MOSQUITO FAUNA OF "TOH DAENG" SWAMP FOREST, THAILAND

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Abstract. Entomological surveys (2001-2005) were carried out in Narathiwat Province to determine mosquito fauna of the peat swamp forest. Fifty-four species belonging to 13 genera were identified from 837 larval specimens and 3,982 adult mosquitoes. These included the major vectors for Brugian fillariasis: *Mansonia annulata*, *Ma. bonneae*, *Ma. dives*, *Ma. uniformis* and *Ma. indiana*. *Ma. annulata* and *An. letifer* were reported for the first time in Thailand as lymphatic filariasis vectors. Three species inhabiting *Nepenthes* pitchers (*N. mirabilis*): *Tripteroides tenax*, *Toxorhynchites manopi* and *Uranotaenia edwardsi*, were recorded for the first time in Thailand; *Zeugnomyia gracilis* was also found common in the peat swamp forest.

INTRODUCTION

Peat swamp forests in Thailand cover about 64,000 ha, and are located mostly in the South. "Toh Daeng" is the largest swamp forest occupying 8,000 ha (Phengklai *et al*, 1991). This forest supports primary peat swamp, *Melaleuca* woodland and scrub and degraded grasslands. These unique habitats support a large variety of flora and fauna. Some 470 plant species in 124 families have been recorded; 217 bird, 52 reptile, 62 fish, 19 amphibian, 106 butterfly and 60 mammal species have been identified (Phlengklai *et al*, 1991; Vijarnsorn, 1996; Hankaew, 2003). Lymphatic filariasis is a serious mosquito-borne disease associated with this peat swamp forest, where little is known about the mosquito fauna. The present study describes the current mosquito fauna in the Toh Daeng peat swamp.

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MATERIALS AND METHODS

Study area

The "Toh Daeng" peat swamp forest is located in Narathiwat Province, 1,149 km south of Bangkok. The site lies parallel to the eastern coastline of southern Thailand, about 7 km inland. The northern and southern parts of the swamp drain into the Bang Nara River and Su-ngai Kolok River, respectively. Toh Daeng contains a research and visitor's facility, "Sirindhorn Research and Nature Study Center", located in the wildlife conservation area. The surrounding areas are privately owned and used for agricultural purposes (rice, rubber and fruit plantations) and settlements. The peat swamp forest is characterized by low-lying flat land with 1.0-1.5 m water present throughout the year. The deposited organic materials causes the

water to be acidic (pH of 4.0-5.5). The poor nutrient content of the acidic soil impedes agricultural use preventing other trees, except *Melaleuca cajuputi*, from becoming established in the swamp due to lack of soil within the peat swamp forest. The area has a constant mean temperature of 26-27ºC with an annual rainfall of 2, 560.2 mm and an average of 171 days of rain per year with the heaviest rainfall in November-December. There is no distinct dry season; the average humidity is 77-83% (Phlengklai *et al*, 1989). Five sites from different habitats were chosen to capture the mosquitoes. The habitats were located in the core or preservation zone (primary swamp forest), periphery or conservation zone (secondary swamp forest) and development or agricultural zone.

Mosquito collection

To optimize the diversity of insects collected, five collection methods were utilized in the study: animal-baited traps (cow and cat, 2 traps per night), human-landing catches (5 persons per night), light traps (5 traps per night), and direct search from breeding places by dippers, pipettes and oviposition traps (30 traps per site). The collections were conducted 4 days per month. Insect monitoring traps, oviposition and light traps, were placed at random in the wildlife conservation areas while the others were conducted at all three collection sites.

In order to develop practical, effective and inexpensive oviposition traps, discarded soft-drink bottles, such as 1-liter Coca-Cola or Sprite plastic bottles were cut in half and used, the lower part hanging from tree trunks in the forest throughout the period of investigation. Mosquito larvae found in oviposition traps were collected monthly and brought back to the laboratory for identification.

Special attention was also given to the collection of *Mansonia* larvae from submerged plants and trees in the swamp forest. The collecting equipment was modified from the device made by Batzer (1993) and the collecting technique was recently described by Apiwathnasorn *et al* (2006a). The larvae were mounted on slides and the species identified using the key of Apiwathnasorn *et al* (1991).

