
		Taunglae village			+	++	+			++	++										++		(+)										++					
28	Shwedaung	Shwedaung Town			+	+	+				+				+		(+)				+											+	*	++	+		++	

3. Ayeyarwady Division

No. of study areas	Township	Sampling sites	p.v.		secondary vector									non-vector																									
			An. dirus	*An. minimus*	*An. aconitus*	*An. annularis*	*An. culicifacies*	*An. sinensis*	*An. jeyporiensis*	*An. maculatus*	*An. philippinensis*	*An. sundaicus*	*An. aitkenii*	*An. argyropus*	*An. barbirostris*	*An. bengalensis*	*An. fluviatilis*	*An. gigas*	*An. nitidus*	*An. insulaeflorum*	*An. Jamesii*	*An. karwari*	*An. kochi*	*An. kyondawensis*	*An. lindesayi*	*An. willmori*	*An. majidi*	*An. nigerrimus*	*An. pallidus*	*An. peditaeniatus*	*An. pseudojamesi*	*An. splendidus*	*An. stephensi*	*An. subpictus*	*An. tesselatus*	*An. theobaldi*	*An. vagus*	*An. varuna*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
29	Myaungmya	Magyipin village			++	++					+	++			++																			*			++	(+)
30	Chaungthar	Seikkyi village	(+)		+				(+)	+		*																					++				++	
31	Chaungthar	Chaungthar Town										*																				+	++					
32	Hinthada	Hinthada Town					(+)								+																		*	++			++	(+)
33	Pathein	Thabyuchaung		(+)	++	+		++		+																									+		++	
		Thalatkhwar village				+		++							+						+														+		++	
34	Ngaputaw	Kaditchaung village	(+)									++																										

4. Mandalay Division

No. of study areas	Township	Sampling sites	*An. dirus*	*An. minimus*	*An. aconitus*	*An. annularis*	*An. culicifacies*	*An. sinensis*	*An. jeyporiensis*	*An. maculatus*	*An. philippinensis*	*An. sundaicus*	*An. aitkenii*	*An. argyropus*	*An. barbirostris*	*An. bengalensis*	*An. fluviatilis*	*An. gigas*	*An. nitidus*	*An. insulaeflorum*	*An. Jamesii*	*An. karwari*	*An. kochi*	*An. kyondawensis*	*An. lindesayi*	*An. willmori*	*An. majidi*	*An. nigerrimus*	*An. pallidus*	*An. peditaeniatus*	*An. pseudojamesi*	*An. splendidus*	*An. stephensi*	*An. subpictus*	*An. tesselatus*	*An. theobaldi*	*An. vagus*	*An. varuna*
			p.v.			secondary vector																non-vector																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
35	Madaya	Sedawgyi	+	*		++		++		*	*																							+				
36	Madaya	Botegone village		++	++	++	++	+	(+)	++	++																						+					
		Zeephyupin	++	++	++	++	++	+		++	++						(+)													+			+		+			+
37	Mandalay	North, Mandalay				*	++								++		(+)						(+)					*				+	++	+	+		++	+
38	Patheingyi	Shwesaryan		++			++										(+)																++					+
		Tawsu village			++		++																															
39	Amarapura	Sargalein village		++	++	++	++	+		++	*																						*					+
		Nyaungnibin			++	++		+			+																						*					+
40	Singu	Nweyone village		++	+	++	++	+		++	+																						+					+
		Shwepyi village				++					+																						+					
41	Singaing	Sezone village			+	++	++	+	(+)	+	+																						+					+
		Badaquinn village		++																																		
42	Meiktila	Aungpintha			+		++				+																						+					
43	Kyaukse	Lunkyaw village		++	++	++	*	+		+	+						++						(+)					*		++			+	+	+		++	+
44	Kyaukpadaung	Legwa village		++	+	+	++	+		+	*				*													++					+					+
45	Nyaung-oo	Shwe-hlaing					++																															
46	Taungtha	Semikan village		++	+	+	++	+			++																						+					+
		Magyibin village				+	++																															
47	Thabeikkyin	Tagaung village			+	+		+			+																						+					+
		Taungtalone		++	+	+	++			+	+						(+)																					+
48	Mogok	Shwenyaungbin		++	+	+	+	++		*							(+)																+					+
49	Mogok	Kabaing village		++	+	+			+	*	+				+	(+)		(+)					(+)					++				(+)					++	+
50	Pyinoolwin	Wetwun village		++	*		+	++	(+)	++	*				++		(+)				+							++	+			+	+	+			++	+
51	Pyinmana	Moeswe village					++																										+					+
		Aungthukha		++	+	+	++	++	(+)	++	++																						+					
52	Mandalay-																																					
	Pyinoolwin	Foothill area		++	++	+	++	++		++	*				*		++				++		+					*				+	++		*		*	+
53	Meiktila	Wundwin village				+	++			+					+																	(+)		+	+		++	+
54	Thazi	Indaingtha village	+	+	+	+	+	++	+	+	+															+							+		+			
55	Yamethin	Kinywa-indaing	(+)	+		+	++	+	+	+	+				+						+	(+)	(+)					+				+	+	+	+		++	+
56	Lewe	Chinsu village	+	+	+	+	+	+		+	+																						+		+			+
		Kantha village					+			+																												

