

quito fauna of this area will contribute substantially to a better understanding of the biology and evolution of mosquitoes.

GENERAL SYSTEMATICS

The morphological characters used here are based on original observations and characters used in previously published literature. The following references were especially helpful: Edwards (1922, 1926), Brug (1931), Barraud (1934), Thurman (1959), and Tanaka *et al.* (1979) for the species in tribes Orthopodomyiini, Toxorhynchitini, and Sabethini; Zavortink (1971) for *Orthopodomyia*; Delfinado and Hodges (1968), and Mattingly (1981) for *Tripteroides*; Ramalingam (1975, 1983), Klein (1977), Miyagi *et al.* (1983, 1989), Dong and Wang (1988), and Miyagi and Toma (1989), and Dong *et al.* (1995), for *Topomyia*; and Harbach *et al.* (2007) for *Kimia*.

SYSTEMATICS SPECIFIC TO THE THAI FAUNA

Primary references dealing specifically with the species of *Orthopodomyia*, *Kimia*, *Malaya*, *Topomyia*, *Tripteroides*, and *Toxorhynchites* that occur in Thailand include Thurman (1959), Delfinado and Hodges (1968), Zavortink (1971), Mattingly (1981), Miyagi and Toma (1989), Harrison *et al.* (1991), Rattanaarithikul *et al.* (2005a), and Harbach *et al.* (2007).

Species of the genera covered herein are basically forest mosquitoes. The larvae breed in natural and artificial container habitats (Table 2). *Kimia*, *Malaya*, *Topomyia*, and *Tripteroides* are genera of tribe Sabethini. *Toxorhynchites* was recognized as the sole genus of subfamily Toxorhynchitinae until this taxon was reduced to tribal status within subfamily Culicinae (tribe Toxorhynchitini) based on cladistic analyses of morphological and molecular data (Harbach and Kitching, 1998; Mitchell *et al.*, 2002). *Orthopodomyia* is the only genus of tribe Orthopodomyiini.

1. Tribe Orthopodomyiini

***Orthopodomyia*.** *Orthopodomyia* is the only genus of tribe Orthopodomyiini. The genus has a worldwide distribution but only seven species are known to occur in Southeast Asia. Thurman (1959) recorded four species in northern Thailand and Zavortink (1971) treated the five species, all belonging to the Albipes Group, that are currently

recognized as members of the Thai mosquito fauna. The Albipes Group is divided into four subgroups, the Albipes, Anopheloides, Flavicosta, and Wilsoni Subgroups, all of which are represented by species that occur in Thailand: *Or. albipes* (Albipes Subgroup), *Or. andamanensis* and *Or. anopheloides* (Anopheloides Subgroup), *Or. siamensis* (Flavicosta Subgroup), and *Or. wilsoni* (Wilsoni Subgroup).

Adults of *Orthopodomyia* are beautifully marked mosquitoes that are easily recognized by their distinctive scutal ornamentation, spotted wings, and banded legs. They are readily distinguished from the adults of all other mosquito genera by having tarsomere 1 of the fore- and midlegs longer than tarsomeres 2-5 combined, and tarsomere 4 shorter than tarsomere 5. Larvae lack a pecten, abdominal segment VIII, and sometimes segments VI and VII, have large dorsal plates, and the comb of the Thai species, like most *Orthopodomyia* (see Zavortink, 1968), has a posterior row of long scales and an anterior row of shorter ones.

Feeding behavior and vector status. *Orthopodomyia* adults inhabit forests and appear to be active only after dark. The feeding habits of females are largely unknown, but birds appear to be the primary hosts. Females of *Or. andamanensis*, *Or. albipes*, and *Or. anopheloides* have been collected in light traps and are known to approach and bite humans (AFRIMS Collections, unpublished). None of the species of *Orthopodomyia* in Thailand are of medical or economic importance to humans.

Habitats of the immature stages. The immature stages of *Orthopodomyia* species are usually found in bamboo, tree holes, stump holes, *Pandanus* axils, rock pools, and artificial containers.

2. Tribe Sabethini

Thurman (1959) recorded and described species of *Malaya*, *Topomyia*, and *Tripteroides* that occur in northern Thailand. Harbach *et al.* (2007) recently transferred *Topomyia suchariti* of subgenus *Suaymyia* to genus *Kimia*.