Processing of collected specimens

As Narathiwat Province is an area endemic with Brugian filariasis, dissection for filarial parasites was carried out on the head and thorax portions of *Mansonia* mosquitoes and other potential species obtained from the human-landing and cow-baited catches. The details of this dissection technique are described by Leemingsawat *et al* (1987). Some adult mosquitoes were pinned and the remainder was preserved dry for further examination. Immature stages collected from ovitraps were kept alive and reared to adults either in single or in mass. Dead specimens and/or larval and pupal skins were removed daily and preserved in 70% alcohol. Larval and pupal specimens were slide-mounted using Hoyer's medium (Rattanarithikul, 1982). Adult specimens were examined unmounted or on pin-mounted paper points. The species of the mosquito specimens were identified using standard light microscopy and a range of taxonomic authorities and keys (Thurman, 1959; Wharton *et al*, 1962; Peyton and Scanlon, 1966; Bram, 1967; Harrison and Scanlon, 1975; Huang, 1979; Rattanarithikul, 1982).

RESULTS

A total of 3,982 mosquitoes were collected, 1,704 from human-landing catches, 2,009 from animal-baited traps, 269 from light traps and 837 larval specimens from 54 species in 13 genera (Table 1). Of the collection methods used, the animal-baited traps yielded the greatest number of species, com-

Table 1
Mosquito species composition and abundance in Toh Daeng peat swamp forest, September 2001 to December 2005.

Mosquito species	Adult mosquitoes collected by method			Immature mosquitoes collected	
	Human-landing catches	Cow-baited catches	Light traps	Ovi-position traps	Pitcher plants
Aedes (Aedimorphus) caecus	1	0	0	-	-
Aedes (Aedimorphus) mediolineatus	0	14	0	-	-
Aedes (Aedimorphus) stenoetrus	0	0	0	+	-
Aedes (Aedimorphus) vexans	0	38	0	-	-
Aedes (Fredwardsius) vittatus	0	3	0	-	-
Aedes (Stegomyia) albopictus	111	0	5	+	-
Aedes (Verrallina) sp	0	0	0	+	-
Anopheles (Anopheles) barbirostris	0	8	0	-	-
Anopheles (Anopheles) barbumbrosus	0	46	0	-	-
Anopheles (Anopheles) campestris	0	5	0	-	-
Anopheles (Anopheles) nigerrimus	1	168	0	-	-
Anopheles (Anopheles) peditaeniatus	0	186	0	-	-
Anopheles (Anopheles) letifer	46	45	0	-	-
Anopheles (Anopheles) sinensis	0	2	0	-	-
Anopheles (Cellia) nivipes	0	7	0	-	-
Anopheles (Cellia) tessellatus	0	9	0	-	-
Anopheles (Cellia) vagus	0	4	0	-	-
Armigeres (Armigeres) kuchingensis	1	0	0	-	-
Armigeres (Armigeres) subalbatus	86	3	0	-	-
Armigeres (Armigeres) theobaldi	2	0	0	-	-
Coquillettidia crassipes	14	44	0	-	-
Coquillettidia nigrosignata	83	0	37	-	-
Coquillettidia ochracea	1	1	3	-	-
Culex (Culex) annulus	0	0	3	-	-
Culex (Culex) bitaeniorhynchus	4	10	2	-	-
Culex (Culex) fuscocephala	0	4	0	-	-
Culex (Culex) gelidus	29	88	37	-	-
Culex (Culex) pseudosinensis	6	0	0	-	-
Culex (Culex) pseudovishnui	9	0	23	-	-
Culex (Culex) sinensis	5	0	0	-	-
Culex (Culex) tritaeniorhynchus	14	113	27	-	-
Culex (Culex) vishnui	9	4	0	-	-
Culex (Culex) whitmorei	0	9	0	-	-
Culex (Culiciomyia) pallidothorax	0	0	42	-	-
Culex (Eumelanomyia) brevipalpis	0	0	7	+	-
Culex (Lophoceraomyia) curtipalpis	0	0	0	-	+
Heizmannia (Heizmannia) reidi	89	0	0	-	-
Mansonia (Mansonioides) annulata	391	0	31	-	-
Mansonia (Mansonioides) bonneae	566	653	0	-	-

Table 1 (Continued).