5. Sagaing Division																																						
			p.v.		secondary vector								non-vector																									
No. of study areas	Township	Sampling sites	*An. dirus*	*An. minimus*	*An. aconitus*	*An. annularis*	*An. culicifacies*	*An. sinensis*	*An. jeyporiensis*	*An. maculatus*	*An. philippinensis*	*An. sundaicus*	*An. aitkenii*	*An. argyropus*	*An. barbirostris*	*An. bengalensis*	*An. fluviatilis*	*An. gigas*	*An. nitidus*	*An. insulaeflorum*	*An. Jamesii*	*An. karwari*	*An. kochi*	*An. kyondawensis*	*An. lindesayi*	*An. willmori*	*An. majidi*	*An. nigerrimus*	*An. pallidus*	*An. peditaeniatus*	*An. pseudojamesi*	*An. splendidus*	*An. stephensi*	*An. subpictus*	*An. tesselatus*	*An. theobaldi*	*An. vagus*	*An. varuna*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
57	Mawlaik	Khamaya (368)		++	+	+	*	++	+	++	*		(+)		+	(+)			+			+	++			*		++	+			+	++	++	+		++	+
58	Kale	Kabaw valley	(+)	++	++	++	++	+	+	++	++				+	(+)					++		++					++	+				++	++	+		++	
59	Kale	Kale valley		++	++	+	+	+		+	++				+	(+)					++		++			++		++					++	++	+		++	+
60	Tamu	Tamu Town	+	+	+	+	+	+		+	+				+	+					+	+	*					+				+		+	+		++	+
		Boke-kann		+	+	+	+	+	+	+	+			(+)	+								++						+			+	+				++	
61	Sagaing	Myothit Quarter				+	+	+															+									+		+			++	
62	Monywa	Monywa Town				+	*			+	+				+																	+	*	++			++	+
63	Wuntho	Bonchaung village	+	+	+	+	++	+		+	+				+		++				+		++					+	+			+	+	+	+		++	+
		Pay-gone village			+	+				+	+																					+						+
64	Inntaw	Nabar village		+	+	+	+	+		+	++				+		++				++	+	+				(+)					+	+	+	+		++	+
65	Katha	Katha Town	(+)	+	+	+	*	++		+	*				+		++					+	*			*	(+)	+	+			+	+	*	+		++	+
66	Shwebo	Shwebo Town			+	++									++		*						++					+	+			+	++	++	+		++	+

N.B. only adult of *An. majidi* (column no. 28) have been recorded.