2.1 Malaya. *Malaya* is a small genus of 12 species, only two of which, *Ml. genurostris* and *Ml. jacobsoni*, are found in Thailand. Adults of *Malaya* are unique in having a "hairy", bent, apically swollen proboscis that is folded beneath the body when at rest. They resemble the adults of *Kimia* and *Topomyia* in having a conspicuous median longitudinal stripe of white or silver scales on the scutum and no setae on the upper calypter, charac-

ters that distinguish them from *Tripteroides*. In the areas where *Malaya* occur, the larvae are distinguished from non-sabethine genera by the presence of a single pair of seta 4-X. *Malaya* larvae differ from those of *Kimia* and *Tripteroides* in having a slit-like occipital foramen and comb scales in two or more rows. The larvae of *Malaya* are distinct from *Kimia* and *Topomyia* in having the maxillary palpus fused with the maxillary body, seta 5-P is pectinate or bipectinate and less than half the length of seta 6-P. Seta 4-X is normally single, but it has 3 or more long branches in *Mi. jacobsoni*. Lane (1972) elucidated features that distinguish the pupae of *Malaya* species in Southeast Asia. The pupa of *Mi. jacobsoni* differs from the pupa of *Mi. genurostris* in having seta 5-VI shorter than the following tergum and seta 6-VII strongly developed, at least half as long as seta 9-VII. Seta 5-VI is longer than the following tergum and seta 6-VII is not as large in *Mi. genurostris*.

Feeding behavior and disease relations. *Malaya* adults are active during the daytime. Their feeding habits are unique among mosquitoes. They feed on the regurgitation of ants. To accomplish this, the mosquito accosts an ant and brings the tip of its proboscis into contact with its mouth until a drop of liquid is produced. The regurgitated liquid is rapidly sucked up and the ant goes away unharmed. Since species of *Malaya* are incapable of taking a blood meal, they are not of medical or economic importance.

Habitats of the immature stages. The immature stages of *Malaya* are found commonly in plant axils, e.g., banana, *Pandanus*, pineapple, *Allocasia*, *Colocasia*, pitcher plants, and occasionally bamboo stumps and internodes.

2.2 *Topomyia*. Thurman and Thurman (1955) reported this genus for the first time in northern Thailand. Thurman (1959) included five new species in subgenus *Topomyia* and introduced the subgenus *Suaymyia* for three new species. Harrison *et al.* (1991) listed six species of subgenus *Suaymyia* and five species of subgenus *Topomyia* in Thailand. Twenty-three species of *Topomyia* are recognized in this study, including eight species of subgenus *Suaymyia* (three unnamed) and 13 species of subgenus *Topomyia* (one unnamed), and two species without subgeneric placement, *i.e.* *To. spathulirostris* and *To. yanbarensis* (R.E. Harbach and Nguyen Duc Manh, personal communication). Harbach *et al.* (2007) removed *Topomyia suchariti* from subgenus *Suaymyia* and transferred it to the new genus *Kimia* (see below).

Topomyia are relatively small, attractive mosquitoes with a median longitudinal stripe of broad white or silver (occasionally brownish) scales on the scutum. Despite overall similarity, the unmodified proboscis of *Topomyia* should never be confused with the "hairy",

bent, and apically swollen proboscis of *Malaya*. In the areas where *Topomyia* occur, the larvae are distinguished from all non-sabethine genera by the single pair of seta 4-X, and from other sabethine genera based on the following characters: presence of a slit-like occipital foramen and absence of seta 13-P (distinctions from *Tripterooides*); presence of seta 8-M and insertion of seta 13-T some distance from the plate bearing setae 9-12-T (distinctions from *Kimia*); maxillary palpus freely attached to the maxillary body; and seta 5-P with aciculate branches and more than twice as long as seta 6-P (distinctions from *Malaya*).