Mosquito species	Adult mosquitoes collected by method			Immature mosquitoes collected	
	Human-landing catches	Cow-baited catches	Light traps	Oviposition traps	Pitcher plants
Mansonia (Mansonioides) dives	46	26	0	-	-
Mansonia (Mansonioides) indiana	72	15	0	-	-
Mansonia (Mansonioides) uniformis	117	502	0	-	-
Mimomyia elegans	0	0	5	-	-
Mimomyia fusca	0	0	18	-	-
Ochlerotatus (Finlaya) albotaeniatus	0	0	0	+	-
Ochlerotatus (Finlaya) niveus subgroup	0	0	0	-	-
Ochlerotatus (Kenknightia) dissimillis	1	0	0	+	-
Ochlerotatus (Mucidus) quasiferinus	0	2	0	-	-
Tripteroides (Rachionotomyia) tenax	0	0	0	-	+
Toxorhynchites (Toxorhynchites) manopi	0	0	0	-	+
Uranotaenia (Uranotaenia) annandalei	0	0	7	-	-
Uranotaenia (Uranotaenia) edwardsi	0	0	17	-	-
Uranotaenia (Uranotaenia) longirostris	0	0	5	-	-
Zeugnomyia gracilis	0	0	0	+	+
Total	1,704	2,009	269	+	+

prising 50.0% of the total number of species caught, followed by human landing catches (44.4%), light traps (29.6%) and oviposition traps (18.5%).

The mosquitoes collected were: *Mansonia* (61.0%), *Anopheles* (13.2%), *Culex* (11.2%), *Coquillettidia* (4.6%), *Aedes* (4.3%), *Armigeres* (2.3%), *Heizmannia* (2.2%) and others (2.2%; *Ochlerotatus*, *Uranotaenia*, *Mimomyia*, *Toxorhynchites*, *Tripteroides* and *Zeugnomyia*). Animal-baited traps and landing catches were similar in recording the most abundant species (*Mansonia* spp), while a greater number of uncommon species were recorded with other collecting means; for instance, a large number of *Ze. gracilis* specimens was obtained from oviposition traps. The discovery of *Ze. gracilis* in Narathiwat Province provided an additional distribution record that was previously reported from a fallen leaf axil found in Trang Province, southern Thailand by Benjaphong and Rattanarithikul (1991).

Owing to breeding place surveys, habitat features associated with each mosquito species were mainly paddy fields, riverine habitats and primary swamp forest. Larvae and pupae of various mosquito species obtained from natural containers of plant origin (tree holes and pitcher plants) and oviposition traps were reported for the first time. Immature *Cx. curtipalpis, Tp. tenax* and *Tx. manopi* were recovered from pitchers of *Nepenthes mirabilis* with larval density varying from 2 to 73 larvae per pitcher cup, *Cx. curtipalpis* was the most abundant. *Ae. albopictus, Oc. albotaeniatus, Oc. dissimillis* and *Oc. niveus* subgroup were collected from tree holes and oviposition traps in the wildlife conservation zone. The oviposition traps

also yielded many immature specimens, including the genus *Aedes, Culex, Ochlerotatus, Tripteroides* and *Zeugnomyia*. Apart from landing catches, *An. letifer* larvae were also dipped from peat swamp water in varying densities (1-16 larvae/dip). Paddy fields in the development zone around the peat swamp favored breeding habitats for various zoophilic species of the genus *Aedes* (*Ae. caecus, Ae. mediolineatus, Ae. vexans*), *Anopheles* (*An. barbirostris, An. campestris, An. donaldi, An. nigerrimus, An. peditaeniatus, An. sinensis, An. nivipes, An. tessellatus* and *An. vagus*) and *Culex*, particularly the vectors of Japanese B encephalitis (*Cx. fuscocephala, Cx. gelidus, Cx. pseudovishnui, Cx. tritaeniorhynchus* and *Cx. vishnui*) most of which were captured by cow-baited traps.