6. Magwe Division

No. of study areas	Township	Sampling sites	p.v.		secondary vector								non-vector																									
			An. dirus	*An. minimus*	*An. aconitus*	*An. annularis*	*An. culicifacies*	*An. sinensis*	*An. jeyporiensis*	*An. maculatus*	*An. philippinensis*	*An. sundaicus*	*An. aitkenii*	*An. argyropus*	*An. barbirostris*	*An. bengalensis*	*An. fluviatilis*	*An. gigas*	*An. nitidus*	*An. insulaeflorum*	*An. Jamesii*	*An. karwari*	*An. kochi*	*An. kyondawensis*	*An. lindesayi*	*An. willmori*	*An. majidi*	*An. nigerrimus*	*An. pallidus*	*An. peditaeniatus*	*An. pseudojamesi*	*An. splendidus*	*An. stephensi*	*An. subpictus*	*An. tesselatus*	*An. theobaldi*	*An. vagus*	*An. varuna*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
67	Yenangyaung	Ywathitgyi village		(+)			++																					++					+					
68	Chauk	Mingyan village	(+)	(+)			++																										+					
69	Myaing	Lingadaw village					++																															
70	Saw	Yinkekaung		(+)		++	++				+						+																+	+			++	
71	Gawgaw	Khaungtone		(+)			++			+																							+	+			++	
72	pakoku	sinlan village				*											+																				++	
73	Seikpyu	Koedaung village					++																															
74	Taungdwingyi	Kamontaung	(+)	(+)	+	++	++	+		+	+				+						+											(+)	+	+			++	
		Thabyepin					++																														++	
75	Natmauk	Khinkaung					++																										+	+			++	
76	Myothit	Yeayetaing		(+)		++	++	+		+	+																						+	+			++	
77	Magwe	Tegyigone				*	++			+	+				+													++					++	*			++	
78	Mezali	Mezali Town					++				+																											
79	Yesagyo	Zitaw village				+	++	+		+	+																						+	+			++	
80	Mayde	Mogaung																															+					
81	Thayet	Ywathit village				++	++				+				+																		+				++	
82	Kama	Gyopin village				++	++	+		+					+																		+	+				
83	Sinbaungwe	Nyaungbintha					++																															
84	Mindon	Zeedaw village			+	++	++	+		+																								+			++	
85	Pwinbyu	Thanatwa		(+)	+	*	++	+		+	+				*													++					+				++	
86	Minbu	Minbu Town									+				++		+																+	++			++	
87	Sagu	Sagu Town					++																															
88	Salin	Linzin village			+		++	+			+				+		+												(+)				+	+			++	
89	Sedoktaya	Sedoktaya Town				++	++	+			+																						+	+			++	
90	Ngape	Padan village			+	++	++	+		+	+				+						+												+	+	+		++	

7. Tanintharyi Division

No. of study areas	Township	Sampling sites	p.v.		secondary vector								non-vector																									
			An. dirus	*An. minimus*	*An. aconitus*	*An. annularis*	*An. culicifacies*	*An. sinensis*	*An. jeyporiensis*	*An. maculatus*	*An. philippinensis*	*An. sundaicus*	*An. aitkenii*	*An. argyropus*	*An. barbirostris*	*An. bengalensis*	*An. fluviatilis*	*An. gigas*	*An. nitidus*	*An. insulaeflorum*	*An. Jamesi*	*An. karwari*	*An. kochi*	*An. kyondawensis*	*An. lindesayi*	*An. willmori*	*An. majidi*	*An. nigerrimus*	*An. pallidus*	*An. peditaeniatus*	*An. pseudojamesi*	*An. splendidus*	*An. stephensi*	*An. subpictus*	*An. tesselatus*	*An. theobaldi*	*An. vagus*	*An. varuna*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
91	Myeik	Shwedu	++							*																												
92	Bokpyin	Hangadaing	*	++						*		++																						+				
93	Kawthaung	Namtun	*	++	++	++				*		++			+																						++	
94	Dawei	Sanchi village	*	++	++	++	+	+		*	+	++			+						+	(+)	+			+	(+)		+					+			++	+
95	Myeik	Monsu village	++	++						*												(+)																

N.B. only adult of *An. majidi* (column no. 28) have been recorded.

