Illustrated keys to the mosquitoes of Thailand IV. Anopheles

Article *in* The Southeast Asian journal of tropical medicine and public health · February 2006

Source: PubMed

5 authors, including:

Bruce Arthur Harrison
Western Carolina University and Dept. of Biology Catawba College in North Carolina
153 PUBLICATIONS **2,836** CITATIONS
SEE PROFILE

Ralph Harbach
Natural History Museum, London
740 PUBLICATIONS **7,726** CITATIONS
SEE PROFILE

ILLUSTRATED KEYS TO THE MOSQUITOES OF THAILAND IV. *ANOPHELES*

Rampa Rattanarithikul[1], Bruce A Harrison[2], Ralph E Harbach[3], Prachong Panthusiri[1], and Russell E Coleman[4]

ILLUSTRATIONS

by

Prachong Panthusiri

[1]Department of Entomology, US Army Medical Component, Armed Forces Research Institute of Medical Sciences, Bangkok, Thailand; [2]Public Health Pest Management, North Carolina Department of Environment and Natural Resources, Winston-Salem, North Carolina, USA; [3]Department of Entomology, The Natural History Museum, London, United Kingdom; [4]Department of Entomology, Walter Reed Army Institute of Research, Silver Spring, Maryland, USA

The Southeast Asian Journal of Tropical Medicine and Public Health
Volume 37 Supplement 2, 2006

Series Editor : Suvanee Supavej

ISSN : 0125 - 1562

Published by
SEAMEO Regional Tropical Medicine and Public Health Network,
Bangkok, Thailand, 2006

Printed by
Thunwa Printing

THE SOUTHEAST ASIAN JOURNAL OF TROPICAL MEDICINE AND PUBLIC HEALTH

Volume 37 Supplement 2 2006

CONTENTS

ILLUSTRATED KEYS TO THE MOSQUITOES OF THAILAND IV. *ANOPHELES*

Rampa Rattanarithikul[1], Bruce A Harrison[2], Ralph E Harbach[3], Prachong Panthusiri[1], and Russell E Coleman[4]

ILLUSTRATIONS

by

Prachong Panthusiri

[1]Department of Entomology, US Army Medical Component, Armed Forces Research Institute of Medical Sciences, Bangkok, Thailand; [2]Public Health Pest Management, North Carolina Department of Environment and Natural Resources, Winston-Salem, North Carolina, USA; [3]Department of Entomology, The Natural History Museum, London, United Kingdom; [4]Department of Entomology, Walter Reed Army Institute of Research, Silver Spring, Maryland, USA

Abstract. Illustrated keys for the identification of the larvae and adult female *Anopheles* mosquitoes of Thailand are presented along with distribution maps, tabulated bionomics information, and a checklist. A total of 73 species are treated, including 71 previously and newly described species (*An. cracens* = *dirus* B, *An. scanloni* = *dirus* C, *An. baimaii* = *dirus* D, *An. latens* = *leucosphyrus* A, and *An. epiroticus* = *sundaicus* A). Also, two undescribed species are included, *i.e.*, *An. minimus* C and a new species near *An. gigas*. Thirty-four chromosomal forms of 14 species are discussed, with suggestions provided for resolving their taxonomic status.

Correspondence: Dr Rampa Rattanarithikul, Department of Entomology, US Army Medical Component, Armed Forces Research Institute of Medical Sciences, 315/6 Ratchawithi Road, Ratchathewi, Bangkok 10400, Thailand.

INTRODUCTION

Keys for the identification of *Anopheles* mosquitoes are required for studies on the epidemiology and transmission of malaria. Many of the illustrated keys to the *Anopheles* of Thailand (Peyton and Scanlon, 1966; Rattanarithikul and Harrison, 1973) are of limited value, as these were published more than 20 years ago and significant advances in our knowledge of the *Anopheles* mosquitoes have occurred in the intervening years. The purpose of the keys presented in this paper is to assist entomologists to identify larvae and adult female *Anopheles* mosquitoes. The keys can be used to initially identify specimens to species group and then to species. Discriminating characteristics are highlighted in drawings and, whenever possible, were chosen so that they could be differentiated using a hand lens (10x) or dissecting microscope (10-40x). The morphological characters used here are based on original observations and previous usage in the literature. The following references were especially helpful: Christophers (1933), Colless (1956, 1957), Reid (1968), Harrison (1972, 1980), Harrison and Scanlon (1975), Rattanarithikul and Green (1986), Harbach *et al.* (2005), Linton *et al.* (2005), and Sallum *et al.* (2005). Nomenclature for morphological characters follows Harrison and Scanlon (1975), Harbach and Knight (1980, 1982), and Wilkerson and Peyton (1990). Generic and subgeneric abbreviations are those of Reinert (2001), Tanaka (2003), and Harbach *et al.* (2005).

SIBLING SPECIES AND GENETIC VARIATION IN ANOPHELINE MOSQUITOES

Combinations of morphological and other systematics methods have proven very useful in the recognition of sibling species in many groups of insects, most notably the medically important anopheline mosquitoes. Many anopheline taxa previously recognized as medically important in Southeast Asia have recently been found to be complexes of morphologically indistinct species. These discoveries suggest that in many Asian countries there is a need for the reassessment of primary vector species that were originally recognized solely on morphological methods. Important vector species should be reconfirmed using a combination of other appropriate techniques, including cytogenetic, biochemical, and molecular methods as exemplified by Baimai (1988a-d), Green (1982), Green *et al.* (1992), Panyim *et al.* (1988), and Rongnoparut *et al.* (1996, 1998, 1999), rather than relying on morphological criteria alone. The non-morphological methods are particularly useful if one has access to adult progeny (with associated larval and

pupal exuviae) reared from feral females. For example, a wild-caught female can be pinned and her morphological characters compared with those of her progeny. Wild-caught females can also be identified by ovarian polytene chromosome banding patterns or by PCR methodology, and also checked for sporogonic-stage malaria parasites using a sporozoite antigen panel assay kit, or by dissecting the salivary glands and examining them for sporozoites. Such approaches can be very revealing.

Until the late 1970s, *An. balabacensis* Baisas was regarded as an important vector of human malaria in Thailand and much of Southeast Asia. However, since then what was previously considered *An. balabacensis* on mainland Southeast Asia has been shown by morphological and non-morphological techniques to be a number of sibling species, namely *An. baimaii* Sallum and Peyton (2005), *An. cracens* Sallum and Peyton (2005), *An. dirus* Peyton and Harrison (1979), *An. nemophilous* Peyton and Ramalingam (1988), and *An. scanloni* Sallum and Peyton (2005), and *An. latens* Sallum and Peyton (2005) of the Leucosphyrus Complex. Recognition of the Dirus Complex prompted a reassessment of the distribution of *An. balabacensis*, which belongs to the Leucosphyrus Complex (Peyton, 1990) and is now restricted to certain islands in the Philippines, Indonesia, and Malaysia. *Anopheles dirus* and *An. baimaii* (Green *et al.*, 1991, as *dirus* D) are now regarded as the principal malaria vectors in Thailand. Another example of the value of using multiple methods, is the combination of morphological, cytogenetic, and related studies that revealed *An. maculatus* E (Delorme *et al.*, 1989; Kittayapong *et al.*, 1992) and *An. culicifacies* A (Subbarao, 1988) are the major vectors of human malaria parasites in Malaysia and India, respectively.

A major concern of individuals interested in the systematics of anophelines is how to deal with chromosomal forms of species that have been designated by letters of the alphabet. If these prove to be distinct species, the International Code of Zoological Nomenclature provides guidelines for taxonomists to establish a name and diagnostic characters for identifying them. However, each putative species has to be shown to be distinct from currently named species. For example, four genetic forms (A, B, C, D) of *An. jeyporiensis* are recognized in Thailand (Baimai *et al.*, 1996a). The question must be asked, which of these, if any, is conspecific with *An. jeyporiensis* James, 1902? This can only be resolved by studying the molecular genetics of *An. jeyporiensis* specimens from the type locality (Nagpur, Jeypur, Orissa and Maharashta States, Central Provinces, India) (Knight and Stone, 1977) and then comparing the Thai chromosomal forms with the species that James described as *An. jeyporiensis* from the type locality (Table 1). If one of the Thai chromosomal forms is identical to the species that James described, then the

other three Thai chromosomal forms will need to be studied further to determine if they represent distinct species. It may turn out that all of the *An. jeyporiensis* chromosomal forms reported from Thailand are distinct from the species described by James. In this case, one or more of the forms in Thailand would need to be formally named and *An. jeyporiensis* James would be deleted from the Thai records. Two recent studies (Rattanarithikul and Harbach, 1990; Linton *et al.*, 2001) involving *An. maculatus* Theobald and *An. sundaicus* (Rodenwaldt), respectively, provide approaches for resolving such problems.

ROLE OF ANOPHELINE MOSQUITOES AS DISEASE VECTORS IN THAILAND

Malaria

Despite decades of successful control programs and dramatic reductions in morbidity and mortality, malaria remains one of the most important infectious diseases in Thailand (Chareonviriyaphap *et al.*, 2000). Malaria remains prevalent along the undeveloped borders of eastern Myanmar, western Cambodia, and northern Malaysia. Although reported malaria cases have declined from a peak of 349,291 in 1988 to 85,625 in 1995, the number of cases has since risen annually (Chareonviriyaphap *et al.*, 2000). All four known human malaria parasites are present in Thailand, with *Plasmodium falciparum* (Welch) and *P. vivax* (Grassi and Feletti) predominant (Gingrich *et al.*, 1990; Snounou *et al.*, 1993). Multi-drug resistant *P. falciparum* occurs in Thailand, with widespread resistance to chloroquine, sulfadoxine-pyrimethamine, 4-aminoquinoline, and mefloquine (Faver *et al.*, 1999). Currently, antimalarial drugs that are used alone or in combination for the radical cure of falciparum malaria in Thailand include mefloquine, primaquine, quinine, tetracycline, and artemeter/artesunate compounds, whereas chloroquine and primaquine remain the choice for radical treatment of *P. vivax*, despite increasing reports of chloroquine resistance in the region (Chareonviriyaphap *et al.*, 2000).

Historically, malaria control in Thailand consisted of a combination of (i) prompt diagnosis and treatment with appropriate antimalarial drugs in government health clinics and in almost 550 specialized malaria clinics, (ii) health education in schools and in the general community, and (iii) an aggressive mosquito control program that relies on countrywide intradomiciliary insecticide spraying once or twice a year with DDT or a synthetic pyrethroid and, if appropriate, the distribution of pyrethroid impregnated bed nets (Chareonviriyaphap *et al.*, 2000). The increased resistance of parasite populations to

antimalarial drugs is the major problem in malaria control in Thailand; however, the emergence of insecticide resistance may also affect malaria control efforts. Although chemical insecticides such as DDT and deltamethrin remain physiologically lethal to all malaria vectors in Thailand (Chareonviriyaphap *et al.*, 1999), a number of malaria vectors have shown greater outdoor biting abundance relative to indoor populations after indoor residual spraying of DDT, suggesting that behavioral resistance may have emerged (Harrison, 1980; Prasittisuk, 1985; Suwonakerd *et al.*, 1990; Chareonviriyaphap *et al.*, 2000).

To determine the roles that different species of *Anopheles* mosquitoes play in maintaining transmission of *P. falciparum* and *P. vivax*, it is necessary to determine mosquito sporozoite rates. Mosquitoes can be tested for the presence of circumsporozoite (CS) antigen using enzyme-linked immunosorbent assay (ELISA) (Baker *et al.*, 1987) or the malaria VecTest assay (Medical Analysis Systems Inc., Camarillo, California, USA) (Ryan *et al.*, 2002, Sattabongkot *et al.*, 2004); however, confirmation of the vector status normally requires examination of salivary glands for sporozoites. In Thailand, *An. aconitus sensu lato*, *An. baimaii*, *An. dirus*, *An. maculatus*, *An. minimus*, and *An. pseudowillmori* have been incriminated as important vectors of human malaria parasites (Green *et al.*, 1991). A number of additional species have been incriminated as either secondary vectors or as potential vectors; however, the majority of these studies have used ELISA rather than salivary gland dissection. Other than the species listed above, the following species have been found infected with either *P. falciparum* and/or *P. vivax*: *An. campestris*, *An. hodgkini*, and *An. sawadwongporni* (Coleman *et al.*, 2002); *An. sawadwongporni* (Somboon *et al.*, 1998); unidentified members of the *An. barbirostris* and *An. hyrcanus* groups, *An. nivipes*, and *An. sawadwongporni* (Rattanarithikul *et al.*, 1996a); *An. nivipes* (Harbach *et al.*, 1987); and *An. kochi*, and *An. philippinensis* (O'Guinn and Coleman, unpublished data). Somboon *et al.* (1994) experimentally infected wild-caught mosquitoes with local human malaria parasites using a membrane feeding method and found that *An. vagus*, *An. kochi*, and *An. annularis* were susceptible to both *P. falciparum* and *P. vivax*, whereas *An. barbirostris* and *An. sinensis* were susceptible to only *P. vivax*. *Plasmodium* oocysts have been found in a variety of other species, including *An. karwari*, *An. maculatus*, *An. philippinensis*, *An. epiroticus*, *An. tessellatus*, and members of the *An. barbirostris* group. A summary of mosquito species that have been found infected with human *Plasmodium* species in Thailand is provided in Table 2 (modified from Rattanarithikul and Panthusiri, 1994b).

Although *Plasmodium* parasites have been reported from a number of species and

chromosomal forms of *Anopheles* that occur in Thailand, only *An. baimaii*, *An. dirus*, *An. minimus*, and *An. maculatus* (each belonging to complexes of species that are often morphologically indistinguishable) are considered major vectors (Pinichpongse and Bullner, 1967; Chareonviriyaphap *et al.*, 1999). The Dirus Complex consists of at least seven closely related species, with five occurring in Thailand (Baimai *et al.*, 1984a,b; Peyton and Ramalingam, 1988; Peyton, 1990; Sallum *et al.*, 2005). Members of this complex inhabit forest and forest-fringe areas, have strong human-biting tendencies, and are generally long-lived, all factors which results in particularly efficient vectors even at low population densities (Rosenberg *et al.*, 1990). In Thailand, the Minimus Complex consists of two species that are commonly found along the quiet, shaded edges of slow moving streams in areas with low hills, with contact with humans usually along the margins of villages (Sucharit *et al.*, 1988; Green *et al.*, 1990). *Anopheles minimus s.l.* are generally reported to be zoophilic, exophilic, and exophagic in their resting and feeding behavior, which reduces their vector efficiency compared to *An. dirus* (Harrison, 1980). The Maculatus Group consists of at least eight sibling species (Rattanarithikul and Green, 1986; Baimai *et al.*, 1993b; Kittayapong *et al.*, 1993). Members of this group usually occur in hilly forested zones where the larvae occur in shaded puddles in drying streams and other temporary habitats such as rock pools (Rattanarithikul *et al.*, 1995; Chareonviriyaphap *et al.*, 2000).

Japanese encephalitis

Japanese encephalitis (JE) is a flavivirus found throughout Southeast Asia. It is endemic in birds and mammals and serological evidence has been reported of widespread human infections in many countries in the region. However, clinical encephalitis has been recognized only sporadically, or in small outbreaks. The primary vectors of JE are various species of the genus *Culex*; however, a number of *Anopheles* species that are found in Thailand have been incriminated as vectors (Table 2). These include *An. subpictus* (Dhanda *et al.*, 1997), *An. sinensis* (Zhang, 1990), *An. annularis*, and *An. vagus* (Olson *et al.*, 1985; Sucharit *et al.*, 1989), *An. peditaeniatus* (Mourga *et al.*, 1989), and various members of the Barbirostris, Hyrcanus, and Umbrosus Groups (Ramachandra Rao, 1984).

Filariasis

Wuchereria bancrofti (Cobbold) and *Brugia malayi* (Buckley) cause Bancroftian and Brugian filariasis, respectively. *Brugia malayi* occurs as periodic and subperiodic forms and is primarily found in the flat coastal plains of southern part of Thailand, whereas *W.*

bancrofti primarily occurs in the hilly, forested areas in the western part of Thailand. The main vectors of *B. malayi* are *Mansonia* mosquitoes; however, some species of *Anopheles* (*i.e.*, *An. campestris*) transmit nocturnal periodic types of the parasite (Suvannadabba, 1993). *Wuchereria bancrofti* is largely an urban and suburban disease in many parts of the world due to the habits of its principal vector *Culex quinquefasciatus* (Say); however, in Thailand the disease is primarily rural with transmission by *Anopheles* species and in some cases *Downsiomyia harinasutai* [= *Aedes* (*Finlaya*) *harinasutai*] (Knight, 1978). Harinasuta *et al.* (1971) reported that >25% of *An. maculatus*, *An. minimus*, *An. philippinensis*, *An. sinensis* (as *An. hyrcanus sinensis*), *An. stephensi*, *An. subpictus*, and *An. vagus* became infected after feeding on a patient diagnosed with a nocturnal subperiodic strain of *W. bancrofti*. However, many of the species he worked with are now considered species complexes, so precise identification is impossible. A number of other *Anopheles* species have been incriminated as vectors of filariasis (Table 2).

THE *ANOPHELES* FAUNA OF THAILAND

Harrison (1980) briefly discussed the bionomics of most of the Thai anophelines with respect to forest type. This supported the suggestion of Lekagul and McNeely (1988) that the country could be split up into six biogeographic regions. For ease of interpretation, the spatial distribution of mosquito taxa has been transferred from a biogeographical reference map onto a map that demarcates political, regional, and provincial boundaries (Fig 1). In the introduction (Section I) of this series of papers (Rattanarithikul *et al.*, 2005) we more completely described each of these subregions. The northern (Subregion 1) and western (Subregion 2) parts of the country are in general hilly, contain high mountains, and dry evergreen forests. The *Anopheles* species in these regions, such as *An. culicifacies* (B), *An. varuna*, and *An. pseudowillmori*, are usually considered to be of Indian origin. The ranges of several of the anophelines found in these regions, such as *An. minimus s.l.* and *An. nivipes*, extend to the most southern Thai provinces and probably into southern Myanmar. The south (Subregion 3) and the primary forests of Chanthaburi and Trat (Subregion 4) contain evergreen rain forests, particularly along the Thai-Malaysia border. The ranges of a number of typically Malayan *Anopheles*, such as *An. donaldi*, *An. paraliae*, and some members of the Umbrosus Group therefore extend into Thailand. The Korat Plateau (Subregion 6) and the central valley (Subregion 5) have similar anopheline faunas. In general (except for the southern slope of the mountains found on the southern edge of the plateau), the Korat Plateau is drier than the other regions of the country. The southern slopes of the mountains in this subregion have

numerous areas of evergreen forest. The banks of the Mekong River in eastern Thailand are generally steep; however, some areas contain large areas of sandflats. A number of *Anopheles* species, to include *An. culicifacies* (B) and *An. pseudowillmori*, are found along the margins of the Mekong River. These species are usually found in flood pools, sand pools, rock pools, and temporary ground pools.