Most females of *Topomyia* are difficult to distinguish and identify to species. As the immature stages of most species are unknown, the identification of larvae is problematic. The identity of specimens used in this study was confirmed by dissection of the male genitalia. The immature stages of *To. aenea*, *To. inclinata*, *To. svastii*, *To. unispinosa* (subgenus *Topomyia*), *To. cristata*, *To. leucotarsis*, and *To. pseudoleucotarsis* (subgenus *Suaymyia*) are unknown and no keys have been published for the identification of larvae of the remaining species. Because a detailed study of the genus as a whole was beyond the scope of the present study, the keys presented herein are based principally on specimens residing in collections at AFRIMS and the Smithsonian Institution. The larva of *To. angkoris* was previously unknown and certain morphological features of the larvae of *To. argyropalpis*, *To. gracilis*, *To. tenuis*, and *To. tipuliformis* are illustrated here for the first time. Key features of the larva of *To. lindsayi* are based on Dong and Wang (1988).

Feeding behavior and disease relations. Females are not attracted to animal-baited traps and are not known to suck blood. Adults have been collected while resting on trees and the overhanging banks of streams in total shade in damp forests. No species of *Topomyia* appear to be of medical or economic importance to humans.

Habitats of the immature stages. Little is known about the bionomics of *Topomyia* larvae. They have been collected from bamboo, plant axils (e.g. banana, *Pandanus*, pineapple, pitcher plants, *Allocasia*, *Colocasia*), coconut husks, and artificial containers.

2.3 *Kimia*. Harbach *et al.* (2007) established genus *Kimia* for five species previously included in *Topomyia* (*Suaymyia*). Only one of these species, *Km. suchariti*, is known to occur in Thailand. However, based on distribution records, *Km. decorabilis* is likely to be found in southern and eastern Thailand.

Kimia are relatively small, attractive mosquitoes with a median longitudinal stripe of

broad silver scales on the scutum. This character, along with the absence of setae or hair-like scales on the upper calypter, distinguishes the adults from all other Old World genera except *Malaya* and *Topomyia*. Despite the overall similarity, the unmodified proboscis of *Kimia* should never be confused with the “hairy”, bent, and apically swollen proboscis of *Malaya*. Females of *Kimia* are distinguished from those of *Topomyia* by the absence of setae and scales on sternum IX; males are distinguished by having the inner foreungues distinctly larger than the outer one. Males also differ in several features of their genitalia. The larvae of *Kimia* are distinguished from all other genera in the Oriental Region based on the following characters: presence of a single pair of seta 4-X (distinction from non-sabethine genera); presence of a rounded (elliptical) occipital foramen and absence of seta 8-M (distinctions from *Malaya* and *Topomyia*); insertion of seta 13-T on a plate with setae 9-12-T and absence of a pecten (distinctions from *Malaya* and *Tripteroides*).

Feeding behavior and disease relations. Little bionomical information is available for species of *Kimia*. Adults have never been collected in the wild and are known only from reared larvae. Species of *Kimia* are of no known medical or economic importance to humans.

Habitats of the immature stages. *Kimia* larvae are found in bamboo stumps and erect bamboo internodes bearing small holes presumably made by beetles. It is uncertain whether larvae are facultative or obligatory predators. The maxillae are modified for grasping. Before reaching the pupal and adult stages, the holotype of *Km. suchariti* was seen to prey on larvae of *Armigeres* and *Tripteroides* (Miyagi and Toma, 1989).

2.4 *Tripteroides*. Fifteen species belonging to subgenera *Rachionotomyia* and *Tripteroides* are known to occur in Thailand. Four species of subgenus *Rachionotomyia* include *Tp. aranoides*, *Tp. serratus*, *Tp. tenax*, and *Tp. affinis*. Mattingly (1981) included the first three species in the Aranoides Subgroup and the last species in the Affinis Subgroup of the Aranoides Group. Mattingly’s “unassociated species 1” and an unnamed species near *Tp. aranoides* species 2 also belong to subgenus *Rachionotomyia*. Nine named species belonging to the Nitidoventer Group of subgenus *Tripteroides* are recognized in this study. Since the immature stages of most species that occur in Thailand are difficult to identify, species identifications were confirmed by examination of associated pupal exuviae.