8. Rakhine State

No. of study areas	Township	Sampling sites	p.v.		secondary vector								non-vector																									
			An. dirus	*An. minimus*	*An. aconitus*	*An. annularis*	*An. culicifacies*	*An. sinensis*	*An. jeyporiensis*	*An. maculatus*	*An. philippinensis*	*An. sundaicus*	*An. aitkenii*	*An. argyropus*	*An. barbirostris*	*An. bengalensis*	*An. fluviatilis*	*An. gigas*	*An. nitidus*	*An. insulaeflorum*	*An. Jamesii*	*An. karwari*	*An. kochi*	*An. kyondawensis*	*An. lindesayi*	*An. willmori*	*An. majidi*	*An. nigerrimus*	*An. pallidus*	*An. peditaeniatus*	*An. pseudojamesi*	*An. splendidus*	*An. stephensi*	*An. subpictus*	*An. tesselatus*	*An. theobaldi*	*An. vagus*	*An. varuna*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
96	Sittwe	Sittwe Town	(+)		*	*	+	+	+	+	+	*	(+)		+	(+)						+						++						+	+		++	+
97	Kyaukpyu	Kyaukpyu Town			*	*	+	+	+	++	+	*			+							+						+			+			+	+		*	+
98	Myebon	Myebon Town										++			+																			+				
99	Gwe	Gwe Town						+		+		++																										
100	Taungpyo	Bangladesh border			++	++		+	++		*	++			+																						++	
101	Taungpyo	Taungyo Town		++		*		+			++	++			+						+	+											+	+	+		++	
102	Maungdaw	10th miles	(+)	++	++	*	+	+	++	++	+				+						+	+											+	+	+		++	+
103	Minbya	Minbya Town					+	+							+								+									(+)	+	+	+		++	+
104	Myohaung	Shwegudaung			*							++																										+
105	Buthedaung	Kardi village		++	++	*		+		++	+	++			+																			+			++	
106	Ann	Ann Town																																				

N.B. only larvae of *An. pseudojamesi* (column no. 32) have been recorded.

9. Mon State

No. of study areas	Township	Sampling sites	p.v.		secondary vector								non-vector																									
			An. dirus	*An. minimus*	*An. aconitus*	*An. annularis*	*An. culicifacies*	*An. sinensis*	*An. jeyporiensis*	*An. maculatus*	*An. philippinensis*	*An. sundaicus*	*An. aitkenii*	*An. argyropus*	*An. barbirostris*	*An. bengalensis*	*An. fluviatilis*	*An. gigas*	*An. nitidus*	*An. insulaeflorum*	*An. Jamesii*	*An. karwari*	*An. kochi*	*An. kyondawensis*	*An. lindesayi*	*An. willmori*	*An. majidi*	*An. nigerrimus*	*An. pallidus*	*An. peditaeniatus*	*An. pseudojamesi*	*An. splendidus*	*An. stephensi*	*An. subpictus*	*An. tesselatus*	*An. theobaldi*	*An. vagus*	*An. varuna*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
107	Mawlamyine	Taungwaing	++			+	+	++		+	+				+			(+)			++														+		+	
		Innwaing	++		+	+	+	++	(+)	+	++	++			+				+	+	++	(+)	(+)	(+)			(+)	+	(+)	+				++	+		+	+
108	Chaungzone	Tagukkana	++		+	+		+		+	+	+			+						++	(+)	(+)						(+)					+	+		+	+
109	Thanbyuzayat	Wetlay village	*									(+)									++	(+)						+						+			+	+
110	Kyaikmaraw	Kalinekaning	++			+		+		+	+				+						++					+								+			+	
111	Mawlamyine	Kawkalok	++		++																																+	
112	Mudon	Quarter 4	*		++	+				+	+				+				+		++	(+)				+	(+)	+		+		(+)		++	+		+	+
113	Thaton	Thinhtow	++			+		+			+				+						++													*			+	
114	Belin	Botayza	++			+		+			+				+						++														+		+	
115	Kyaikto	Kinmonchaung	++			+		+			+				.						++																+	

N.B. (i) only larvae of *An. kyondawensis* (column no. 25) have been recorded.
(ii) only adult of *An. majidi* (column no. 28) have been recorded.