The earliest publication containing references to the anophelines of Thailand is Theobald (1910), whereas the first papers dealing specifically with the genus *Anopheles* and the role of anopheline species in the transmission of malaria in Thailand are those of Barnes (1923a,b). Barnes listed 17 species of *Anopheles* and included notes on their biology and vector relationships. The publications of Barraud and Christophers (1931), Anigstein (1932), and Causey (1937a,b) dealt with both anophelines and culicines. These papers can be important references when there is difficulty in resolving the identity of some specimens. Thurman (1959) provided a checklist of 47 species of anophelines that occurred in Thailand. Scanlon *et al.* (1968) listed 52 species of *Anopheles* known to occur in Thailand, and Harrison *et al.* (1990) listed a total of 72 species of *Anopheles*, including four unnamed species that had been confirmed using cytogenetic and molecular techniques. In this study, we report a total of 73 species of *Anopheles* (Table 3), including 71 named species, a new species near *An. gigas*, and an informally designated species, *An. minimus* C. However, 34 chromosomal forms have been recognized in 14 of the named species (Table 1) (Baimai *et al.*, 1993a,b; 1994; 1995; 1996a,b). These 34 chromosomal forms remain unnamed and require further study to determine if they are distinct species or intra-species genetic polymorphs. These forms include *An. argyropus* (A, B), *An. barbirostris* (A, B, C), *An. crawfordi* (A, B), *An. sinensis* (A, B), *An. aconitus* (A, B, C), *An. culicifacies* (A, B), *An. jamesii* (A, B), *An. jeyporiensis* (A, B, C, D), *An. karwari* (A, B, C), *An. maculatus* (E, K), *An. nigerrimus* (A, B), *An. nivipes* (A, B), *An. subpictus* (B, C, D), and *An. vagus* (A, B) (Table 1). Although 14 of these named species in Table 3 are represented by 34 chromosomal forms, the status of these forms in relation to presently named species, new sibling species or intra-species chromosomal polymorphs has not been resolved because the forms have not been compared to specimens from the type localities. Given the huge number of species and the generic diversity of mosquitoes occurring in Thailand, we feel that studies of these mosquitoes are far from complete.

Notes on habitats

In Thailand, anopheline mosquitoes occur at altitudes ranging from coastal and lowland areas of the central valley to the high mountains of the north. They are frequently

associated with a variety of types of forest cover, including primary and secondary tropical rain forests, wet to dry evergreen forests, and secondary evergreen and deciduous forests. Anopheline mosquitoes are common throughout Thailand and utilize a wide variety of habitats (Table 4). Also, we here propose 13 informal infrasubgenetic categories (Table 3).

Anopheline larvae usually require clean water; however, some are found in highly polluted water with high concentrations of buffalo dung and urine (*e.g.*, *An. barbirostris*), in muddy water, or in brackish water (*e.g.*, *An. baezai*). Most species are found in still to slowly running water, in water-filled containers, or in various other ground-water habitats. A complete listing of known larval habitats based on collection records is provided in Table 4. The majority of habitats that support the development of *Anopheles* larvae contain submerged, emergent, and/or floating vegetation. Larvae are found in both temporary and permanent water sources that are located in a variety of sunlight conditions ranging from direct sunlight to heavy shade.

Feeding behavior

Female anopheline mosquitoes feed primarily on mammalian and avian blood, with the former predominating. Most records from Thailand refer to nocturnal feeding on humans (these records generally resulted from studies on the transmission of malaria). The nocturnal feeding periodicity varies greatly among the different species, *e.g.*, *An. baimaii* and *An. dirus* predominantly feed between 20 00-23 00 hr and *An. minimus* feeds throughout the night without a clearly discernible peak. Mosquitoes like *An. maculatus* and *An. sawadwongporni*, and those of the Barbirostris and Hyrcanus Groups, are predominantly collected between 18 00 and 20 00 hr (Rattanarithikul *et al.*, 1996b). Many species (*e.g.*, *An. minimus* and *An. sawadwongporni*) can be collected during the day while resting in houses or other sheltered areas, whereas some species such as *An. dirus* (in heavily forested areas) (Rattanarithikul, unpublished data), *An. separatus*, *An. barbirostris*, and *An. campestris* (near their larval habitats) will feed during the day (Harrison, unpublished).

Habitats of the Groups and Subgroups of *Anopheles*

A description of the known habitats of each of the members of the various group-level taxa of *Anopheles* follows. A complete listing of the species found in each Group and Subgroup is presented in Table 3, and the known habitats of each species are presented in Table 4.

1. *Anopheles* (*Anopheles*), Anopheles Series. Eleven species of this Series are found in Thailand, including seven in the Aitkenii Group, one in the Culiciformis Group, and three in the Lindesayi Group. The known distributions of these 11 species in Thailand are shown in Figs 2 and 3.

1.1 Aitkenii Group. The species of the Aitkenii Group in Thailand include *An. aberrans*, *An. bengalensis*, *An. fragilis*, *An. insulaeflorum*, *An. palmatus*, *An. stricklandi*, and *An. tigertti* (Fig 2). The most common species are typically found in ground-water habitats in mountainous areas, including streams and stream margins, seepage areas, rock pools, and elephant footprints. They are occasionally found in swamps, ditches, marshes, and lakes in rural villages and low-lying areas adjacent to or in forested areas. *Anopheles tigertti* is only found in fresh-water crabholes, seepage bogs, and rock pools. Members of the Aitkenii Group are widely distributed throughout Thailand; however, *An. fragilis* and *An. stricklandi* have only been recorded from peninsular and western Thailand (Fig 2).

1.2 Culiciformis Group. This Group is represented in Thailand by *An. sintonoides* (Fig 2). Larvae of *An. sintonoides* have been found in a variety of natural containers, including treeholes, holes in stumps, holes between tree roots, bamboo stumps, split bamboo, bamboo internodes, *Pandanus* axils, and banana stumps (Table 4).

1.3 Lindesayi Group. This Group in Thailand includes *An. baileyi,* a new species near *An. gigas*, and *An. lindesayi cameronensis* (Fig 3). The species in this group are prevalent at altitudes >1,200 m. Larvae of *An. lindesayi cameronensis*, n. sp. near *An. gigas*, and *An. baileyi* are found in stream pools, stream margins, seepage areas, swamps, and rock pools on the tops of mountains (Table 4).

2. *Anopheles* (*Anopheles*), Lophoscelomyia Series. Three species of this Series are found in Thailand, including two species in the Asiaticus Group and one species not associated with a specific group. The distribution of these three species in Thailand is shown in Fig 3.

2.1 Asiaticus Group. This Group is represented by *An. asiaticus* and *An. interruptus*. *Anopheles interruptus* are known only from tree holes and root holes, whereas the immature stages of *An. asiaticus* are found in bamboo stumps, fallen split bamboo, and bamboo internodes (Table 4).

2.2 Unassociated Species. *Anopheles bulkleyi* is the only unassociated species in

this Series. The only specimen (the lost type specimen) of *An. bulkleyi* was a reared male that was collected in 1937 from a tree hole in tropical rain forest in Chanthaburi Province (Fig 3).

3. *Anopheles* (*Anopheles*), Myzorhynchus Series. Twenty-one species of this Series are found in Thailand, including one in the Albotaeniatus Group, six in the Barbirostris Group, eight in the Hyrcanus Group, and six in the Umbrosus Group. The distributions of the Albotaeniatus and Barbirostris Groups are shown in Fig 4; those of the Hyrcanus and Umbrosus Groups are shown in Figs 5 and 6, respectively.

3.1 Albotaeniatus Group. *Anopheles montanus*, the only species in the Albotaeniatus Group that occurs in Thailand, breeds in jungle habitats such as ground and rock pools, swamps, and elephant footprints. It is found only in southern Thailand (Fig 4).

3.2 Barbirostris Group. The Barbirostris Group in Thailand includes five species of the Barbirostris Subgroup (*An. barbirostris*, *An. campestris*, *An. donaldi*, *An. hodgkini*, and *An. pollicaris*) and one species of the Vanus Subgroup (*An. barbumbrosus*). The most common species in the Barbirostris Group are *An. barbirostris* and *An. campestris*. Both species are normally closely associated with humans, with immature stages found in rice fields and other ground-water habitats. *Anopheles barbumbrosus*, *An. donaldi*, *An. hodgkini*, and *An. pollicaris* are forest-dwelling species, with larvae found in shaded stream pools, ground pools, and rock pools. The relatively uncommon *An. pollicaris* has been collected from temporary ground pools and from stream pools in the south of Thailand. The distribution of this Group is shown in Fig 4.

3.3 Hyrcanus Group. The Hyrcanus Group in Thailand includes three species of the Lesteri Subgroup (*An. crawfordi*, *An. paraliae*, and *An. peditaeniatus*), three species of the Nigerrimus Subgroup (*An. nigerrimus*, *An. nitidus*, and *An. pursati*), and two unassociated species (*An. argyropus* and *An. sinensis*). Immature stages of most species in the Hyrcanus Group are primarily found in rice fields, marshy and swampy areas, ponds, and other similar habitats that contain emergent vegetation. They prefer shaded areas in these habitats. The most abundant and widely distributed mosquitoes of this Group in Thailand are *An. argyropus*, *An. nigerrimus*, *An. peditaeniatus*, and *An. sinensis*. These species occur in valleys and mountainous areas. *Anopheles nitidus* and *An. crawfordi* are primarily found in forested areas. *Anopheles paraliae* larvae are normally found in shaded semi- to permanent brackish water and not in rice fields. *Anopheles paraliae* is confined to coastal areas of peninsular and southeastern Thailand. *Anoph-*

eles pursati has a wide distribution in Thailand. The distribution of the Hyrcanus Group is shown in Fig 5.

3.4 Umbrosus Group. The Umbrosus Group in Thailand includes members of the Baezai Subgroup (*An. baezai*), the Letifer Subgroup (*An. letifer*, *An. roperi*, and *An. whartoni*), the Separatus Subgroup (*An. separatus*), and the Umbrosus Subgroup (*An. umbrosus*). *Anopheles baezai*, *An. roperi*, and *An. separatus* are generally associated with coastal brackish water habitats such as *Nipa* or mangrove swamps. *Anopheles whartoni* was not recognized as distinct from *An. letifer* until 1963, and the larvae of these two species remain indistinguishable. Thus, their habitats are poorly known. The distribution of the Umbrosus Group is shown in Fig 6.

4. *Anopheles* (*Baimaia*). This subgenus is based on the nominotypical species, *An. kyondawensis*, which is rarely collected. Until recently, only the larval stage was known and the species was assigned to the Anopheles Series, subgenus *Anopheles*. The first known adults of *An. kyondawensis* were reared from larvae collected in fresh-water crabholes (Table 4). Unique characteristics on the adults, pupa, and male genitalia prompted the recent description of a new subgenus for this species (Harbach *et al.*, 2005). It has been found in three provinces of Thailand (Fig 2). Nothing is known about the behavior of the adults.

5. *Anopheles* (*Cellia*), Myzomyia Series. Seven species belonging to the Funestus Group of this Series are found in Thailand, including the unassociated *An. jeyporiensis* (Jeyporiensis Complex), three species in the Aconitus Subgroup, one species in the Culicifacies Subgroup (Culicifacies Complex), and two species in the Minimus Subgroup (Minimus Complex) (Garros *et al.*, 2004, 2005). The distribution of these groups is shown in Fig 7.

5.1 Jeyporiensis Complex. *Anopheles jeyporiensis*, an unassociated member of the Funestus Group, includes four chromosomal forms in Thailand. These forms are found primarily in marshy depressions with submerged and emergent vegetation.

5.2 Aconitus Subgroup. This subgroup is represented in Thailand by *An. aconitus*, *An. pampanai*, and *An. varuna*. Immatures have been collected from ground-water habitats near foothills and forest fringe areas. Typical habitats include ponds, lakes, *Nipa* palm swamps, large pits, streams, river margins, rock pools, stream pools, flood pools, swamps, seepage pools and springs, small ditches, bogs and marshes, ground pools,

and rice fields (including fallow rice fields and pools in dry rice fields). Recently, Junkum *et al.*, (2005), using multiple techniques, determined that *An. aconitus* karyotype Forms B and C are not distinct species, but cytological races of the same species.

5.3 Culicifacies Subgroup. *Anopheles culicifacies* is the only species found in Thailand. Immature stages are found in a variety of habitats, to include stream margins, stream pools, and rice fields. Chromosomal forms A and B of *An. culicifacies* are sympatric in Chiang Mai Province (Baimai *et al.*, 1996a), whereas species B is common in the western subregion and eastern edge of the Korat Plateau subregion.

5.4 Minimus Subgroup. This subgroup is represented in Thailand by two species of the Minimus Complex, *An. minimus* [formerly *An. minimus* species A (Harbach *et al.*, 2006)] and the informally designated *An. minimus* C. These species occur principally in stream pools and stream margins. *Anopheles minimus* has also been collected in habitats similar to those of members of the Aconitus Subgroup (Table 4). *Anopheles minimus* is distributed throughout the country, whereas species C occurs only in the western and northern subregions. Previously unpublished collections of *An. minimus* C from Mae Sot in Tak Province and Mae Rim in Chiang Mai Province are reported here for the first time. Integrated molecular and ecological studies are needed to determine the full range of breeding sites occupied by both of these species.

6. *Anopheles* (*Cellia*), Neocellia Series. Fourteen species of the Series are found in Thailand, including three species in the Annularis Group, three in the Jamesii Group, six in the Maculatus Group, and two that are unassociated with a specific group. The distributions of the Annularis and Jamesii Groups are shown in Fig 8. The distribution of the Maculatus Group and the unassociated species is shown in Fig 9.

6.1 Annularis Group. The Annularis Group in Thailand includes *An. annularis*, *An. nivipes*, and *An. philippinensis*. These species are abundant throughout much of the country. Larvae are found in clean water with considerable vegetation. They occur in a variety of habitats, including ponds, swamps, marshes, ditches, pits, wells, grassy pools, sand pools, ground pools, flood pools, stream pools, stream margins, seepage springs, and rice fields.

6.2 Jamesii Group. The Jamesii Group consists of three species, *An. jamesii*, *An. pseudojamesi*, and *An. splendidus*, all of which occur in Thailand. *Anopheles pseudojamesi* (elevated from synonymy by Nurul Huda and Harrison, 1985) has been found in rice

fields and ground pools, whereas *An. jamesii* and *An. splendidus* occur in a wider range of habitats, including ground pools, stream pools, stream margins, and rice fields. The immature habitats of *An. splendidus* are similar to those of *An. maculatus*.

6.3 Maculatus Group. The Maculatus Group in Thailand includes *An. dravidicus*, *An. maculatus*, *An. notanandai*, *An. pseudowillmori*, *An. sawadwongporni*, and *An. willmori*. Members of this Group are found in or near hilly areas, as well as high mountainous areas. Larvae are found in a variety of habitats, including ponds, lakes, swamps, ditches, wells, grassy pools, sand pools, ground pools, flood pools, stream pools, stream margins, seepage springs, rice fields, foot prints, wheel tracks, artificial containers, and occasionally holes in fallen trees and bamboo stumps. *Anopheles maculatus* and *An. sawadwongporni* are widely distributed throughout the country except for the far south, whereas *An. maculatus* (E) is common throughout the peninsular region (Baimai *et al.*, 1993b; Rattanarithikul *et al.*, 1996c; Rongnoparut *et al.*, 1999). *Anopheles willmori*, a primary malaria vector in Nepal (Pradhan *et al.*, 1970), occurs at altitudes between 990-1,475 m in the north of Thailand. Larvae are found only in stream margins. *Anopheles pseudowillmori*, a secondary vector in northwestern Thailand along the Myanmar border (Green *et al.*, 1992), is found primarily in rice fields, stream margins, ponds, pits, and wells (Rattanarithikul *et al.*, 1995). A number of specimens have been collected in sand pools along the Mekong River in northeastern Thailand (Rattanarithikul *et al.*, 1994).

6.4 Unassociated Species. *Anopheles karwari* and *An. stephensi* are the only members of the Series in Thailand that are not associated with a specific group. The larval habitats of *An. karwari* are similar to those of *An. maculatus*. *Anopheles stephensi*, an important malaria vector in India and the Middle East, is rare in Thailand. Larvae have been found in ground pools, stream pools, and on one occasion in a tree hole. In India, *An. stephensi* larvae have been found in many habitats, including flood pools that covered the concrete floor under a construction site (Dhir, 1969).

7. *Anopheles* (*Cellia*), Neomyzomyia Series. Twelve species of the Series are found in Thailand, including one species in the Kochi Group, 10 in the Leucosphyrus Group, and one in the Tessellatus Group. The distributions of the 12 species are shown in Fig 10.

7.1 Kochi Group. *Anopheles kochi* is the only member of this group. It occurs throughout Thailand in a wide variety of larval habitats and preferentially feeds on large animals such as cattle and water buffalo.

7.2 Leucosphyrus Group. Ten species of this Group, *An. baimaii*, *An. cracens*, *An. dirus*, *An. hackeri*, *An. introlatus*, *An. latens*, *An. macarthuri*, *An. nemophilous*, *An. pujutensis*, and *An. scanloni*, occur in Thailand. The most favored habitats of the Leucosphyrus Group appear to be footprints (especially elephant footprints), wheel-tracks, temporary ground pools (*e.g.*, stream margins, flood pools, and seepage-springs), and in pits dug for mining with partial to heavily-shaded areas. Larvae have occasionally been collected in water jars, cut tree stumps, bamboo stumps, and root holes. Many species in the Dirus Complex occur in sympatry in Thailand, *e.g.*, *An. baimaii* and *An. dirus* (Rattanarithikul *et al.*, 1995). *Anopheles dirus* is the only species that is widespread throughout Thailand. *Anopheles cracens*, *An. hackeri*, *An. introlatus*, *An. latens*, *An. macarthuri*, *An. nemophilous*, and *An. pujutensis* occur primarily in peninsular Thailand (Fig 10).