DISCUSSION

Brugian filariasis transmitted by *Mansonia* mosquitoes is the only main vector-borne disease occurring in the peat swamp forest of Narathiwat Province with wild and domestic animals as reservoir hosts (Phantana *et al*, 1987; 1995; Kobasa *et al*, 2004; Apiwathnasorn *et al*, 2006b). In our study, *Mansonia* mosquitoes were collected with each method used except for oviposition traps, and were found widely distributed throughout the peat swamp, particularly in the wildlife conservation area. The most abundant species were *Ma. bonneae* (26.8% of all mosquitoes collected) followed by *Ma. uniformis* (13.6%) and *Ma. annulata* (9.3%). The prevalence of mosquitoes infected with *B. malayi* was 0.47% for *Ma. annulata* and 0.25% for *Ma. bonneae* by dissection. Immature *bonneae* and *uniformis* were obtained from common sedges of the family Cyperaceae: *Cyperus babakan, C. corymbosus, Lepironia articulata, Rhynchospora corymbosa, Scirpodendron ghaeri, Scleria sumatrensis,* and *Sacclolepis indica*. The larvae were also collected from larger trees, *Metroxylon sagus* and *Melaleuca cajuputi*, but in fewer numbers of larvae per scraping (1-7). *Ma. uniformis* was recovered from most of the host plants, however, *Ma. bonneae* preferred submerged plants rather than floating aquatic plants, *Eichhornia crassipes* and *Pistia stratiotes*.

Ninety-one *An. letifer* specimens were captured by human landing and cow-baited methods with an infection rate of 2.2% by dissection for *B. malayi*. *An. letifer* was reported for the first time in Thailand as an additional vector for Brugian filariasis with outdoor biting habit during the day and the night. *An. letifer* has been reported as a vectors for filariasis and malaria in Malaysia and is predominant in peat swamp areas (Wharton *et al*, 1962; Thevasagayam and Fah, 1980; Rahman *et al*, 1997). *An. letifer* was earlier reported in Thailand by Iyengar and Menon (1956), Reid (1963) and Scanlon *et al* (1968), however, no specimens were available for confirmation of species presence (Harrison and Scanlon, 1975). The present study confirms the presence of *An. letifer* in the peat swamp forest of Narathiwat Province, where adults were captured from baited traps and the larvae were found breeding in peat water.

In summary, the abundance and species distribution varied by swamp topography (the wildlife conservation area in the central zone surrounded by arboreal lowland and riverine vegetation with agricultural development areas in the outmost areas). Many species collected in the present study are known to be vectors of diseases: *Ae. albopictus* (a vector of dengue fever), *An. barbirostris* and *An. letifer* (vectors of malaria and lymphatic filariasis), *Oc. niveus* subgroup (vectors of bancroftian filariasis, rural type), and *Cx. fuscocephala, Cx. gelidus* and *Cx. tritaeniorhynchus* (vectors of Japanese B encephalitis). Notably *Ae. aegypti* was absent from the specimens collected, possibly be-

cause this species is more commonly found indoors in urban areas. The roles of these species in transmitting disease have not been determined in Narathiwat Province. Three species of mosquitoes were found for the first time breeding in pitcher plants (*N. mirabilis*): *Cx. curtipalpis, Tp. tenax* and *Tx. manopi. Zeugnomyia gracilis*, recovered from oviposition traps, was also reported for the first time in the peat swamp forest of Thailand. Information regarding mosquito fauna in the Toh Daeng peat swamp is still inadequate. Some endemic species have yet to be discovered and identified.

ACKNOWLEDGEMENTS

We are grateful to Professor David Molyneux and Dr Philip J McCall for their valuable comments and suggestions during data analysis. We thank the Leverhulme Trust for the financial support provided throughout the present study and special thanks to the Faculty of Tropical Medicine, Mahidol University for providing the research facilities.

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