10. Shan State

No. of study areas	Township	Sampling sites	p.v.		secondary vector								non-vector																									
			An. dirus	*An. minimus*	*An. aconitus*	*An. annularis*	*An. culicifacies*	*An. sinensis*	*An. jeyporiensis*	*An. maculatus*	*An. philippinensis*	*An. sundaicus*	*An. aitkenii*	*An. argyropus*	*An. barbirostris*	*An. bengalensis*	*An. fluviatilis*	*An. gigas*	*An. nitidus*	*An. insulaeflorum*	*An. Jamesii*	*An. karwari*	*An. kochi*	*An. kyondawensis*	*An. lindesayi*	*An. willmori*	*An. majidi*	*An. nigerrimus*	*An. pallidus*	*An. peditaeniatus*	*An. pseudojamesi*	*An. splendidus*	*An. stephensi*	*An. subpictus*	*An. tesselatus*	*An. theobaldi*	*An. vagus*	*An. varuna*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
116	Momeik	Khalaya	+	+	+	+	+	*		+	++				+			(+)			+		+								+			+	+		++	
117	Hsipaw	Hsipaw Town	(+)	+	+	+	++	++		+	+				+		+						(+)					+						+	+		++	
118	Lashio	Mansan fall	(+)	+	+	+	++	++	+	+	*		(+)		+	(+)	+	(+)			+	(+)	(+)			++	(+)	+				(+)		+	+	(+)	++	+
119	Mabein	Mabein Town				+														(+)																	++	
120	Kyaukme	Quarter 4	(+)	+	+	+		++		+	+				+		+																				++	+
121	Loilem	Loilem Town				+																										(+)	+					
122	Kunlong	Kunlong Town		+	+	+		++		+					+																							
123	Chinshwehor	China border					+	+	++																													
124	Kengtung	Kengtung Town		+	+	+	+	+		+	++				+						+	(+)	+					+				(+)	+				++	+
125	Tachileik	Tachileik Town					+																														++	
126	Heho	Heho Town				+	+																															+
127	Hopone	Hopone Town		+	+	+	+	++		+					+		+																				++	+
128	Yutsawk	Yutsawk Town		+	+	+	+	+					(+)																									
129	Aungban	Aungban Town				+											+																					
130	Pindaya	Thayetgon		+	+	+			+	+	+				+								(+)														++	
131	Nyaungshwe	Nyaungshwe Town		+	+	+	+			+	+				+																						++	+
132	Ywangan	Myogyi village		+	+	+	+			+	+						+																					
133	Kalaw	Nanpandit village		+	+	+	+			+	+		(+)		+	(+)	+				+		(+)		(+)	++	(+)		+				+				++	+
134	Namsam	Namsam Town											(+)			(+)		(+)																				
135	Shwenyaung	Phetmun village		+	+	+	++		+	+	+				+													+						+			++	+
136	Sesai	Aungthapye Quarter		+	+	+		+	+	+	+				+		*																					
137	Indaw	Indaw Town		+	+	+		+		+	+						+				+																+	
138	Taunggyi	Yebu village		+	+	+	+	+	+	+	+				+		*				+		(+)									(+)	+		+		+	(+)

N.B. (i) only larvae of *An. insulaeflorum* (column no. 21) have been recorded. (ii) only adult of *An. majidi* (column no. 28) have been recorded.