7.3 Tessellatus Group. *Anopheles tessellatus* is the only member of this Group. The breeding habitats of *An. tessellatus* are similar to species in the Subpictus Group, which include a variety of ground-water habitats such as ponds, swamps, ground pools, stream pools, and stream margins.

8. *Anopheles* (*Cellia*), Pyretophorus Series. Four species of the Pyretophorus Series are found in Thailand, including one species in the Ludlowae Group and three in the Subpictus Group. The distributions of these mosquitoes are shown in Fig 11.

8.1 Ludlowae Group. This Group is represented in Thailand by *An. epiroticus* (=*sundaicus* A), recently described by Linton *et al.* (2005). Larvae of this species are typically found in sunlit brackish pools containing algae; however, *An. epiroticus* has also adapted itself to breeding in freshwater. The major breeding sites of this species include ponds, lakes, marshes, stream pools, stream margins, and rock pools in coastal areas.

8.2 Subpictus Group. This Group in Thailand includes *An. indefinitus*, *An. subpictus*, and *An. vagus*. Larvae of *An. indefinitus* are typically found in fresh-water habitats such as grassy pools, ponds, ditches, seepage pools, stream margins, and rice fields. They have also been found in slightly brackish water. *Anopheles vagus* is the most abundant species in this Group, with larvae most commonly found in a wide variety of ground-water habitats. *Anopheles vagus* larvae occasionally have been found in water jars and in holes in logs. Immature stages of *An. subpictus* are found in many habitats similar to those in which *An. epiroticus* is found, but they also occur in ditches, wells, ground pools, rice fields, animal footprints, and artificial containers.

ACKNOWLEDGEMENTS

We are grateful to James W Jones, Chief of the Department of Entomology, Armed Forces Research Institute of Medical Sciences, Bangkok, for his encouragement, support, and for reviewing the manuscript, and to Richard C Wilkerson, Walter Reed Biosystematics Unit, Smithsonian Institution, Washington, DC, for reviewing the manuscript. We thank all of our colleagues who collected the specimens used in this study, particularly those at AFRIMS and Mahidol University.

REFERENCES

Amerasinghe PH, Amerasinghe FP, Wirtz RA, *et al*. Malaria transmission by *Anopheles subpictus* (Diptera: Culicidae) in a new irrigation project in Sri Lanka. *J Med Entomol* 1992; 29: 577-81.

Anigstein L. Malaria and Anophelines in Siam. *Q Bull Health Org* 1932; League of Nations 1: 233-306.

Baimai V, Andre RG, Harrison BA, Kijchalao U, Panthusiri L. Crossing and chromosomal evidence for two additional species within the taxon *Anopheles dirus* Peyton and Harrison (Diptera: Culicidae) in Thailand. *Proc Entomol Soc Wash* 1984a; 89: 157-66.

Baimai V, Green C, Andre RG, Harrison BA, Peyton EL. Cytogenetic studies of some species complexes of *Anopheles* in Thailand and Southeast Asia. *Southeast Asian J Trop Med Public Health* 1984b; 15: 536-46.

Baimai V, Harbach RE, Kijchalao U. Cytogenetic evidence for a fifth species within the taxon *Anopheles dirus* in Thailand. *J Am Mosq Control Assoc* 1988a; 4: 333-8.

Baimai V, Harbach RE, Sukowati S. Cytogenetic evidence for the two species within the current concept of the malaria vector *Anopheles leucosphyrus* in Southeast Asia. *J Am Mosq Control Assoc* 1988b; 4: 44-50.

Baimai V. Population cytogenetics of the malaria vector *Anopheles leucosphyrus* group. *Southeast Asian J Trop Med Public Health* 1988c; 19: 667-80.

Baimai V. Constitutive heterochromatin differentiation and evolutionary divergence of karyotype in Oriental *Anopheles* (*Cellia*). *Pac Sci* 1988d; 42: 13-47.

Baimai V, Rattanarithikul R, Kijchalao U. Metaphase karyotypes of *Anopheles* of Thailand and Southeast Asia: I. The Hyrcanus Group. *J Am Mosq Control Assoc* 1993a; 9:

59-67.

Baimai V, Kijchalao U, Rattanarithikul R, Green CA. Metaphase karyotype of *Anopheles* of Thailand and Southeast Asia: II. Maculatus Group, Neocellia Series, subgenus *Cellia*. *Mosq Syst* 1993b; 25: 116-23.

Baimai V, Treesucon A, Rattanarithikul R. Metaphase karyotypes of *Anopheles* of Thailand and Southeast Asia: III. The Neocellia Series (*Cellia*). *Mosq Syst* 1994; 26: 116-24.

Baimai V, Rattanarithikul R, Kijchalao U. Metaphase Karyotypes of *Anopheles* of Thailand and Southeast Asia: IV. The Barbirostris and Umbrosus species groups, subgenus *Anopheles* (Diptera: Culicidae). *J Am Mosq Control Assoc* 1995; 11: 323-8.

Baimai V, Kijchalao U, Rattanarithikul R. Metaphase Karyotypes of *Anopheles* of Thailand and Southeast Asia: V. The Myzomyia Series, subgenus *Cellia* (Diptera: Culicidae). *J Am Mosq Control Assoc* 1996a; 12: 97-105.

Baimai V, Kijchalao U, Rattanarithikul R. Metaphase karyotypes of *Anopheles* of Thailand and Southeast Asia: VI. The Pyretophorus and the Neomyzomyia Series, subgenus *Cellia* (Diptera: Culicidae). *J Am Mosq Control Assoc* 1996b; 12: 669-75.

Baker EZ, Beier JC, Meek SR, Wirtz RA. Detection and quantification of *Plasmodium falciparum* and *P. vivax* infections in Thai Kampuchean *Anopheles* (Diptera: Culicidae) by enzyme linked immunosorbent assay. *J Med Entomol* 1987; 24: 537-41.

Banerjee K, Deshmukh PK, Ilkal MA, Dhanda V. Experimental transmission of Japanese encephalitis virus through *Anopheles tessellatus* and *Culex fatigans* mosquitoes. *Indian J Med Res* 1977; 65: 746-52.

Barnes ME. Notes on the anopheline mosquitoes of Siam. *Am J Hyg* 1923a; 3: 121-6.

Barnes ME. Anopheline mosquitoes with special reference to the species found in Siam. *J Nat Hist Soc Siam* 1923b; 6: 65-79.

Barraud PJ, Christophers SR. On a collection of anopheline and culicine mosquitoes from Siam. *Rec Malar Surv India* 1931; 2: 269-85.

Bonne-Wepster, Swellengrebel NH. The anopheline mosquitoes of the Indo-Australian Region. Amsterdam: JH De Bussy, 1953; 504 pp.

Causey OR. Some anopheline and culicine mosquitoes of Siam with remarks on malarial control in Bangkok. *Am J Hyg Monogr Ser* 1937a; 25: 400-20.

Causey OR. New anopheline and culicine mosquitoes from Siam. *J Parasitol* 1937b; 23: 543-5.

Chareonviriyaphap T, Aum-Aung B, Ratanatham S. Current insecticide resistance patterns in mosquito vectors in Thailand. *Southeast Asian J Trop Med Public Health* 1999; 30: 131-41.

Chareonviriyaphap T, Bangs MY, Rattanatham S. Status of malaria in Thailand. *Southeast Asian J Trop Med Public Health* 2000; 31: 225-37.

Chen B, Butlin RK, Harbach RE. Molecular phylogenetics of the Oriental members of the Myzomyia Series of *Anopheles* subgenus *Cellia* (Diptera: Culicidae) inferred from nuclear and mitochondrial DNA sequences. *Syst Entomol* 2003; 28: 57-67.

Chen B, Harbach RE, Butlin RK. Molecular and morphological studies on the *Anopheles minimus* group of mosquitoes in southern China: taxonomic review, distribution and malaria status. *Med Vet Entomol* 2002; 16: 253-65.

Cheong WH, Omar AH. *Anopheles maculatus*, a new vector of *Wuchereria bancrofti* in Malaysia (Pulau Aur) and a potential vector on mainland Malaya. *Med J Malaya* 1965; 20: 74-5.

Christophers SR. The fauna of British India, including Ceylon and Burma. Diptera. Family Culicidae. Tribe Anophelini. London: Taylor and Francis, 1933; 5: 371 pp.

Coleman RE, Sithiprasasna R, Kankaew P, *et al*. Naturally occurring mixed infection of *Plasmodium vivax* VK210 and *P. vivax* VK247 in *Anopheles minimus* and *An. maculatus* (Diptera: Culicidae) in western Thailand. *J Med Entomol* 2002; 39: 556-9.

Colless DH. The *Anopheles leucosphyrus* group. *Trans R Entomol Soc London* 1956; 108: 37-116.

Colless, DH. Further notes on the systematics of the *Anopheles leucosphyrus* group (Diptera: Culicidae). *Proc R Entomol Soc London* 1957; 26: 131-9.

Delorme DE, Wirtz RA, Loong KP, Lewis GE Jr. Identification of sporozoites in *Anopheles maculatus* from Malaysia by enzyme-linked immunosorbent assays. *Trop Biomed* 1989; 6: 21-6.

Dhanda V, Thenmozhi V, Kumar NP, *et al*. Virus isolation from wild-caught mosquitoes during a Japanese encephalitis outbreak in Kerala in 1996. *Indian J Med Res* 1997; 106: 4-6.

Dhir SL. A focal outbreak of malaria in Delhi in 1969. *J Commun Dis* 1969; 1: 195-202.

Elias M, Rahman AJMM, Ali MM, Begum J, Chowdhury AR. The ecology of malaria carrying mosquito *Anopheles philippinensis* Ludlow and its relation to malaria in

Bangladesh. *Bangladesh Med Res Counc Bull* 1987; 13: 15-28.

Faver EM, Barnish G, Yamokgul P, Rooney W. Sensitivity *in vitro* of *Plasmodium falciparum* to three currently used anitimalarial drugs on the western border of Thailand. *Trans R Soc Trop Med Hyg* 1999; 93: 180-4.

Garros C, Harbach RE, Manguin S. Systematics and biogeographical implications of the phylogenetic relationships between members of the Funestus and Minimus groups of *Anopheles* (Diptera: Culicidae). *J Med Entomol* 2004; 42: 7-18.

Garros C, Harbach RE, Manguin S. Morphological assessment and molecular phylogenetics of the Funestus and Minimus Groups of *Anopheles* (*Cellia*). *J Med Entomol* 2005; 42: 522-36.

Ghosh KK, Chakraborty S, Bhattacharya S, Palit A, Tandon N, Hati AK. *Anopheles annularis* as a vector of malaria in rural West Bengal. *Indian J Malariol* 1985; 22: 65-9.

Gingrich J, Weatherhead A, Sattabongkot J, Pilakasiri C, Wirtz RA. Hyperendemic malaria in a Thai village: dependence of year-round transmission on focal and seasonally circumscribed mosquito (Diptera: Culicidae) habitats. *J Med Entomol* 1990; 27: 1016-26.

Gould DJ, Esah S, Pranith U. Relation of *Anopheles aconitus* to malaria transmission in the central plain of Thailand. *Trans R Soc Trop Med Hyg* 1967; 61: 441-2.

Green CA. Population genetical studies in the genus *Anopheles*. Johannesburg: University of the Witwatersrand, 1982; 107 pp. Ph.D. Thesis.

Green CA, Harrison BA, Klein TA, Baimai V. Cladistic analysis of polytene chromosome rearrangements in anopheline mosquitoes, subgenus *Cellia*, series Neocellia. *Canad J Genet Cytol* 1985; 27: 123-33.

Green CA, Gass RF, Munsterman LE, Baimai V. Population genetic evidence for 2 species in *Anopheles minimus* in Thailand. *Med Vet Entomol* 1990; 4: 25-34.

Green CA, Rattanarithikul R, Pongparit S, Sawadwongporn P, Baimai V. A newly recognized vector of human malaria parasites in the Oriental region, *Anopheles* (*Cellia*) *pseudowillmori* (Theobald, 1910). *Trans R Soc Trop Med Hyg* 1991; 85: 35-6.

Green, CA, Rattanarithikul R, Charoensub A. Population genetic confirmation of species status of the malaria vectors *Anopheles willmori* and *An. pseudowillmori* in Thailand and chromosome phylogeny of the Maculatus group of mosquitoes. *Med Vet Entomol*

1992; 6: 335-41.

Harbach RE, Knight KL. Taxonomists' glossary of mosquito anatomy. Marlton, NJ: Plexus Publishing, 1980; 415 pp.

Harbach RE, Knight KL. Corrections and additions to taxonomists' glossary of mosquito anatomy. *Mosq Syst* 1982; 13: 201-17.

Harbach RE, Gingrich JB, Pang LW. Some entomological observations on malaria transmission in a remote village in northwestern Thailand. *J Am Mosq Control Assoc* 1987; 3: 296-301.

Harbach RE. The classification of genus *Anopheles* (Diptera: Culicidae): a working hypothesis of phylogenetic relationships. *Bull Entomol Res* 2004; 94: 537-53.

Harbach RE, Rattanarithikul R, Harrison BA. *Baimaia*, a new subgenus for *Anopheles kyondawensis* Abraham, a unique crabhole-breeding anopheline in Southeast Asia. *Proc Entomol Soc Wash* 2005; 107: 750-61.

Harbach RE, Parkin E, Chen B, Buttin RK. *Anopheles* (*Cellia*) *minimus* Theobald (Diptera: Culicidae): Neotype designation, characterization, and systematics. *Proc Entomol Soc Wash* 2006; 108: 198-209.

Harinasuta C, Sucharit S, Vutikes S. Experimental studies on potential mosquito vectors of bancroftian filariasis. *Southeast Asian J Trop Med Public Health* 1971; 2: 102-3.

Harinasuta T, Gilles HM, Sandosham AA. Malaria in Southeast Asia. *Southeast Asian J Trop Med Public Health* 1976; 7: 645-78.

Harrison BA. A new interpretation of affinities within the *Anopheles hyrcanus* complex in Southeast Asia. *Mosq Syst* 1972; 4: 73-83.

Harrison BA, Scanlon JE. Medical entomology studies: II. The subgenus *Anopheles* in Thailand (Diptera: Culicidae). *Contrib Am Entomol Inst* (Ann Arbor) 1975; 12: 1-307.

Harrison BA. Medical entomology studies: XIII. The Myzomyia Series of *Anopheles* (*Cellia*) in Thailand, with emphasis on intra-interspecific variations (Diptera: Culicidae). *Contrib Am Entomol Inst* (Ann Arbor) 1980; 17: 1-195.

Harrison BA, Rattanarithikul R, Peyton EL, Mongkolpanya K. Taxonomic changes, revised occurrence records and notes on the Culicidae of Thailand and neighboring countries. *Mosq Syst* 1990; 22: 196-227.

Iyengar MOT. Filaria in Thailand. *Bull WHO* 1953; 9: 731-66.

Junkum A, Komalamisra N, Jitpakdi A, *et al*. Evidence to support two conspecific cytological races of *Anopheles aconitus* in Thailand. *J Vector Ecol* 2005; 30: 213-24.

Khoon CC. Status of malaria vectors in Malaysia. *Southeast Asian J Trop Med Public Health* 1985; 16: 133-8.

Kirnowardoyo S. Status of *Anopheles* malaria vectors in Indonesia. *Southeast Asian J Trop Med Public Health* 1985; 16: 129-32.

Kittayapong P, Clark JM, Edman JE. Survey of the *Anopheles maculatus* complex (Diptera: Culicidae) in peninsular Malaysia by analysis of cuticular lipids. *J Med Entomol* 1993; 30: 969-74.

Kittayapong P, Edman JD, Harrison BA, Delorme DR. Female body size, parity, and malaria infection of *Anopheles maculatus* (Diptera: Culicidae) in peninsular Malaysia. *J Med Entomol* 1992; 29: 379-83.

Knight KL. A new *Aedes* (*Finlaya*) mosquito from Thailand. *Mosq Syst* 1978; 10: 106-16.

Knight KL, Stone A. A catalog of the mosquitoes of the world (Diptera: Culicidae). 2nd ed. *Thomas Say Found, Entomol Soc Am* 1977; 6: 1-611.

Ksiazek TG, Trosper JH, Cross JH, Basaca-Sevilla V. Additional isolations of Japanese encephalitis virus from the Philippines. *Southeast Asian J Trop Med Public Health* 1980; 11: 507-9.

Lee VH, Atmosoedjono S, Rusmiarto S, Aep S, Semendra W. Mosquitoes of Bali Island, Indonesia; Common species in the village environment. *Southeast Asian J Trop Med Public Health* 1983; 14: 298-307.

Lekagul B, McNeely JA. Mammals of Thailand. Bangkok: Assoc Conserv Wildl 1988: 758 pp.

Linton YM, Harbach RE, Chang MS, Anthony TG, Matusop A. Morphological and molecular identity of *Anopheles* (*Cellia*) *sundaicus* (Diptera: Culicidae), the nominotypical member of a malaria vector species complex in Southeast Asia. *Syst Entomol* 2001; 26: 357-66.

Linton YM, Dusfour I, Howard TM, *et al. Anopheles* (*Cellia*) *epiroticus* (Diptera: Culicidae), a new malaria vector species in the Southeast Asian Sundaicus Complex. *Bull Entomol Res* 2005; 95: 329-39.

Maheswary NP, Habib MA, Elias M. Incrimination of *Anopheles aconitus* Doenitz as a vector of epidemic malaria in Bangladesh. *Southeast Asian J Trop Med Public Health* 1992; 13: 798-801.

Mourga DT, Ilkal MA, Mishra AC, *et al.* Isolation of Japanese encephalitis virus from mosquitoes collected in Karnataka state, India from 1985 to 1987. *Trans R Soc Trop Med*

Hyg 1989; 83: 550-2.

Nurul Huda KN, Harrison BA. Priority of the name *Anopheles pseudojamesi* for the species previously called *An. ramsayi* (Diptera: Culicidae). *Mosq Syst* 1985; 17: 49-51.

Olson JG, Ksiazek TG, Lee VH, Tan R, Shope RE. Isolation of Japanese encephalitis virus from *Anopheles annularis* and *Anopheles vagus* in Lombok, Indonesia. *Trans R Soc Trop Med Hyg* 1985; 79: 845-7.