Genus *Tripteroides* is distinguished from all other genera that occur within its

distribution based on one or more of the following characters in the adult and larval stages. Adults: erect scales of head restricted to occiput, acrostichal setae absent from median longitudinal area of scutum, scutellum tri-lobed, prespiracular setae present, upper calypter of wing with marginal setae, and anal vein ends beyond base of mediocubital crossvein. Larvae: seta 3-C ventral, occipital foramen circular with distinct collar, seta 13-P present, comb scales in a single row, and the presence of a single pair of seta 4-X. The adults of *Tripteroides* differ from those of *Kimia*, *Malaya*, and *Topomyia* in lacking a median longitudinal stripe of metallic scales on the scutum. The head and thoracic pleura of species of subgenus *Tripteroides* are covered with brilliant metallic blue or silvery scales whereas these scales are white or grayish in species of subgenus *Rachionotomyia*. *Tripteroides* larvae are similar to those of *Kimia*, *Malaya*, and *Topomyia*, but differ in having prominent stellate setae on the thorax and abdominal segments. *Tripteroides* larvae resemble *Kimia* larvae in having a rounded (elliptical) occipital foramen and comb scales arranged in a single row, but are easily distinguished by the insertion of seta 13-T some distance from the plate bearing setae 9-12-T and the presence of a pecten on the siphon. The round (elliptical) occipital foramen of *Tripteroides* larvae distinguishes them from the larvae of *Malaya* and *Topomyia*, which have a transverse slit-like occipital foramen.

Feeding behavior and disease relations. Little is known about the bionomics of *Tripteroides*. The genus includes both domestic and forest species. The adults appear to be active during the daytime. A few species attack and bite humans, but the feeding habits of most species are unknown. Among the Thai species, only *Tp. aranoides* is known to bite humans. *Tripteroides serratus* have been collected in cattle-baited net traps, and hence are known to take blood meals. No species of *Tripteroides* are known to be involved in the transmission of pathogenic agents.

Habitats of the immature stages. *Tripteroides* larvae have been collected from knot holes, hollow logs, tree holes, stump holes, bamboo, axils of *Allocaasia*, *Colocasia* and other plants, flower bracts of ginger plants, coconut shells, husks, and artificial containers. They feed on arthropods or their remains.

3. Tribe Toxorhynchitini

Toxorhynchites. *Toxorhynchites* includes the largest mosquitoes. Adults are easily recognized by their large size and strongly bent proboscis. The body is covered with brightly colored iridescent scales and the posterior abdominal segments have lateral scale-tufts. The scutellum is evenly rounded (as in *Anopheles*) and the posterior margin

of the wing is distinctly emarginated opposite the termination of vein CuA. Larvae are very large and easily distinguished from larvae of other genera. They are reddish brown, and possess modified mouth brushes comprised of 10 or fewer thick, flattened filaments for grasping prey. The abdominal setae occur in groups of three to five on common sclerites and a comb and pecten are both absent.

Toxorhynchites is the only genus of tribe Toxorhynchitini, and only species of subgenus *Toxorhynchites* occur in Thailand. Thurman (1959) and Harrison *et al.* (1991) listed nine species of *Toxorhynchites* in Thailand. Among these, *Tx. splendens* and *Tx. gravelyi* are the most common species in the country. *Toxorhynchites bickleyi*, *Tx. manopi*, and *Tx. sunthorni* were described as new species from individual males (Thurman, 1959). As the adult and immature stages of most species that occur in Thailand are unknown, their identification is based on Thurman (1959). The identification of specimens used in this study was confirmed by the examination of associated pupal stages. Based on this method, we found that *Tx. gravelyi*, *Tx. magnificus*, *Tx. manopi*, and *Tx. leicesteri* each comprise two species.

Feeding behavior and disease relations. Both males and females feed exclusively on nectar and other sugary substances; hence, *Toxorhynchites* are not involved in the transmission of human or animal pathogens. Resting adults have been collected in and around shelters and on vegetation in forests. Adults of *Tx. splendens* are commonly found in villages and orchards.

Habitats of the immature stages. The larval habitats are tree holes, stump holes, bamboo internodes, bamboo stumps, split bamboo, axils of *Allocaasia* and *Colocasia*, and artificial containers. The larvae of all species are predacious. They feed mainly on the larvae of other mosquito species, but exhibit cannibalism in the absence of suitable prey. The larvae of a few species have been used with some success to control the larvae of medically important mosquitoes, *e.g.*, *Stegomyia aegypti*, that inhabit artificial containers.

ACKNOWLEDGEMENTS

We are grateful to Jittawadee Murphy, Chief Department of Entomology for support, encouragement, and critically reviewing the manuscript. We are also grateful to Richard C. Wilkerson, Smithsonian Institution, Museum Support Center, for many helpful suggestions and reviewing the manuscript.