11. Kayah State

No. of study areas	Township	Sampling sites	p.v.		secondary vector								non-vector																										
			An. dirus	*An. minimus*	*An. aconitus*	*An. annularis*	*An. culicifacies*	*An. sinensis*	*An. jeyporiensis*	*An. maculatus*	*An. philippinensis*	*An. sundaicus*	*An. aitkenii*	*An. argyropus*	*An. barbirostris*	*An. bengalensis*	*An. fluviatilis*	*An. gigas*	*An. nitidus*	*An. insulaeflorum*	*An. Jamesii*	*An. karwari*	*An. kochi*	*An. kyondawensis*	*An. lindesayi*	*An. willmori*	*An. majidi*	*An. nigerrimus*	*An. pallidus*	*An. peditaeniatus*	*An. pseudojamesi*	*An. splendidus*	*An. stephensi*	*An. subpictus*	*An. tesselatus*	*An. theobaldi*	*An. vagus*	*An. varuna*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
139	Mawchi	Mawchi mines		+		+	+			+			(+)			(+)					+		(+)													+		
140	Demoesoe	Myenigone				+	+	+			+				(+)																			+			+	
141	Loikaw	Nwalasoe		+	+	+	+	+		+	+				(+)								(+)				(+)		+					+	+		+	(+)

N.B. only adult of *An. majidi* (column no. 28) have been recorded.

12. Kachin State

No. of study areas	Township	Sampling sites	p.v.		secondary vector								non-vector																										
			An. dirus	*An. minimus*	*An. aconitus*	*An. annularis*	*An. culicifacies*	*An. sinensis*	*An. jeyporiensis*	*An. maculatus*	*An. philippinensis*	*An. sundaicus*	*An. aitkenii*	*An. argyropus*	*An. barbirostris*	*An. bengalensis*	*An. fluviatilis*	*An. gigas*	*An. nitidus*	*An. insulaeflorum*	*An. Jamesii*	*An. karwari*	*An. kochi*	*An. kyondawensis*	*An. lindesayi*	*An. willmori*	*An. majidi*	*An. nigerrimus*	*An. pallidus*	*An. peditaeniatus*	*An. pseudojamesi*	*An. splendidus*	*An. stephensi*	*An. subpictus*	*An. tesselatus*	*An. theobaldi*	*An. vagus*	*An. varuna*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
142	Myitkyina	Mawphaung	(+)	++	+	+	+	+	+	+	++				+		(+)						(+)			+	(+)	++				+	+		+		++	++
143	Mohnyin	Aungthapye		+	+	++		+		+	+															+							+					
144	Kamaing	Lawa				++																																	
145	Tanaing	Minekune		+	+	++		+		+	+				+						+																	
146	Moegaung	Kyuntaw				+		+		+	+				+								(+)			+											++	++
147	Bhamo	Bhamo Town	(+)	+	+	+	+	+	+	+	++				+						+		(+)			+		++						++	+		++	++
148	Myothit	Myothit Town				+		+													+						(+)										++	

N.B. only adult of *An. majidi* (column no. 28) have been recorded.

13. Chin State

No. of study areas	Township	Sampling sites	p.v.		secondary vector								non-vector																									
			An. dirus	*An. minimus*	*An. aconitus*	*An. annularis*	*An. culicifacies*	*An. sinensis*	*An. jeyporiensis*	*An. maculatus*	*An. philippinensis*	*An. sundaicus*	*An. aitkenii*	*An. argyropus*	*An. barbirostris*	*An. bengalensis*	*An. fluviatilis*	*An. gigas*	*An. nitidus*	*An. insulaeflorum*	*An. Jamesii*	*An. karwari*	*An. kochi*	*An. kyondawensis*	*An. lindesayi*	*An. willmori*	*An. majidi*	*An. nigerrimus*	*An. pallidus*	*An. peditaeniatus*	*An. pseudojamesi*	*An. splendidus*	*An. stephensi*	*An. subpictus*	*An. tesselatus*	*An. theobaldi*	*An. vagus*	*An. varuna*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
149	Falam	Panunchaung		+		+		+		+	+		(+)			(+)		(+)															+				+	
150	Paletwa	Htaungza		+		+		+		+	+										(+)	(+)							+								+	
151	Mindat	Mindat Town		+									(+)			(+)									(+)							(+)						
152	Kanpetlet	Syawlaung		+									(+)			(+)									(+)							(+)					+	