Panyim S, Yasothornsrikul S, Baimai V, Rosenberg R, Andre RG, Green CA. Identification of isomorphic malaria vectors using a DNA probe. *Am J Trop Med Hyg* 1988; 38: 47-9.

Peyton EL, Scanlon JE. Illustrated key to the female *Anopheles* mosquitoes of Thailand. Bangkok: US Army Medical Component, Southeast Asia Treaty Organization, 1966: 47 pp.

Peyton EL, Harrison BA. *Anopheles* (*Cellia*) *dirus*, a new species of the Leucosphyrus Group from Thailand (Diptera: Culicidae). *Mosq Syst* 1979; 11: 40-52.

Peyton EL, Ramalingam S. *Anopheles* (*Cellia*) *nemophilous*, a new species of the Leucosphyrus group from peninsular Malaysia and Thailand (Diptera: Culicidae). *Mosq Syst* 1988; 20: 272-99.

Peyton EL. A new classification for the Leucosphyrus group of *Anopheles* (*Cellia*). *Mosq Syst* 1990; 21: 197-205.

Pinichpongse S, Bullner GR. The current status of malaria entomology in Thailand. *Warasan Mal* 1967; 11: 43.

Pradhan JN, Shrestha SL, Vaidya RG. Malaria transmission in high mountain valleys of west Nepal including first record of *Anopheles willmori* (James) as a third vector of malaria. *J Nepal Med Assoc* 1970; 8: 89-97.

Prasittisuk C. Present status of malaria in Thailand. *Southeast Asian J Trop Med Public Health* 1985; 16: 141-5.

Ramachandra Rao T. The anophelines of India. (Revised Edition). Malaria Research Center, Delhi: *Indian Council of Medical Research*, 1984; 518 pp.

Rattanarithikul R, Harrison BA. An illustrated key to the *Anopheles* larvae of Thailand. Bangkok: US Army Medical Component, Southeast Asia Treaty Organization, 1973: 42 pp.

Rattanarithikul R, Green CA. Formal recognition of the species of the *Anopheles maculatus* group (Diptera: Culicidae) occurring in Thailand including the description of two new

species and a preliminary key to females. *Mosq Syst* 1986; 18: 246-78.

Rattanarithikul R, Harbach RE. *Anopheles maculatus* (Diptera: Culicidae) from the type locality of Hong Kong and two new species of the Maculatus Complex from the Philippines. *Mosq Syst* 1990; 22: 160-83.

Rattanarithikul R, Mongkolpanya K, Noigamol C, Chanaimongkol S, Mahapibul P, Nakngen S. Dry-season distribution of mosquito larvae in the bed of the Mekong River, northwestern Thailand. *J Am Mosq Control Assoc* 1994; 10: 197-201.

Rattanarithikul R, Panthusiri P. Illustrated keys to the medically important mosquitoes of Thailand. *Southeast Asian J Trop Med Public Health* 1994; 25 (suppl 1): 1-66.

Rattanarithikul R, Green CA, Panyim S, Noigamol C, Chanaimongkol S, Mahapibul P. Larval habitats of malaria vectors around a transmission focus in northwestern Thailand. *J Am Mosq Control Assoc* 1995; 11: 428-33.

Rattanarithikul R, Konishi E, Linthicum KJ. Detection of *Plasmodium vivax* and *Plasmodium falciparum* circumsporozoites antigen in anopheline mosquitoes collected in southern Thailand. *Am J Trop Med Hyg* 1996a; 54: 114-21.

Rattanarithikul R, Konishi E, Linthicum KJ. Observations on the nocturnal biting activity and host preference of anophelines collected in southern Thailand. *J Am Mosq Control Assoc* 1996b; 12: 52-7.

Rattanarithikul R, Linthicum KJ, Konishi E. Seasonal abundance and parity rates of A*nopheles* species in southern Thailand. *J Am Mosq Control Assoc* 1996c; 12: 75-83.

Rattanarithikul R, Harrison BA, Panthusiri P, Coleman RE. Illustrated keys to the mosquitoes of Thailand I. Background; geographic distributions; List of genera, subgenera, and species; and a key to genera. *Southeast Asian J Trop Med Public Health* 2005; 36 (suppl 1): 1-80.

Reid JA. A preliminary account of the forms of *Anopheles leucosphyrus* Doenitz (Diptera: Culicidae). *Proc R Entomol Soc London, Ser B Taxonomy* 1949; 18: 42-53.

Reid JA. The *Anopheles umbrosus* group (Diptera: Culicidae). Part I. Systematics, with descriptions of two new species. *Trans R Entomol Soc London* 1950; 101: 281-318.

Reid JA. The *Anopheles hyrcanus* group in Southeast Asia. *Bull Entomol Res* 1953; 44: 5-76.

Reid JA. The *Anopheles barbirostris* group. *Bull Entomol Res* 1962; 53: 1-57.

Reid JA, Knight KL. Classification within the subgenus *Anopheles* (Diptera, Culicidae). *Ann Trop Med Parasitol* 1961; 55: 474-88.

Reid JA. Anopheline mosquitoes of Malaya and Borneo. *Stud Inst Med Res Malaya* 1968; 3: 1-520.

Reinert JF. Revised list of abrreviations for genera and subgenera of Culicidae (Diptera) and notes on generic and subgeneric changes. *J Am Mosq Control Assoc* 2001; 17: 51-5.

Rongnoparut P, Yaicharoen S, Sirichotpakorn N, Rattanarithikul R, Lanzaro GC, Linthicum KJ. Microsatellite polymorphism in *Anopheles maculatus*, a malaria vector in Thailand. *Am J Trop Med Hyg* 1996; 55: 589-94.

Rongnoparut P, Yaicharoen S, Sirichotpakorn N, Rattanarithikul R, Linthicum KJ. Sequence heterogeneity in *Copia*-like retrotransposons in *Anopheles* (Diptera: Culicidae) in Thailand. *J Med Entomol* 1998; 35: 771-7.

Rongnoparut P, Sirichotpakorn N, Rattanarithikul R, Yaicharoen S, Linthicum KJ. Estimates of gene flow among *Anopheles maculatus* populations in Thailand using microsatellite analysis. *Am J Trop Med Hyg* 1999; 60: 508-15.

Rosenberg R, Andre RG, Somchit L. Highly efficient dry season transmission of malaria in Thailand. *Trans R Soc Med Hyg* 1990; 89: 22-8.

Ryan JR, Dave K, Collins KM, *et al.* Extensive multiple test centre evaluation of Vec Test malaria antigen panel assay. *Med Vet Entomol* 2002; 16: 321-7.

Saguna SG, Rathinam KG, Rajavel AR, Dhanda V. Morphological and chromosomal descriptions of new species in the *Anopheles subpictus* complex. *Med Vet Entomol* 1994; 9: 88-94.

Sallum MAM, Peyton EL, Wilkerson RC. Six new species of the *Anopheles leucosphyrus* group, reinterpretation of *Anopheles elegans* and vector implications. *Med Vet Entomol* 2005; 19: 158-99.

Sattabongkot J, Kiattibut C, Kumpitak C, *et al.* Evaluation of the Vec Test Malaria Antigen Panel assay for the detection of *Plasmodium falciparum* and *P. vivax* circumsporozoit protein in anopheline mosquitoes in Thailand. *J Med Entomol* 2004; 41: 209-14.

Scanlon JE, Peyton EL, Gould DJ. An annotated checklist of the *Anopheles* of Thailand. *Thai Natl Sci Pap Fauna Ser* 1968; 2: 1-35.

Scanlon JE, Sandhinand U. The distribution and biology of *Anopheles balabacensis* in Thailand. *J Med Entomol* 1965; 2: 61-9.

Snounou G, Viriyakosol S, Jarra W, Thaithong S, Brown KN. Identification of the four malaria parasite species in field samples by the polymerase chain reaction and de-

tection of a high prevalence of mixed infections. *Mol Biochem Parasitol* 1993; 58: 283-92.

Somboon P, Suwonakerd W, Lines JD. Susceptibility of Thai zoophilic anophelines and suspected malaria vectors to local strains of human malaria parasites. *Southeast Asian J Trop Med Public Health* 1994; 25: 766-70.

Somboon P, Aramrattana A, Lines J, Webber R. Entomological and epidemiological investigations of malaria transmission in relation to population movements in forest areas of north-west Thailand. *Southeast Asian J Trop Med Public Health* 1998; 29: 3-9.

Subbarao SK. The *Anopheles culicifacies* complex and control of malaria. *Parasitol Today* 1988; 4: 72-5.

Sucharit S, Komalamisra N, Leemingsawat S, Apiwathnasorn C, Thongrungkiat S. Population genetic studies on the *Anopheles minimus* complex in Thailand. *Southeast Asian J Trop Med Public Health* 1988; 19: 7-23.

Sucharit S, Surathin K, Shrestha SR. Vectors of Japanese encephalitis virus (JEV): species complexes of the vectors. *Southeast Asian J Trop Med Public Health* 1989; 20: 611-21.

Sukowati S, Baimai V, Harun S, Dasuki Y, Andris H, Efriwati M. Isozyme evidence for three sibling species in the *Anopheles sundaicus* complex from Indonesia. *Med Vet Entomol* 1999; 13: 408-14.

Sungvornyothin S, Garros S, Chareonviriyaphap T, Manguin S. How reliable is the humeral pale spot for identification of cryptic species of the Minimus Complex? *J Am Mosq Control Assoc* 2006; 22: (in press).

Suvannadabba S. Current status of filariasis in Thailand. *Southeast Asian J Trop Med Public Health* 1993; 24 (suppl 2): 5-7.

Suwonakerd W, Amg-Ang B, Rimwangtrakul K. A field study on the response of *Anopheles dirus* to DDT and fenitrothion sprayed to huts in Phetchaboon Province, Thailand. *Trop Med* 1990; 32: 1-5.

Tanaka K. Studies on the pupal mosquitoes of Japan (9) Genus *Lutzia*, with establishment of two new subgenera, *Metalutzia* and *Insulalutzia* (Diptera: Culicidae). *Jpn J Syst Entomol* 2003; 9: 159-69.

Theobald FV. Monograph of the Culicidae or mosquitoes. Vol V. London: British Museum of Natural History, 1910: 646 pp.

Thurman EB. A contribution to a revision of the Culicidae of northern Thailand. *Univ MD*

Agric Exp Stn Bull A 1959: 100 pp.

Van Bortel W, Trung HD, Manh ND, Roelants P, Verle P, Coosemans M. Identification of two species within the *Anopheles minimus* complex in northern Vietnam and their behavioural divergences. *Trop Med Int Health* 1999; 4: 257-65.

Wattal BL. Dissection records of wild caught anopheline mosquitoes other than the reported vectors of malaria "Vectors of malaria in India". *Nat Soc Ind Mal Mosq Dis* 1961; 1: 187-237.

Wharton RH. Studies on filariasis in Malaya. Field and laboratory investigations of the vectors of a rural strain of *Wuchereria bancrofti*. *Ann Trop Med Parasitol* 1960; 54: 78-91.

Wilkerson RC, Peyton EL. Standardized nomenclature for the costal wing spots of the genus *Anopheles* and other spotted wing mosquitoes (Diptera: Culicidae). *J Med Entomol* 1990; 27: 207-24.

Zhang HL. The natural infection rate of mosquitoes by Japanese encephalitis B virus in Yunnan Province. *Zhonghua Yu Fang Yi Xue Za Zhi* 1990; 24: 265-7.

Table 1

Type locality information for species in Thailand for which one or more chromosomal forms have been described.

Species	Genetic forms*	Type locality
An. aconitus	A,B,C	Kajoe Tanam, Sumatra, Indonesia
An. argyropus	A,B	Deli, Sumatra, Indonesia
An. barbirostris	A,B,C	Mt. Ardjoeno, E. Java, Indonesia
An. crawfordi	A,B	Kuala Lumpur, Malaysia
An. culicifacies	A,B	Hoshangabad, India
An. jamesii	A,B	Quilon, Travancore, India
An. jeyporiensis	A,B,C,D	Orissa and Maharashtra states, India
An. karwari	A,B,C	Karwar, Bombay, India
An. maculatus	E,K	*An. maculatus* (B) in Thailand = type Hong Kong, China
An. nivipes	A,B	Kuala Lumpur, Selangor, Malaysia
An. nigerrimus	A, B	Calcutta, India
An. sinensis	A,B	China
An. subpictus	B,C,D	India
An. vagus	A,B	Java and Sumatra, Indonesia

* These chromosomal forms must be compared with specimens from the type locality to determine if they are conspecific or undescribed species. Studies such as cross-mating, polytene chromosome, and molecular genetics can be used to define the species. If two or more chromosomal forms are identified at the type locality, then after serious consideration, an arbitrary selection of one of the chromosomal forms must be made to fix the name of the species previously described from that type locality.

Table 2

Known anopheline vectors and potential vectors of malaria, Japanese encephalitis, and lymphatic filariasis in Thailand and neighboring countries.

Disease/vector	Vector in Thailand*	Vector elsewhere	References
Malaria			
An. aconitus	x	x	Gould *et al.*, 1967; Green *et al.*, 1991; Maheswary *et al.*, 1992
An. annularis	(x)	x	Ghosh *et al.*, 1985; Baker *et al.*, 1987
An. campestris	(x)	-	Coleman *et al.*, 2002
An. culicifacies	-	x	Ramachandra Rao, 1984; Subbarao, 1988
An. dirus	x	x	Scanlon and Sandhinand, 1965 as *balabacensis*; Rosenberg *et al.*, 1990; Green *et al.*, 1991
An. baimaii (=*dirus* D)	x	-	Green *et al.*, 1991
An. hodgkini	(x)	-	Coleman *et al.*, 2002
An. karwari	[x]	-	Rosenberg *et al.*, 1990
An. kochi	(x)	x	Wattal, 1961; Baker *et al.*, 1987; O'Guinn and Coleman, unpublished data
An. maculatus	[x]	x	Scanlon *et al.*, 1968; Delorme *et al.*, 1989; Green *et al.*, 1991
An. minimus	x	x	Harrison, 1980; Green *et al.*, 1991; Rattanarithikul *et al.*, 1996
An. nivipes	(x)	-	Harbach *et al.*, 1987; Rattanarithikul *et al.*, 1996
An. philippinensis	[x]	x	Elias *et al.*, 1987; Rosenberg *et al.*, 1990; O'Guinn and Coleman, unpublished data
An. pseudowillmori	x	-	Green *et al.*, 1991
An. stephensi	-	x	Ramachandra, 1984
An. subpictus	-	x	Kirnowardoyo, 1985; Amerasinghe *et al.*, 1992
An. epiroticus (=*sundaicus* A)	[x]	x	Scanlon *et al.*, 1968; Reid, 1968
An. tessellatus	[x]	x	Harinasuta *et al.*, 1976; Ramachandra, 1984
An. sawadwongporni	(x)	-	Rattanarithikul *et al.*, 1996; Somboon *et al.*, 1998; Coleman *et al.*, 2002

Table 2 (Continued).

Disease/vector	Vector in Thailand*	Vector elsewhere	References
An. vagus	(x)	x	Ramachandra, 1984; Baker *et al.*, 1987
An. willmori	-	x	Pradhan *et al.*, 1970
Barbirostris Group	[x]	x	Harrison and Scanlon, 1975; Rattanarithikul *et al.*, 1996a
Hyrcanus Group	(x)	x	Harrison and Scanlon, 1975; Rattanarithikul *et al.*, 1996a
Umbrosus Group	-	x	Harrison and Scanlon, 1975; Khoon, 1985
Japanese encephalitis			
An. annularis	-	x	Ksiazek *et al.*, 1980; Olson *et al.*, 1985; Sucharit *et al.*, 1989
An. peditaeniatus	-	x	Mourga *et al.*, 1989
An. sinensis	-	x	Zhang, 1990
An. subpictus	-	x	Dhanda *et al.*, 1997
An. tessellatus	-	x	Banerjee *et al.*, 1977
An. vagus	-	x	Olson *et al.*, 1985; Sucharit *et al.*, 1989
Barbirostris Group	-	x	Ramachandra, 1984
Hyrcanus Group	-	x	Ramachandra, 1984
Umbrosus Group	-	x	Ramachandra, 1984
Filariasis			
An. annularis	-	x	Ramachandra, 1984
An. campestris	-	x	Suvannadabba, 1993
An. maculatus	-	x	Cheong and Omar, 1965
An. tessellatus	-	x	Iyengar, 1953
An. subpictus	-	x	Lee *et al.*, 1983
An. varuna	-	x	Ramachandra, 1984
Barbirostris Group	-	x	Lee *et al.*, 1983; Ramachandra Rao, 1984
Hyrcanus Group	-	x	Ramachandra Rao, 1984; Zang *et al.*, 1991
Umbrosus Group	-	x	Wharton, 1960; Harrison and Scanlon, 1975

* For malaria only, x = sporozoites in the salivary glands, [x] = oocysts, (x) = ELISA

Table 3

Checklist of the *Anopheles* of Thailand.

SUBGENUS *ANOPHELES*

Anopheles Series (Edwards, 1932)

Aitkenii Group (Reid and Knight, 1961)

1. *aberrans* Harrison and Scanlon, 1975
2. *bengalensis* Puri, 1930
3. *fragilis* (Theobald, 1903)
4. *insulaeflorum* (Swellengrebel and Swellengrebel de graaf, 1920)
5. *palmatus* (Rodenwaldt, 1926)
6. *stricklandi* Reid, 1965
7. *tigertti* Scanlon and Peyton, 1967

Culiciformis Group (Reid and Knight, 1961)

8. *sintonoides* Ho, 1938

Lindesayi Group (Reid and Knight, 1961), (Bonne-Webster and Swellengrebel; 1953, Reid; 1968, Harrison *et al.*, 1991)

Gigas Complex (Harrison *et al.*, 1991)

9. *baileyi* Edwards, 1929
10. n. sp. near *An. gigas*

Lindesayi Complex (Harrison *et al.*, 1991)

11. *lindesayi cameronensis* Edwards, 1929

Lophoscelomyia Series (Edwards, 1932)

Asiaticus Group (Reid, 1968)

Asiaticus Subgroup (New Subgroup)

12. *asiaticus* Leicester, 1903

Interruptus Subgroup (New Subgroup)

13. *interruptus* Puri, 1929

Unassociated Species

14. *bulkleyi* Causey, 1937

Myzorhynchus Series (Edwards, 1932)

Albotaeniatus Group (Reid and Knight, 1961)

15. *montanus* Stanton and Hacker, 1917

Barbirostris Group (Reid, 1962)

Barbirostris Subgroup (Reid, 1968)

16. *barbirostris* Van der Wulp, 1884 (genetic forms A, B, C)[a]

Table 3 (Continued).

17. *campestris* Reid, 1962
18. *donaldi* Reid, 1962
19. *hodgkini* Reid, 1962
20. *pollicaris* Reid, 1962

Vanus Subgroup (Reid, 1968)

21. *barbumbrosus* Strickland and Chowdhury, 1927

Hyrcanus Group (Reid, 1953)

Lesteri Subgroup (Harrison, 1972)

22. *crawfordi* Reid, 1953 (genetic forms A, B)[a]
23. *paraliae* Sandosham, 1959
24. *peditaeniatus* (Leicester, 1908)

Nigerrimus Subgroup (Harrison, 1972)

25. *nigerrimus* Giles, 1900 (genetic form A, B)[a]
26. *nitidus* Harrison, Scanlon, and Reid, 1973
27. *pursati* Laveran, 1902

Unassociated Species

28. *argyropus* (Swellengrebel, 1914) (genetic forms A, B)[a]
29. *sinensis* Wiedemann, 1828 (genetic forms A, B)[a]

Umbrosus Group (Reid, 1950)

Baezai Subgroup (New Subgroup)

30. *baezai* Gater, 1933

Letifer Subgroup (Reid, 1968)

31. *letifer* Sandosham, 1944
32. *roperi* Reid, 1950
33. *whartoni* Reid, 1963

Separatus Subgroup (New Subgroup)

34. *separatus* (Leicester, 1908)

Umbrosus Subgroup (New Subgroup)

35. *umbrosus* (Theobald, 1903)

SUBGENUS BAIMAIA

36. *kyondawensis* Abraham, 1947

SUBGENUS *CELLIA*

Myzomyia Series (Christophers, 1924)

Jeyporiensis Complex (New Complex)

Table 3 (continued).

37. *jeyporiensis* James, 1902 (genetic forms A, B, C, D)[a]

Funestus Group (Garros *et al.*, 2004)

Aconitus Subgroup (Chen *et al.*, 2003)

38. *aconitus* Doenitz, 1902 (genetic forms A, B, C)[a]
39. *pampanai* Buttiker and Beales, 1959
40. *varuna* Iyengar, 1924

Culicifacies Subgroup (Garros *et al.*, 2004)

41. *culicifacies* Giles, 1901 (genetic forms A, B)[a]

Minimus Subgroup (Chen *et al.*, 2003)

Minimus Complex (Green *et al.*, 1990)

42. *minimus* Theobald, 1901
43. *minimus* C

Neocellia Series (Christophers, 1924)

Annularis Group (Reid, 1968)

44. *annularis* Van derWulp, 1884
45. *philippinensis* Ludlow, 1902

Nivipes Complex (Green *et al.*, 1985, Harrison *et al.*, 1991)

46. *nivipes* (Theobald, 1903) (genetic forms A,B)[a]

Jamesii Group (New Group)

47. *jamesii* Theobald, 1901 (genetic forms A, B)[a]
48. *pseudojamesi* Strickland and Choudhury, 1931
49. *splendidus* Koidzumi, 1920

Maculatus Group (New Group)

Maculatus Subgroup (New Subgroup)

50. *dravidicus* Christophers, 1924
51. *maculatus* Theobald, 1901 (plus genetic forms E, K)[a]

Sawadwongporni (New Subgroup)

52. *notanandai* Rattanarithikul and Green, 1986
53. *sawadwongporni* Rattanarithikul and Green, 1986

Unassociated Species

54. ps*eudowillmori* (Theobald, 1910)
55. *willmori* (James, 1903)

Unassociated Species

56. *karwari* (James, 1903) (genetic forms A, B, C)[a]
57. *stephensi* Liston, 1901

Table 3 (continued).

Neomyzomyia Series (Christophers, 1924)

Kochi Group (New Group)

58. *kochi* Doenitz, 1901

Leucosphyrus Group (Reid, 1949)

Elegans Subgroup (Peyton, 1990)

59. *hackeri* Edwards, 1921

60. *pujutensis* Colless, 1948

Leucosphyrus Subgroup (Peyton, 1990)

Dirus Complex (Peyton and Ramalingam, 1988)

61. *baimaii* Sallum and Peyton, 2005 (=*dirus* D)

62. *cracens* Sallum and Peyton, 2005 (=*dirus* B)

63. *dirus* Peyton and Harrison, 1979

64. *nemophilous* Peyton and Ramalingam, 1988

65. *scanloni* Sallum and Peyton , 2005 (=*dirus* C)

Leucosphyrus Complex (Peyton, 1990)

66. *introlatus* Colless, 1957

67. *latens* Sallum and Peyton, 2005 (=*leucosphyrus* A)

Riparis Subgroup (Peyton, 1990)

68. *macarthuri* Colless, 1956

Tessellatus Group (New Group)

69. *tessellatus* Theobald, 1901

Pyretophorus Series (Edwards, 1932)

Ludlowae Group (New Group)

Sundaicus Complex (Sukowati *et al.*, 1999)

70. *epiroticus* (Linton and Harbach, 2005) (=*sundaicus* A)

Subpictus Complex (Saguna *et al.*, 1994)

71. *indefinitus* (Ludlow, 1904)

72. *subpictus* Grassi, 1899 (genetic forms B, C, D)[a]

73. *vagus* Doenitz, 1902 (genetic forms A, B)[a]

[a] Thirty-four additional genetic forms have been identified by cytogenetic studies but require additional study before full species status can be confirmed (Table 1).

Table 4

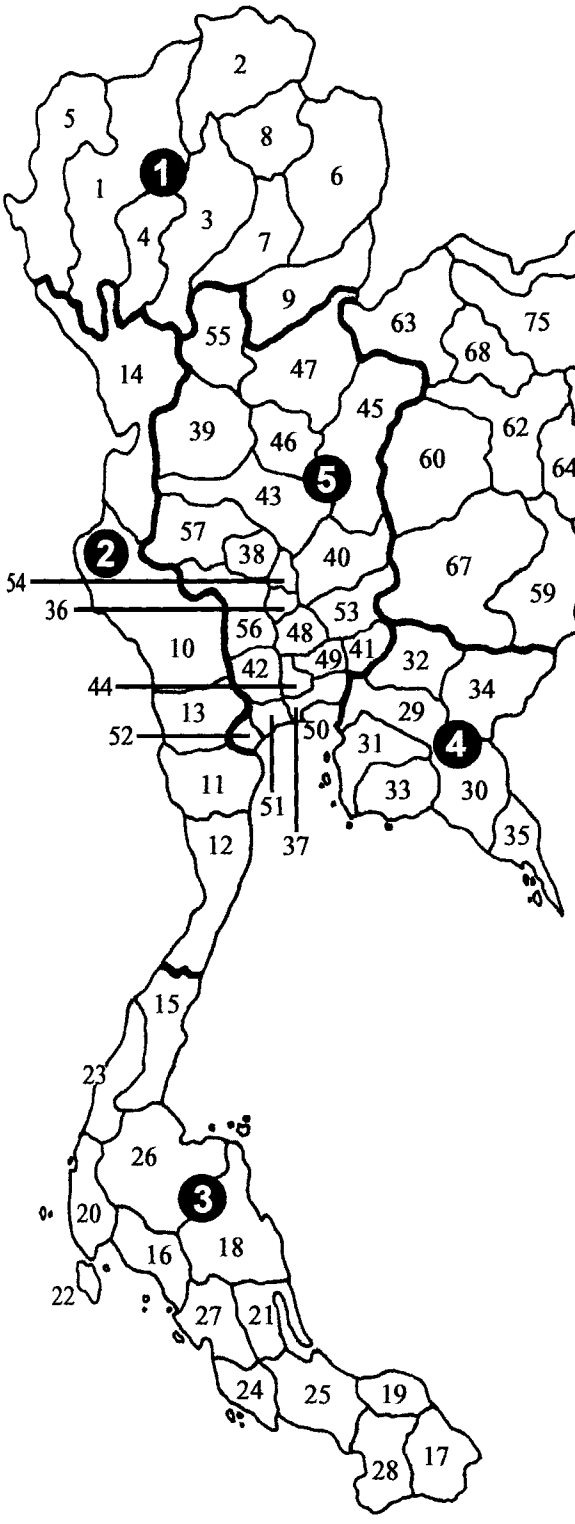
Known breeding habitats of immatures of *Anopheles* mosquitoes in Thailand.

	Ground water habitats																			Container habitats													
	Pond / lake	Swamp	Marsh and bog	Ditch	Pit / well	Stump ground hole	Grassy pool	Sand pool	Ground pool	Flood pool	Stream pool	Stream margin	Seep or seepage-spring	Rice field	Wheel track / tire depressions	Elephant and other footprints	Salt marsh	Mangrove / *Nipa* swamp	Crab hole	Artificial container	Hollow log	Rock pool	Rock hole	Cave hole	Tree hole	Root hole	Hole in tree stump	Bamboo internode	Bamboo stump	Bamboo split	*Pandanus* axils	Banana stump
Anopheles (Anopheles)																																	
An. aberrans											+	+	+			+						+											
An. argyropus		+	+	+	+		+				+	+	+	+				+														
An. asiaticus																											+	+	+			
An. baezai					+												+	+															
An. baileyi		+									+	+	+									+											
An. barbirostris	+	+	+	+	+	?	+	+	+	+	+	+	+	+	+	+		+	+			+											
An. barbumbrosus	+	+	+		+	+			+	+	+	+	+	+	+	+				?	+	+		+			+						
An. bengalensis		+	+	+					+		+	+	+		+	+			+			+		+									
An. bulkleyi																									+								
An. campestris	+	+	+	+	+	?			+	+	+	+	+	+	+			+															
An. crawfordi	+	+	+	+	+				+		+	+	+	?	+	+		+		?			+										
An. donaldi		+						?	+	+		+	?	+																			
An. fragilis		+									+	+	+			+																	
n.sp. near *An. gigas*											+	+	+										+										
An. hodgkini	+	+	+	+	+				+	+	+	+	+	+		+																	
An. insulaeflorum			+			+			+		+	+	+						+	?		+											
An. interruptus																									+	+							
An. l. cameronensis		+							+		+	+	+																				
An. letifer			+										+								?		+										

An. montanus		+								+	+					+						+										
An. nigerrimus	+	+	+	+	+				+	+	+	+		+								+										
An. nitidus		+	+	+	+				+	+	+	+	+	+		+		+				+										
An. palmatus											+	+																				
An. paraliae		+	+						+		+	+	+		+			+				+										
An. peditaeniatus	+	+	+	+	+	+	+		+	+	+	+	+	+	+					+	+	+										
An. pollicaris										+	+																					
An. pursati	+			+					+			+	+	+																		
An. roperi	+	+		+					+	+	+	+						+														
An. separatus		+											?				+	+														
An. sinensis	+	+	+	+	+	+	+			+	+	+	+	+	+							+										
An. sintonoides																									+	+	+	+	+	+	+	+
An. stricklandi											+		+			+																
An. tigertti													+						+			+										
An. umbrosus		+					?						+																			
An. whartoni		+					+						+																			
***Anopheles* (*Baimaia*)**																																
An. kyondawensis																			+													
***Anopheles*(*Cellia*)**																																
An. aconitus		+	+	+	+	+		+		+	+	+	+	+	+		+		+				+									
An. annularis	+	+	+					+	+	+	+	+	+	+		+						+										
An. baimaii (=*dirus* D)		+		+	+	+		+	+	+	+	+	+	+	+	+				+		+										
An. cracens (=*dirus* B)									+	+	+	+	+		+	+						+										
An. culicifacies					+			+	+		+	+	+	+	+																	
An. dirus					+	+			+	+	+	+	+	?	+	+				+	+	+					+		?			
An. dravidicus									+	+	+	+	+	+	+																	
An. epiroticus (=*sundaicus* A)	+	+	+			+		+	+		+	+		?			+					+										
An. hackeri							?						+		+			+		+	?	+										
An. indefinitus	+			+		+	+	+				+	+	+	+																	
An. introlatus									+	+	+		+		+	+						+	+									
An. jamesii	+	+		+	+			+	+	+	+	+	+	+	+			+				+										
An. jeyporiensis	+	+			+		+	+	+	+		+	+	+																		
An. karwari	+	+			+				+	+	+	+	+	+	+																	
An. kochi	+	+	+	+	+				+	+	+	+	+	+	+	+				+												
An. latens (=*leucosphyrus* A)						+		+	+	+	+	+	+		+	+						+										

Table 4 (continued).

		Ground water habitats																								Container habitats									
		Pond / lake	Swamp	Marsh and bog	Ditch	Pit / well	Stump ground hole	Grassy pool	Sand pool	Ground pool	Flood pool	Stream pool	Stream margin	Seep or seepage-spring	Rice field	Wheel track / tire depressions	Elephant and other footprints	Salt marsh	Mangrove / *Nipa* swamp	Crab hole	Artificial container	Hollow log	Rock pool	Rock hole	Cave hole	Tree hole	Root hole	Hole in tree stump	Bamboo internode	Bamboo stump	Bamboo split	*Pandanus* axils	Banana stump
	An. macarthuri			+	+	+	+		+	+	+	+	+	+		+	+						+	+									
	An. maculatus		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+			+	+		+	+				+					
	An. minimus		+	+	+	+		+	+	+	+		+	+	+								+										
	An. minimus C											+	+																					
	An. nemophilous									+	+	+	+	+		+																		
	An. nivipes	+	+	+	+	+	+	+	+	+	+	+	+	+	+																			
	An. notanandai								+			+	+											+										
	An. pampanai		+									+	+		+																			
	An. philippinensis		+	+		+	+	+			+	+	+	+	+																			
	An. pseudojamesi									+	+			+	+																			
	An. pseudowillmori			+		+		+	+		+	+	+		+		+																	
	An. pujutensis							+		+				+			+		?		+		+				?	+						
	An. sawadwongporni		+	+	+		+		+		+	+	+	+	+	+	+						+	+									
	An. scanloni (=*dirus* C)										+			+			+						+											
	An. splendidus		+	+	+			+	+	+	+	+	+	+	+	+																		
	An. stephensi									+		+																						
	An. subpictus		+	+	+	+	+	+		+	+		+		+	+		+	+															
	An. tessellatus		+	+	+	+	+			+	+		+	+	+	+	+						+											
	An. vagus		+	+	+	+	+	+	+	+	+	+	+	+		+	+	+			+		+	+										
	An. varuna				+	+				+	+	+	+																						
	An. willmori												+																						



Subregion 1
1. Chiang Mai
2. Chiang Rai
3. Lampang
4. Lamphun
5. Mae Hong Son
6. Nan
7. Phrae
8. Phayao
9. Uttaradit

Subregion 2
10. Kanchanaburi
11. Phetchaburi
12. Prachuap Khiri Khan
13. Ratchaburi
14. Tak

Subregion 3
15. Chumphon
16. Krabi
17. Narathiwat
18. Nakhon Si Thammarat
19. Pattani
20. Phang-nga
21. Phatthalung
22. Phuket
23. Ranong
24. Satun
25. Songkhla
26. Surat Thani
27. Trang
28. Yala

Subregion 4
29. Chachoengsao
30. Chanthaburi
31. Chon Buri
32. Prachin Buri
33. Rayong
34. Sa Kaeo
35. Trat

Subregion 5
36. Ang Thong
37. Bangkok
38. Chai Nat
39. Kamphaeng Phet
40. Lop Buri
41. Nakhon Nayok
42. Nakhon Pathom
43. Nakhon Sawan
44. Nonthaburi
45. Phetchabun
46. Phichit
47. Phitsanulok
48. Phra Nakhon Si Ayutthaya
49. Pathum Thani
50. Samut Prakan
51. Samut Sakhon
52. Samut Songkhram
53. Saraburi
54. Sing Buri
55. Sukhothai
56. Suphan Buri
57. Uthai Thani

Subregion 6
58. Amnat Charoen
59. Buri Ram
60. Chaiyaphum
61. Kalasin
62. Khon Kaen
63. Loei
64. Maha Sarakham
65. Mukdahan
66. Nakhon Phanom
67. Nakhon Ratchasima
68. Nong Bua Lam Phu
69. Nong Khai
70. Roi Et
71. Sakon Nakhon
72. Si Sa Ket
73. Surin
74. Ubon Ratchathani
75. Udon Thani
76. Yasothon

Fig 1–Map of Thailand showing the six subregions and the 76 provinces.