14. Kayin State

No. of study areas	Township	Sampling sites	p.v.		secondary vector								non-vector																									
			An. dirus	*An. minimus*	*An. aconitus*	*An. annularis*	*An. culicifacies*	*An. sinensis*	*An. jeyporiensis*	*An. maculatus*	*An. philippinensis*	*An. sundaicus*	*An. aitkenii*	*An. argyropus*	*An. barbirostris*	*An. bengalensis*	*An. fluviatilis*	*An. gigas*	*An. nitidus*	*An. insulaeflorum*	*An. Jamesii*	*An. karwari*	*An. kochi*	*An. kyondawensis*	*An. lindesayi*	*An. willmori*	*An. majidi*	*An. nigerrimus*	*An. pallidus*	*An. peditaeniatus*	*An. pseudojamesi*	*An. splendidus*	*An. stephensi*	*An. subpictus*	*An. tesselatus*	*An. theobaldi*	*An. vagus*	*An. varuna*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
153	Thandaung	Thandaung Town					+			++	+		(+)			(+)		(+)	+													+	+				++	+
154	Kawkareik	Khamaya				+		+		++	+				+						++	(+)												+			++	
155	Kyrainseikkyi	Kyaikdon		+		+		+		++	+				+						++	(+)													+		++	+
156	Pyapon	Kamanoung						+							+						++		+					+	++			+		+	+		++	
157	Hpaan	Haungkhayaing	++	+	+	+		+		++	+				+						++	(+)	+									+	+	+	+		++	+

Table 2. Dissection records on anopheline vectors infection rates in different localities in Myanmar.

Species	Localities		No. dissected	No. of species with gut infection	No. of species with gland infection	Infection rate (%)
	Division/State	Township				
An. dirus	Bago Division	Htiphado	150	1	3	2.66 (4/150)
	Mandalay Division	Botegone	150	0	2	1.33 (2/150)
	Tanintharyi Division	Namtun	150	1	2	2.00 (3/150)
An. minimus	Sagaing Division	Kabaw	150	1	3	2.66 (4/150)
	Bago Division	Thabyewa	150	1	1	1.33 (2/150)
	Rakhine State	Sittwe	150	0	2	1.33 (2/150)
An. aconitus	Rakhine State	Sittwe	150	1	1	1.33 (2/150)
	Ayeyarwady Division	Sagagyi	150	0	1	0.66 (1/150)
An. annularis	Rakhine State	Sittwe	150	0	1	0.66 (1/150)
		Myohaung	150	0	1	0.66 (1/150)
An. culicifacies	Sagaing Division	Mawlaik	150	2	2	2.66 (4/150)
	Shan State	Hsipaw	150	0	1	0.66 (1/150)
	Magwe Division	Mezali	150	1	2	2.00 (3/150)
An. hyrcanus	Shan State	Myanmar-China border	150	1	2	2.00 (3/150)
An. jeyporensis	Rakhine State	Myanmar-Bangladesh border	150	0	1	0.66 (1/150)
	Sagaing Division	Kale valley	150	0	1	0.66 (1/150)
An. maculatus	Madalay Division	Kabaing	150	0	1	0.66 (1/150)
	Tanintharyi Division	Myeik	150	1	0	0.66 (1/150)
An. philippinensis	Sagaing Division	Katha	150	0	1	0.66 (1/150)
	Kachin State	Bahamor	150	1	1	1.33 (2/150)
An. sundaicus	Rakhine State	Sittwe	150	1	0	0.66 (1/150)
	Ayeyarwady Division	Sagagyi	150	0	1	0.66 (1/150)
		Chaungthar	150	1	1	1.33 (2/150)

attempt can be made to tackle the major problem of malaria control in Myanmar.

The earliest references to Myanmar mosquitoes were written by Stott (1916) and Christophers (1933). Stott was dealing mainly with the clinical aspects of malaria, especially in the Mandalay area. Christophers basically wrote a taxonomical monograph that included valuable information on *Anopheles* biology. He recorded 26 species of anophelines in Myanmar. Fox (1949) later listed a total of 27 species of anophelines in Myanmar.