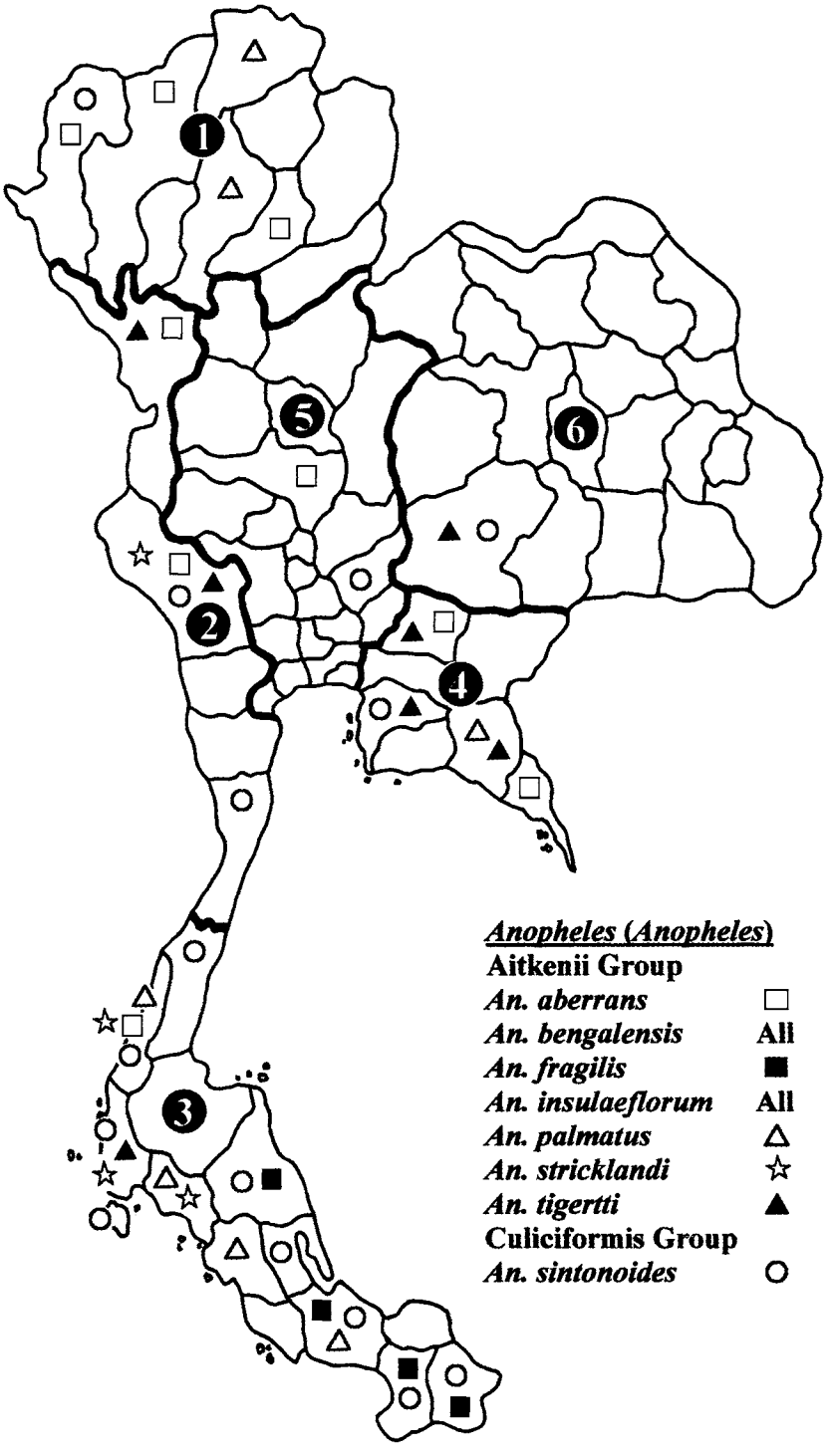


Fig 2–Distributions of Aitkenii and Culiciformis Groups of *Anopheles (Anopheles)*.

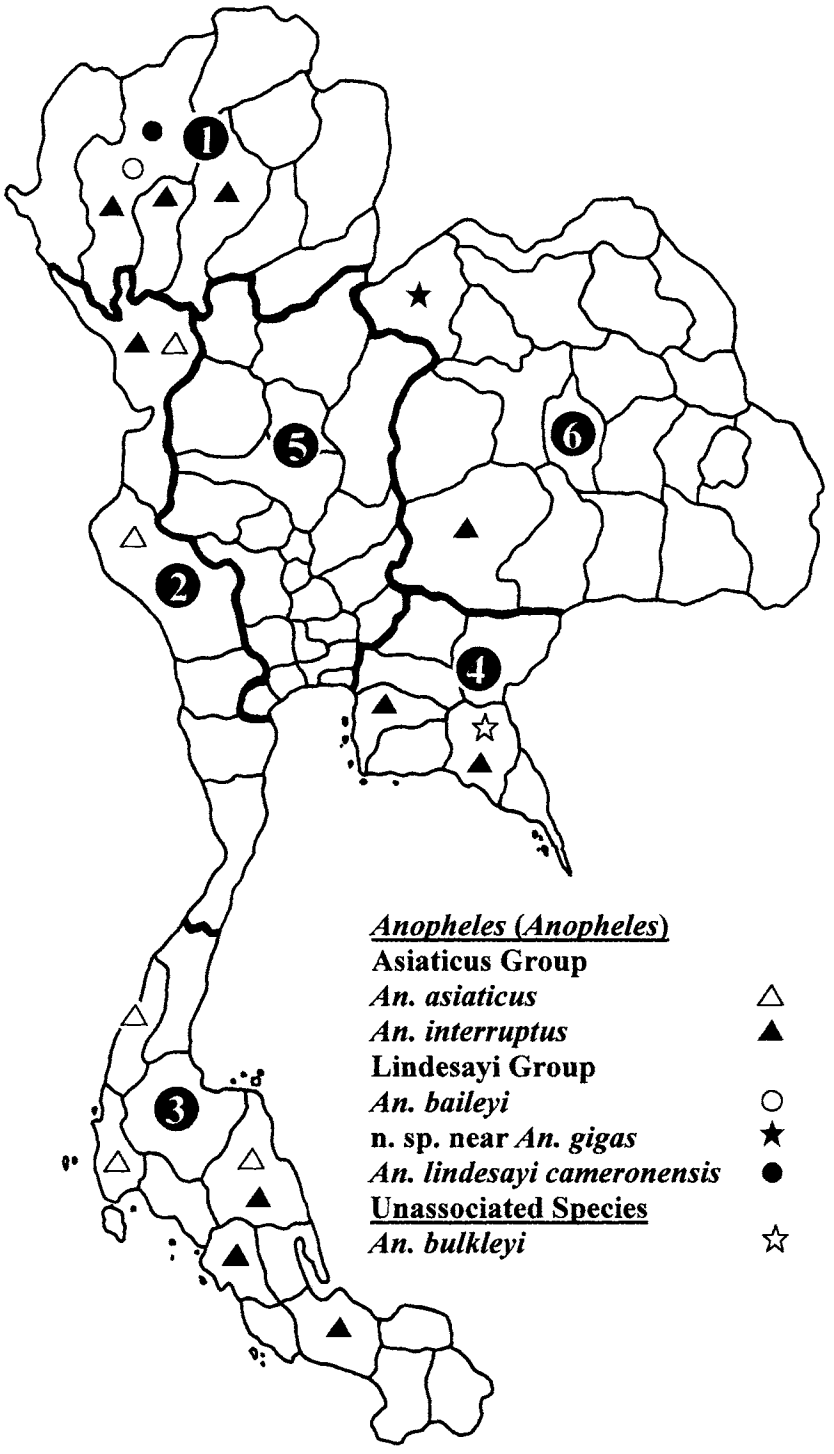


Fig 3–Distributions of Asiaticus and Lindesayi Groups, and *An. bulkeyi* of *Anopheles (Anopheles)*.

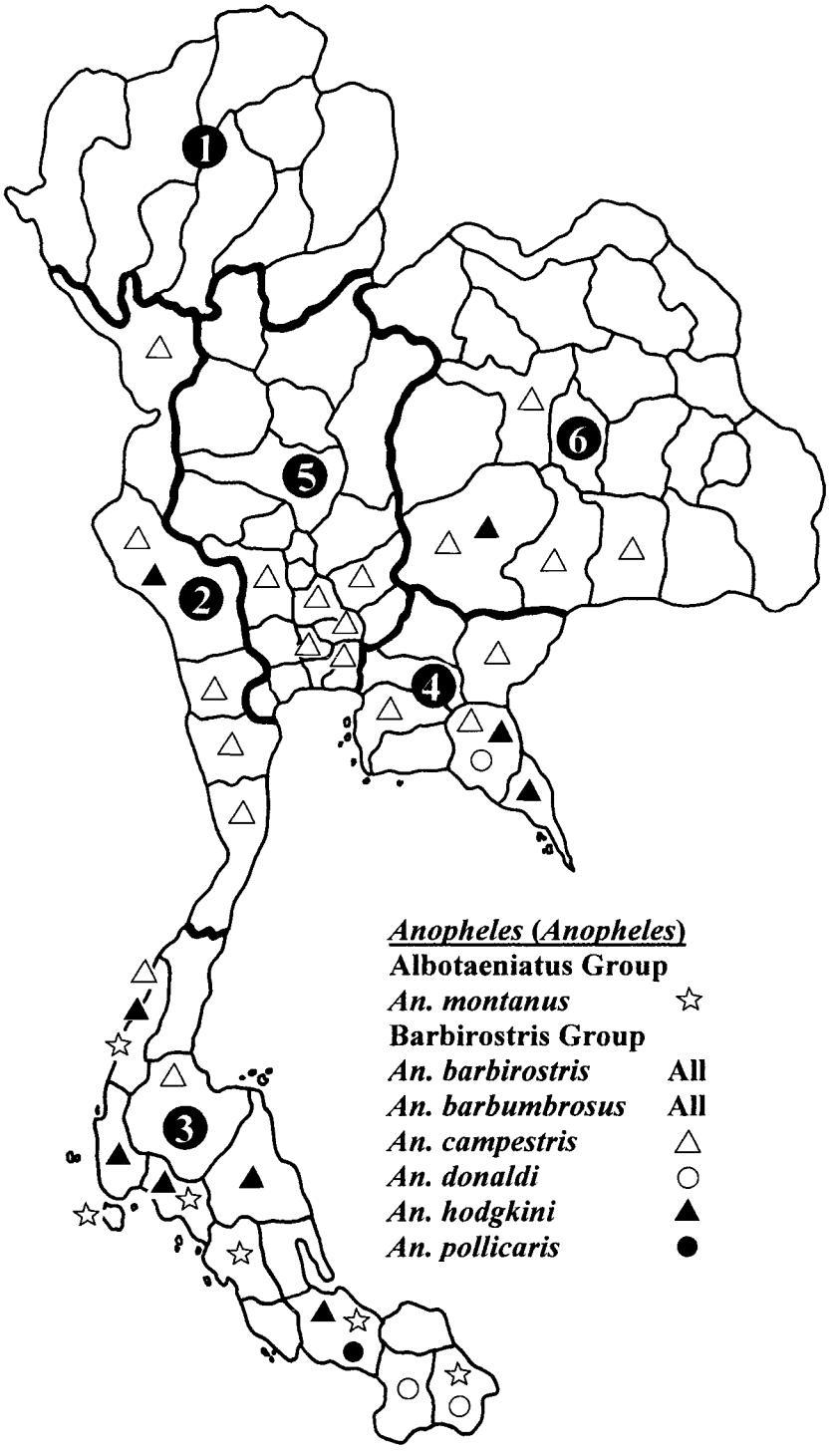


Fig 4–Distributions of Albotaeniatus and Barbiorstris Groups of *Anopheles (Anopheles)*.

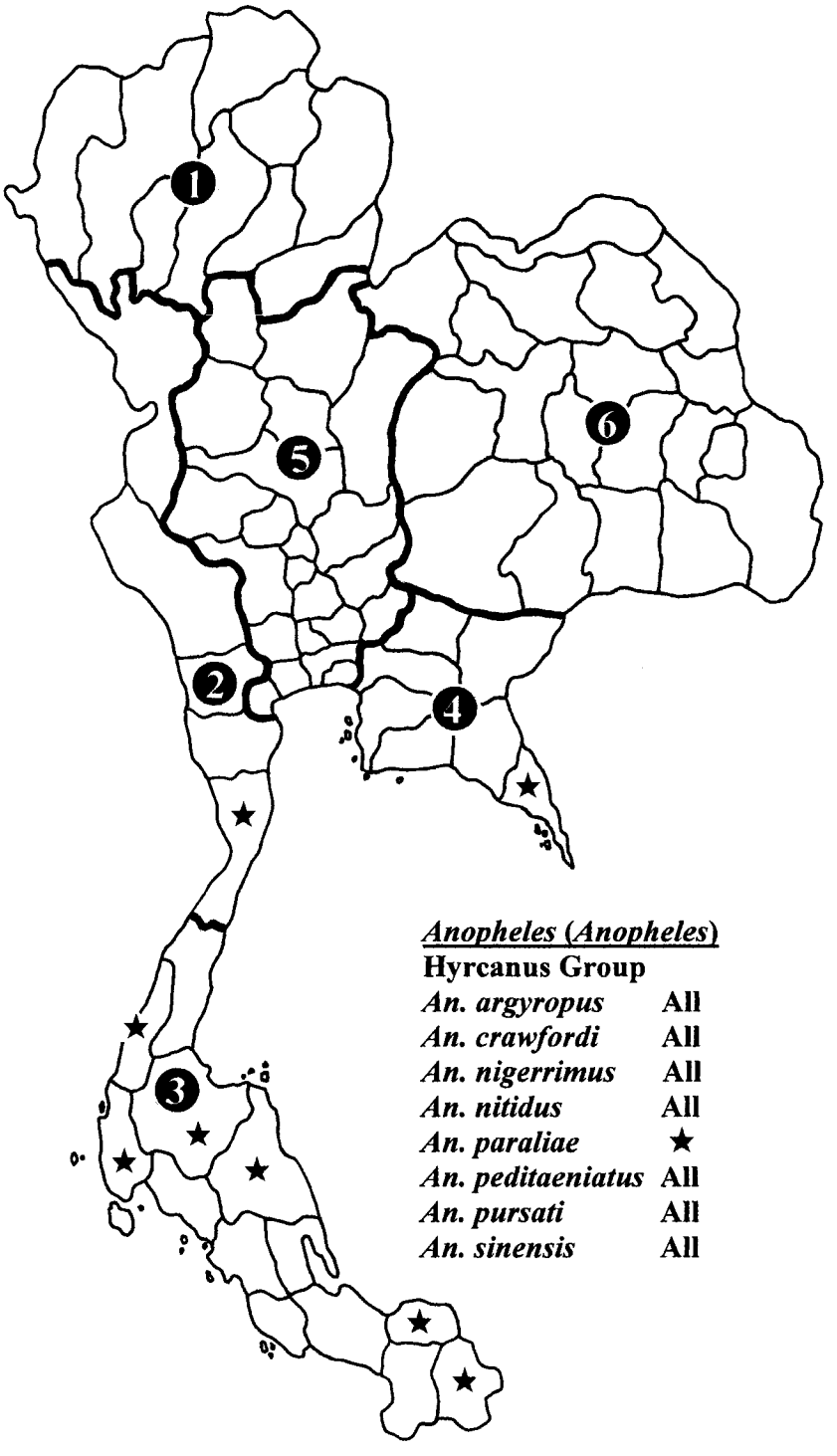


Fig 5–Distributions of Hyrcanus Group of *Anopheles (Anopheles)*.

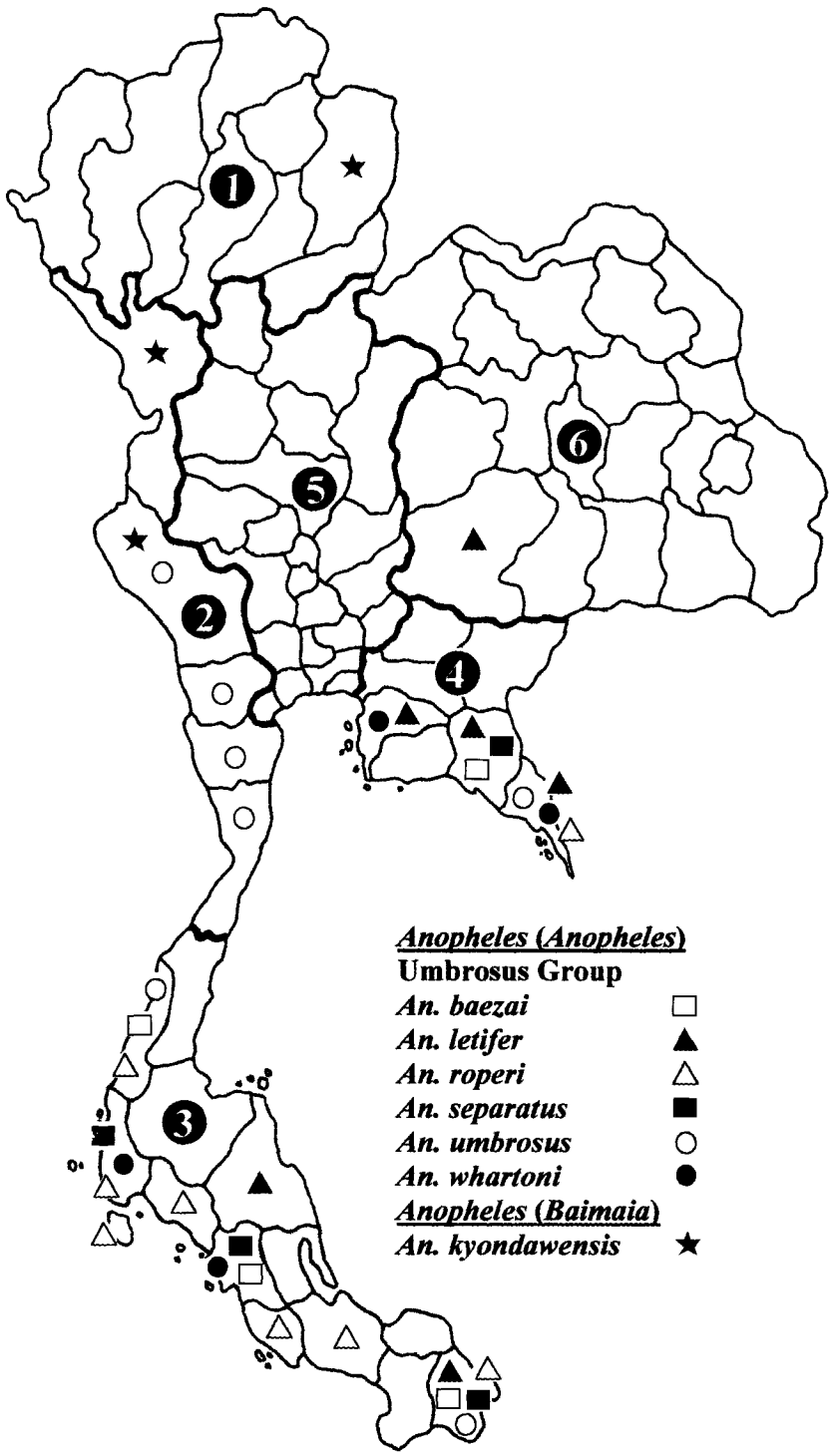


Fig 6–Distributions of Umbrosus Group of *Anopheles (Anopheles)* and *An. kyondawensis* of *Anopheles* (*Baimaia*).

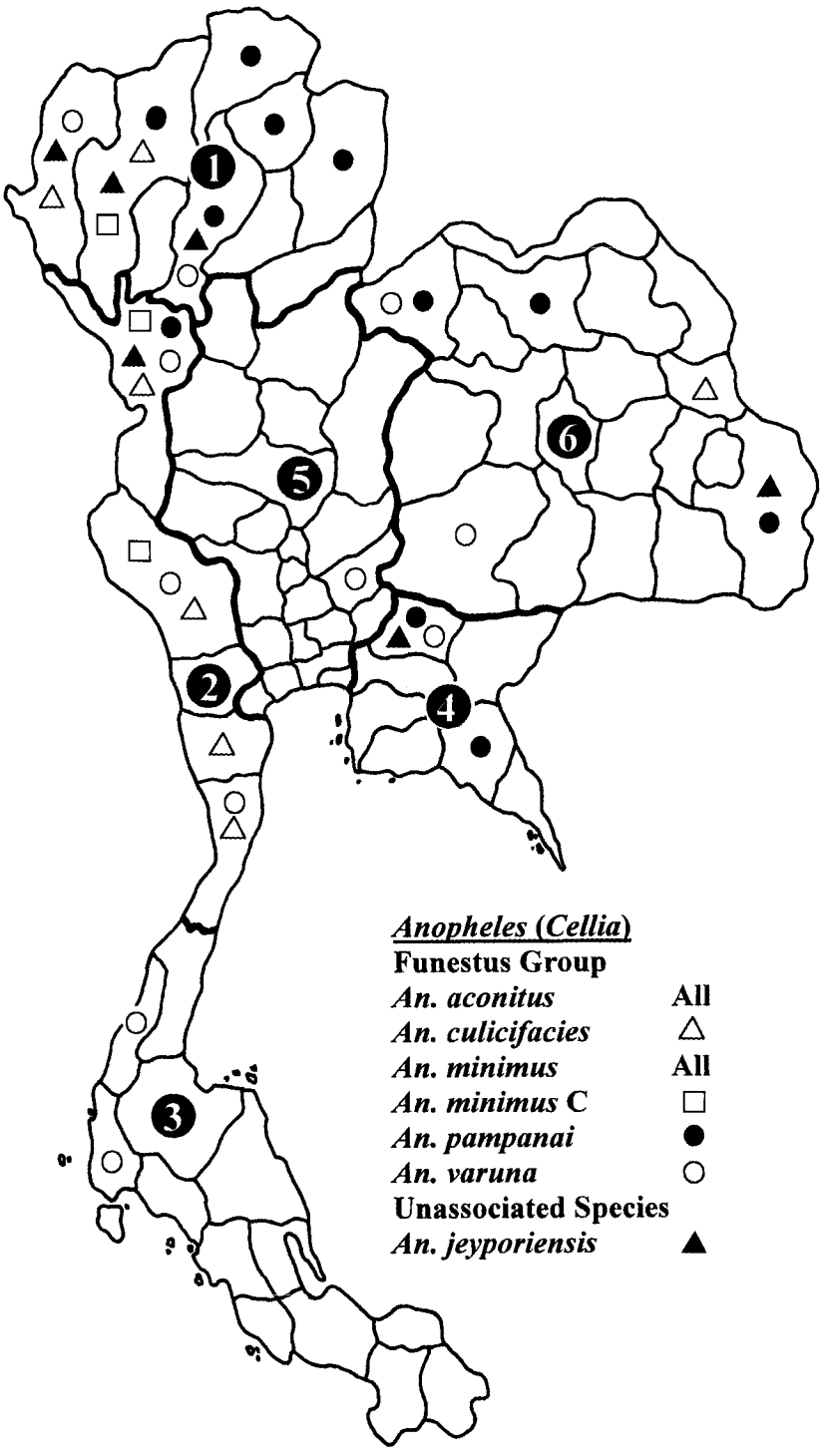


Fig 7–Distributions of Funestus Group and *An. jeyporiensis* of *Anopheles (Cellia).*

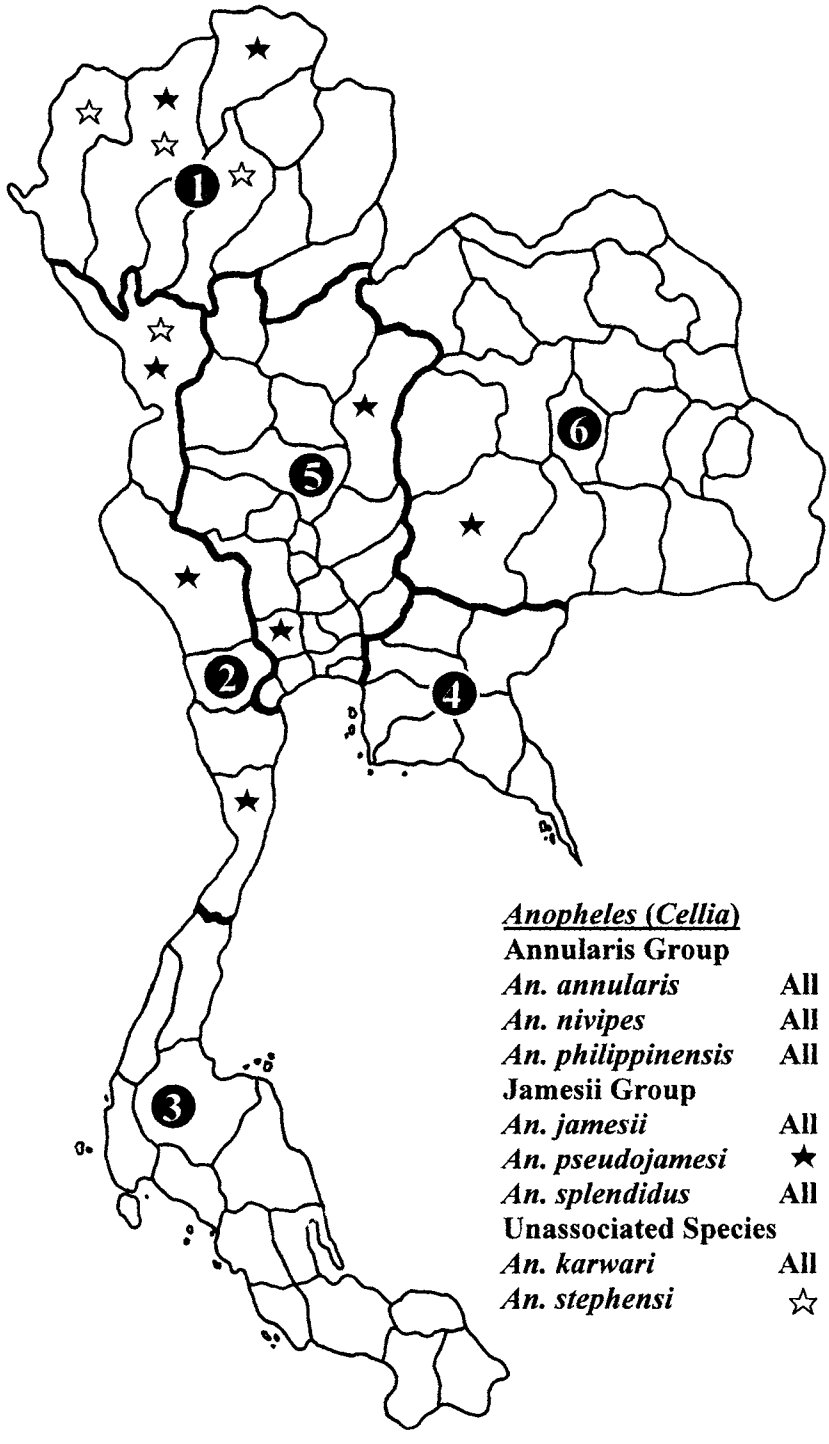
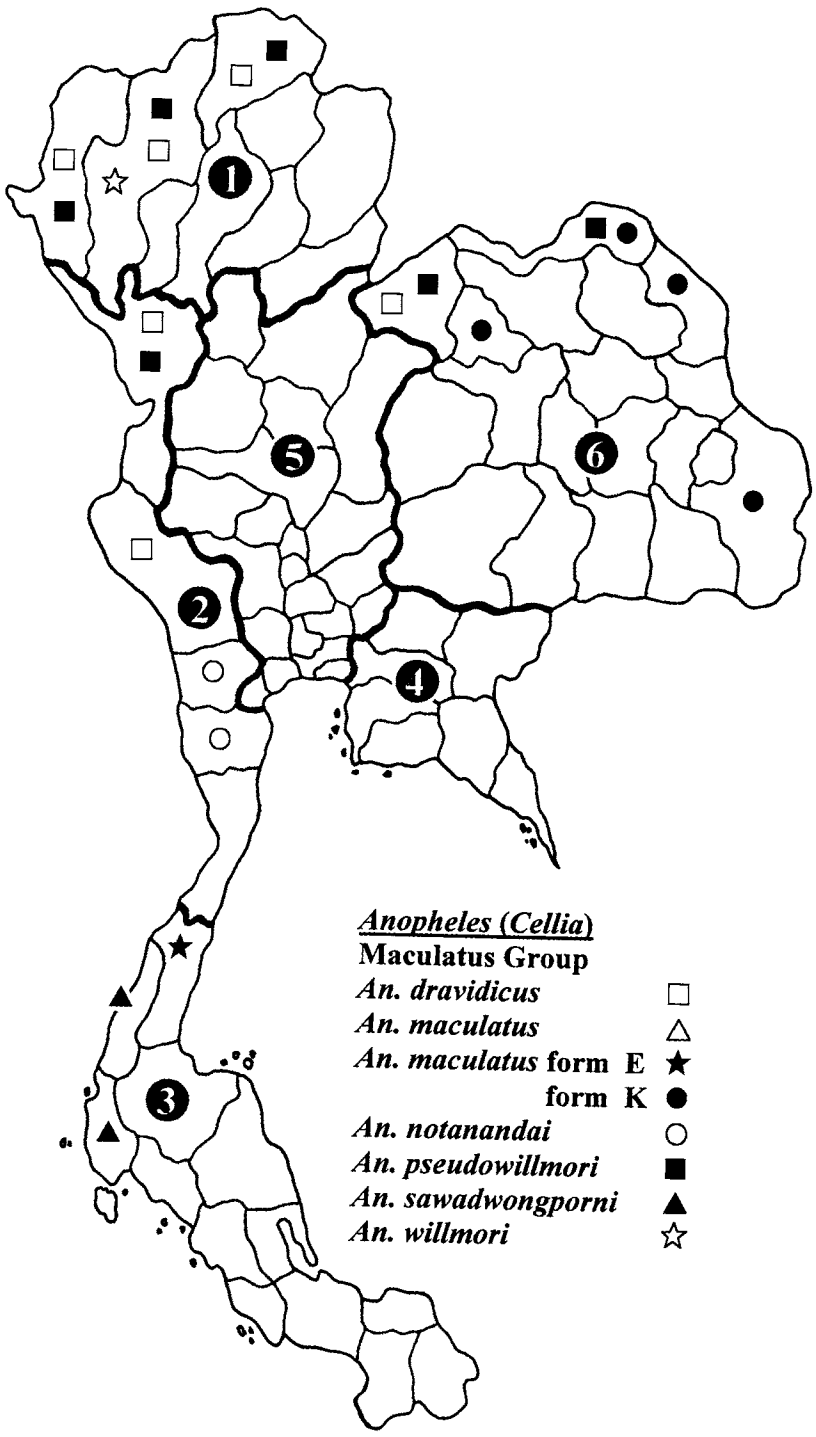


Fig 8–Distributions of Annularis and Jamesii Groups, *An. karwari* and *An. stephensi* of *Anopheles (Cellia)*.



△ **Distributed throughout the country except in the South.**
★ **Distributed only from Chumphon to the South.**
▲ **Distributed through most areas of the country, uncommon in the South.**

Fig 9–Distributions of Maculatus Group of *Anopheles (Cellia)*.

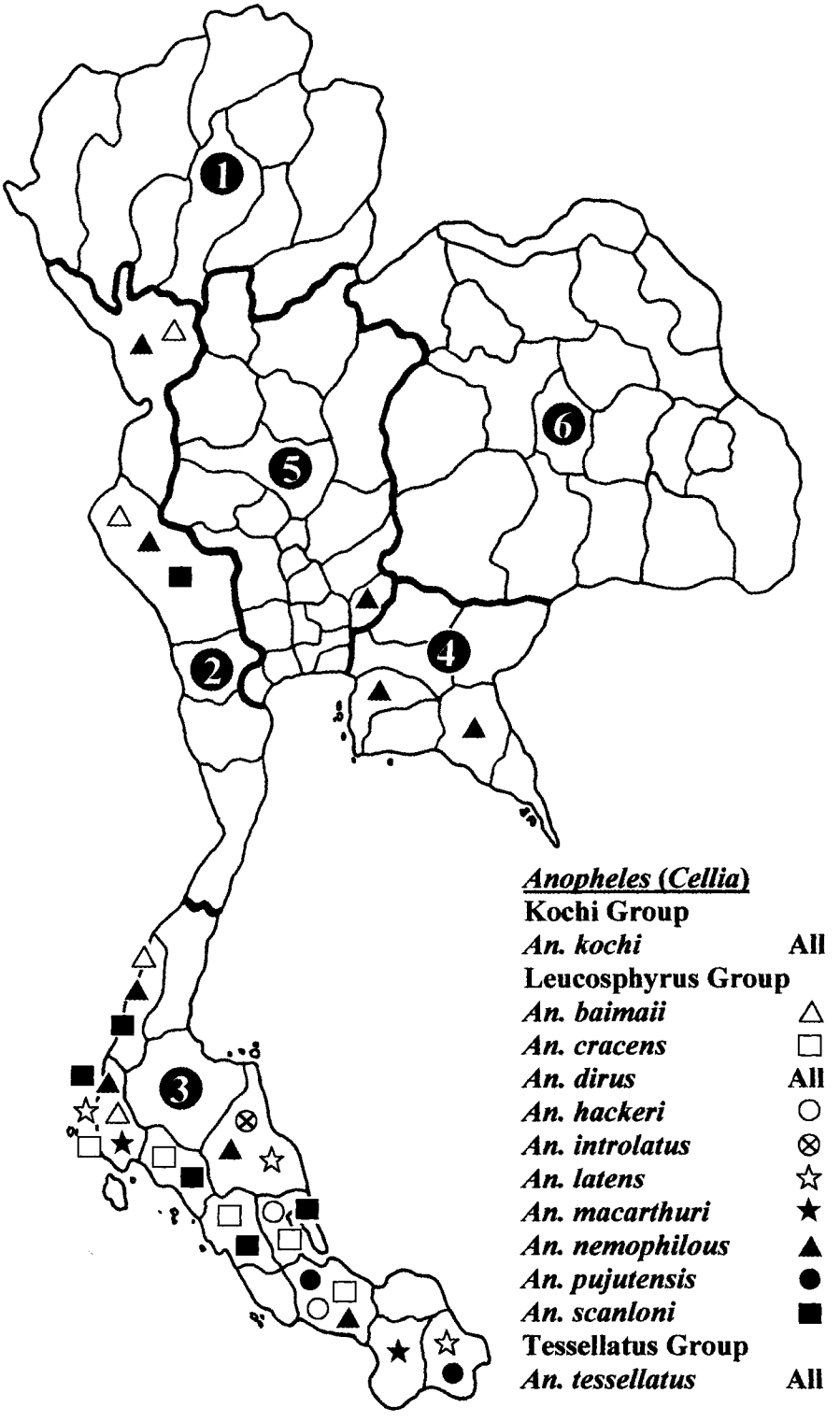


Fig 10–Distributions of Kochi, Leucosphyrus, and Tessellatus Groups of *Anopheles (Cellia)*.

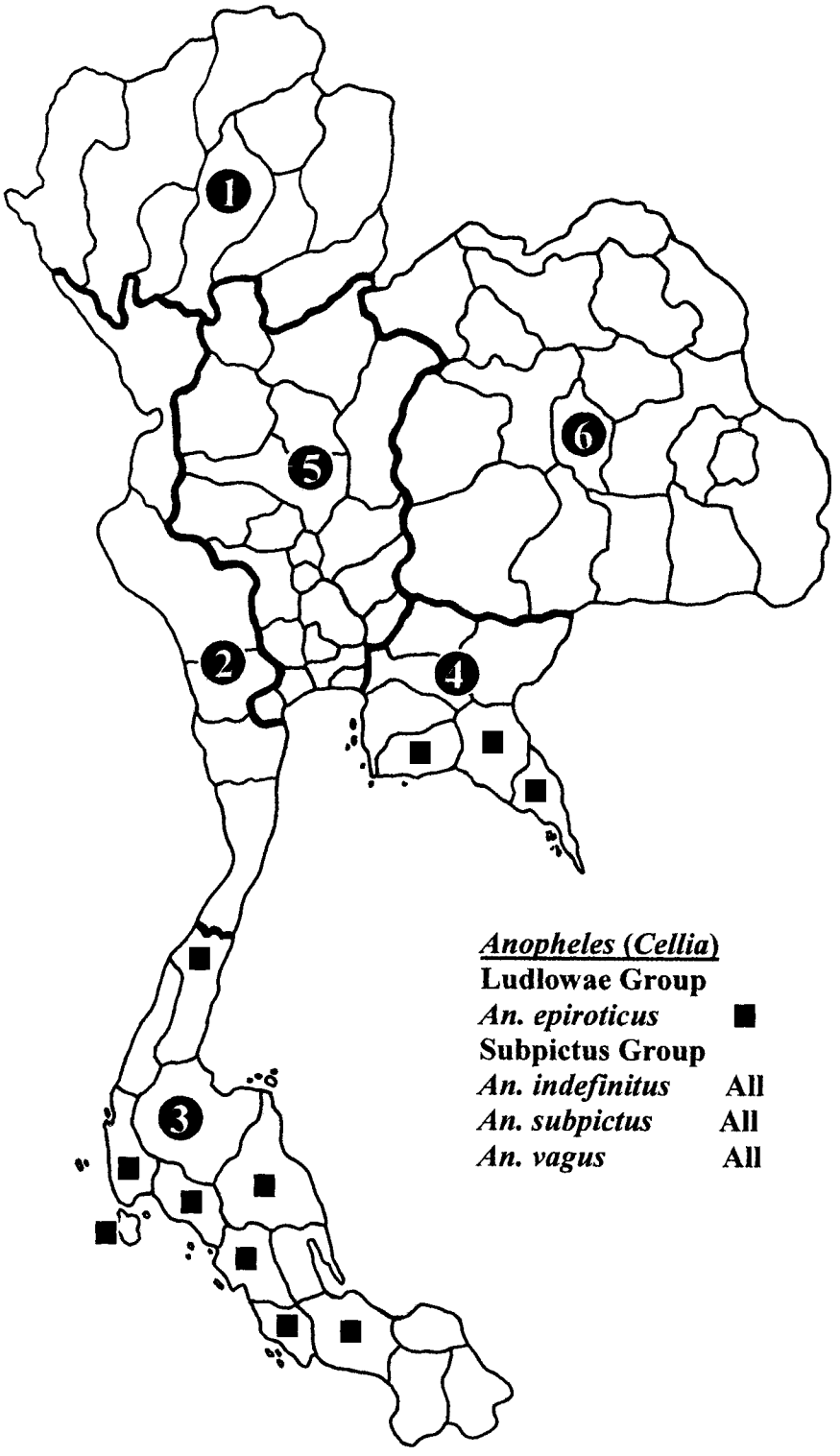


Fig 11–Distributions of Ludlowae and Subpictus Groups of *Anopheles (Cellia)*.