There were 33 species and varieties of anophelines in Myanmar in 1954, recorded by national and WHO entomologists. This list did not include *An. kyondawensis* and *An. barbirostris* var. *ahomi* (only larvae of *An. kyondawensis* were found in Kyondow village, Moulmein Township, Mon State, and *An. barbirostris* var. *ahomi* was found in Southern Shan State by Abraham in 1947, unpublished).

An. kyondawensis was also described by Delphin and Rao (1957) and Kyi (1971) in the same region noted by Abraham. During this study period in Innwaing area (near Kyondow village), Moulmein Township, Mon State, only one larva of *An. kyondawensis* was found in a shady pool along a forest stream associated with larvae

of *An. insulaeflorum*. *An. barbirostris* var. *ahomi* has only been described by Abraham in Myanmar.

An. pampani is listed in *A catalog of the mosquitoes of the world* by Knight and Stone (1977). However, this species has never been found in Myanmar. *Anopheles sawadwongporni* is a new species of the *An. maculatus* group in Myanmar. Adult specimens were collected from Kyauktagar Township, Bago Division, forested foothills of the Bago Yoma range during December 1985 by the DMR survey team (Paing and Naing 1985). This species could not be recorded during the study period.

Kyi (1971) has documented a total of 37 species of anopheline encountered in Myanmar. In our study period, the same species that had been stated by Kyi (1971) were also observed. However, the following names are no longer available for use:

(i) *An. indiensis* was synonymized under *nigerrimus* by Harrison et al. (1973) and the species called *indiensis* by Reid in Malaysia and Thailand was renamed *nitidus*. Thus, *nitidus* Harrison, Scanlon, and Reid would be the correct name for this species in Myanmar.

(ii) *An. jeyporiensis* var. *candidiensis* was synonymized under *jeyporiensis* by Harrison (1980). Thus, *jeyporiensis* James is the correct name for this species in Myanmar.

(iii) *An. maculatus* var. *willmorei* was elevated to full species by Rattanarithikul and Green (1986) and the spelling was corrected to *willmori*. Thus, *An. willmori* (James) is the correct name for this species in Myanmar.

(iv) *An. ramsayi* was found to be a junior synonym of *An. pseudojamesi* by Nurul Hunda and Harrison (1985). Thus, *pseudojamesi* Strickland and Chowdhury is the correct name for this species in Myanmar.

Previously, *An. leucosphyrus* was described as a *Leucosphyrus* group of species in Myanmar. However, Kyi (1971) examined specimens of *An. leucosphyrus* from the collections at the Malaria Institute of Myanmar and identified them as *An. balabacensis balabacensis*, which he regarded as an important vector of malaria in Myanmar. When the DMR initiated studies on malaria vectors in 1983, the prevalence of *An. dirus* was recognized for the first time in Myanmar. Subsequent surveys by DMR teams in various parts of the country did not yield *An. balabacensis balabacensis*. DMR teams investigated its bionomic and relationship to malaria transmission under varied ecological conditions. In addition to detailed morphological studies, cytogenetics and isoenzyme studies were undertaken to differentiate sibling species. DMR confirmed the species as *An. dirus*.

An. dirus Peyton and Harrison (1979) (= *dirus* A), which currently has *dirus* B, *dirus* C, and *dirus* D are confirmed as distinct species (but still unnamed). Baimai et al. (1988) have identified only *An. dirus* species D from materials originating in southern Myanmar (well-breeding *An. dirus*) and in Bago Division (forest-breeding *An. dirus*). Actually, the most common *An. dirus* in Myanmar is almost certainly *An. dirus* D, which is the primary species (and vector) in Bangladesh (Baimai, unpublished data). The distribution of *An. dirus* extends into eastern Myanmar, but *An. dirus* D is probably the more common member of this complex in Myanmar.

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