ADULT MORPHOLOGY

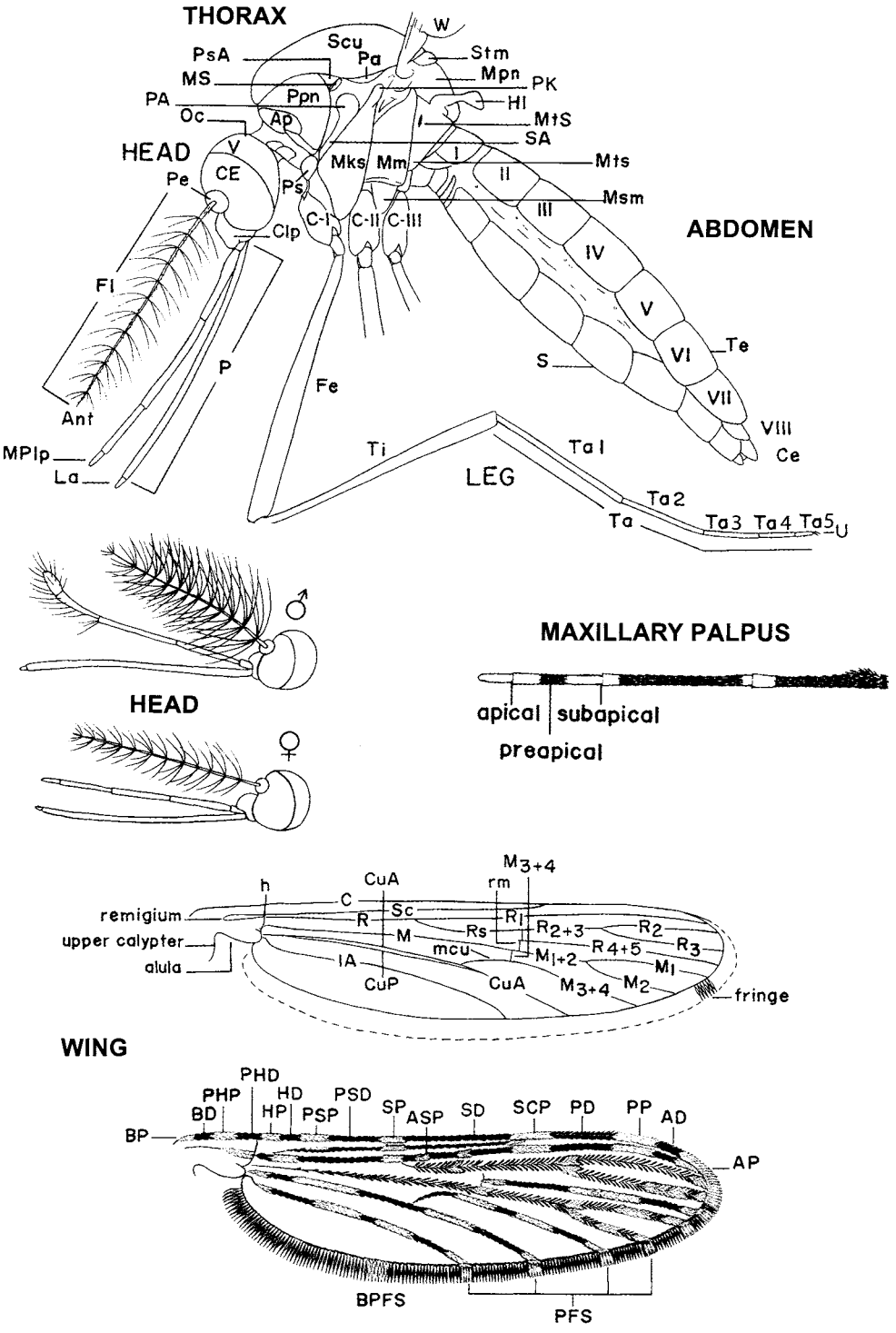


Fig 12

ABBREVIATIONS
ADULT

HEAD

Ant	=	antenna
CE	=	compound eye
Clp	=	clypeus
Fl	=	flagellum
La	=	labellum
MPlp	=	maxillary palpus
Oc	=	occiput
Pe	=	pedicel
P	=	proboscis
V	=	vertex

THORAX

Ap	=	antepronotum
Hl	=	halter
Mks	=	mesokatepisternum
Mm	=	mesepimeron
Mpn	=	mesopostnotum
MS	=	mesothoracic spiracle
Msm	=	mesomeron
MtS	=	metathoracic spiracle
Mts	=	metepisternum
Pa	=	paratergite
PA	=	postspiracular area
PK	=	prealar knob
Ppn	=	postpronotum
Ps	=	proepisternum
PsA	=	prespiracular area
SA	=	subspiracular area
Scu	=	scutum
Stm	=	scutellum
W	=	wing

LEG

C-I	=	forecoxa
C-II	=	midcoxa
C-III	=	hindcoxa
Fe	=	femur
Ta 1-Ta 5	=	tarsomeres 1-5
Ti	=	tibia
U	=	unguis

WING VEINS

C	=	costa
CuA	=	cubitus anterior
CuP	=	cubitus posterior
h	=	humeral crossvein
M	=	media
M_1, M_2, M_{1+2}, M_{3+4}	=	branches of media
mcu	=	mediocubital crossvein
R	=	radius
R_1, R_2, R_3, R_{2+3}, R_{4+5}	=	branches of radius
rm	=	radiomedial crossvein
Rs	=	radial sector
Sc	=	subcosta
1A	=	anal vein

WING SPOTS

AD	=	apical dark
AP	=	apical pale
ASP	=	accessory sector pale
BD	=	basal dark
BP	=	basal pale
BPFS	=	basal pale fringe spot
HD	=	humeral dark
HP	=	humeral pale
PD	=	preapical dark
PFS	=	pale fringe spot
PHD	=	prehumeral dark
PHP	=	prehumeral pale
PP	=	preapical pale
PSD	=	presector dark
PSP	=	presector pale
SCP	=	subcostal pale
SD	=	sector dark
SP	=	sector pale

ABDOMEN

Ce	=	cercus
Te	=	tergum
S	=	sternum
I-VIII	=	abdominal segments

LARVAL MORPHOLOGY

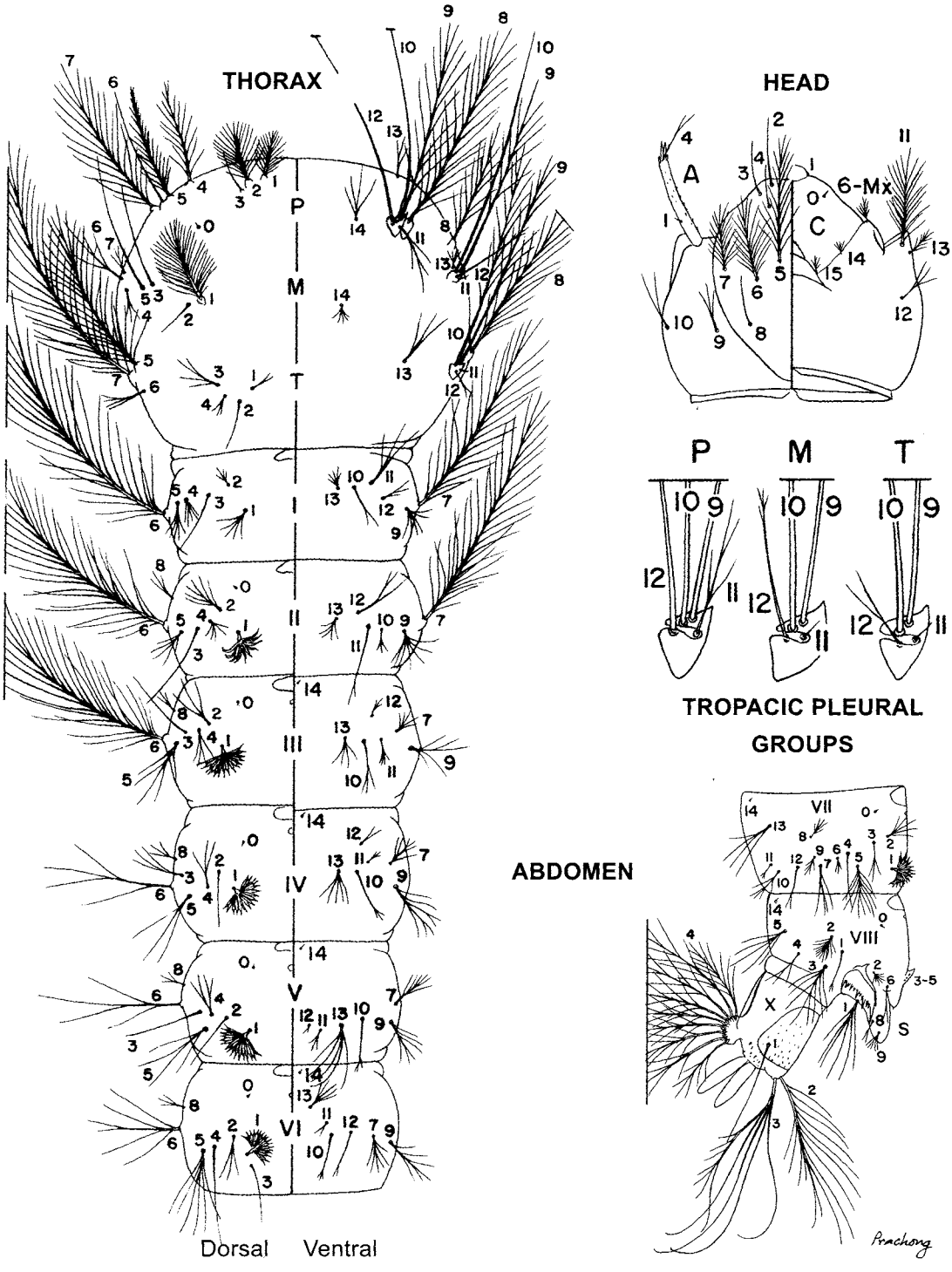


Fig 13

ABBREVIATIONS
LARVA

HEAD

A	=	antenna
C	=	cranium head capsule

THORAX

P	=	prothorax
M	=	mesothorax
T	=	metathorax
1-14	=	setae on designated areas, *e.g.*, seta 1-M, seta 1-T

ABDOMEN

I-VIII, X	=	abdominal segments
S	=	spiracular apparatus
1-14	=	setae on designated areas, *e.g.*, seta 1-I, seta 5-IV

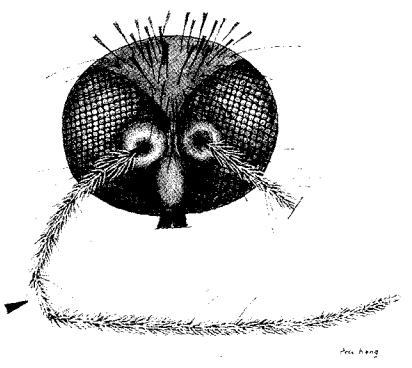
PLATE 1

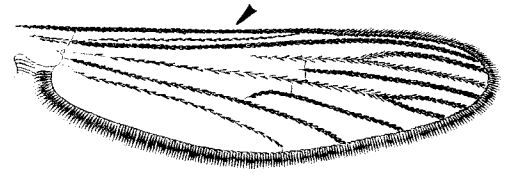
KEY TO THE SUBGENERA OF *ANOPHELES* ADULT FEMALES

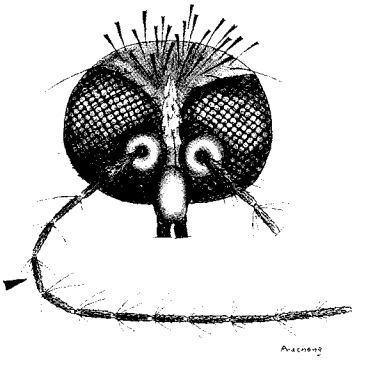
Characters: Scutellum evenly rounded; maxillary palpus approximately same length as proboscis

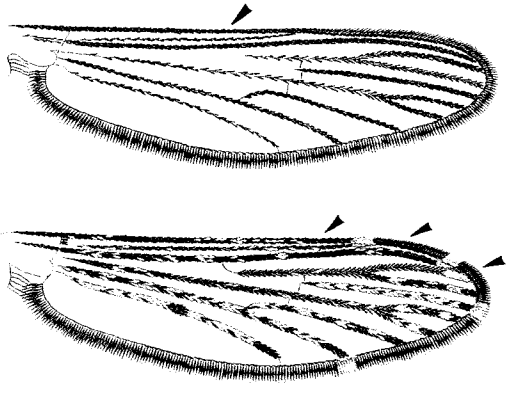
1. Antennal flagellomeres with dense covering of long pale sensilla between whorls that provide fuzzy appearance
2. Wing entirely dark-scaled

1. Antennal flagellomeres with or without sparse covering of long pale sensillae between whorls, without dense covering of long pale sensillae
2. Wing entirely dark or spotted with pale and dark marks









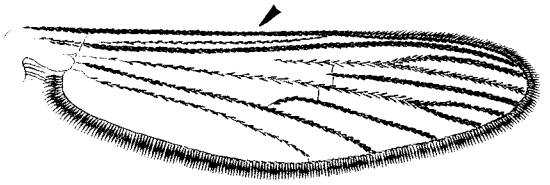
Subgenus *Baimaia*
An. kyondawensis

To PLATE 2

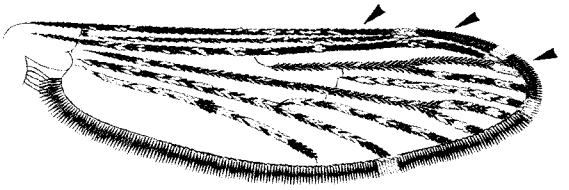
PLATE 2

From PLATE 1: Antennal flagellomeres with or without sparse covering of long pale sensillae between whorls, without dense covering of long pale sensillae; wing entirely dark or spotted with pale and dark marks

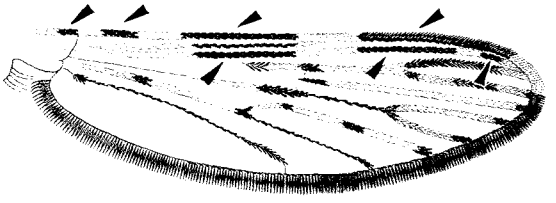
- Wing entirely dark- scaled (Aitkenii and Culiciformis Groups) **or**



- Wing with 3 dark marks involving both costa and veins R-R_1 (Albotaeniatus, Asiaticus, Barbirostris, Hyrcanus, Umbrosus Groups, and *An. bulkleyi*) **or**

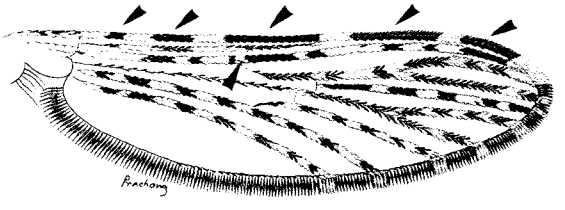


- Wing with 4 dark marks on costa but veins R-$R_1$with not more than 3 dark areas, accessory sector pale (ASP) spot absent (Lindesayi Group)



Subgenus *Anopheles* → To PLATE 3

- Wing with 4 or more dark marks involving both costa and veins R-R_1, accessory sector pale (ASP) spot present on costa and/or subcosta, **and/or** R_1



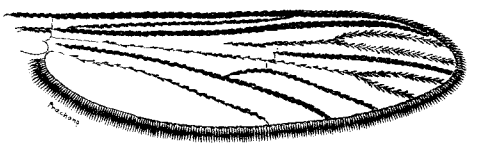
Subgenus *Cellia* → To PLATE 19

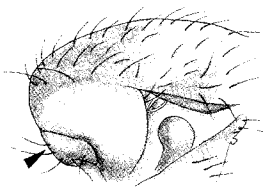
PLATE 3

KEY TO THE SERIES AND THE SPECIES GROUPS OF SUBGENUS *ANOPHELES* ADULT FEMALES

From PLATE 2: Wing entirely dark-scaled, with 3 dark marks involving both costa and veins R-R_1, or with 4 dark marks on costa, but veins R-R_1 with not more than 3 dark areas, accessary sector pale (ASP) spot absent

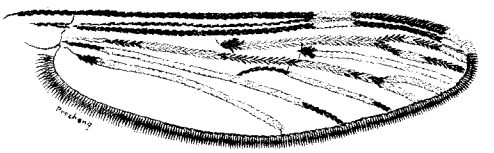
1. Wing scales all dark
2. Antepronotal lobe without scales





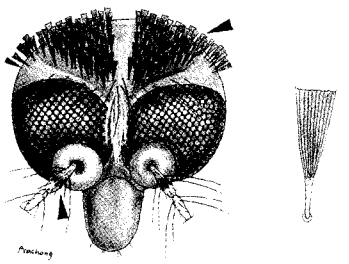
Anopheles Series (in part)

1. Wing with pale and dark scales
2. Antepronotal lobe with scales



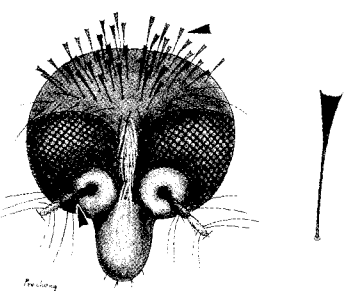
To PLATE 4

1. Erect head scales widely expanded apically
2. Antennal flagellomere 1 with dark scales



Culiciformis Group
An. sintonoides

1. Erect head scales long and narrow, only slightly expanded apically
2. Antennal flagellomere 1 with or without scales



Aitkenii Group[a]

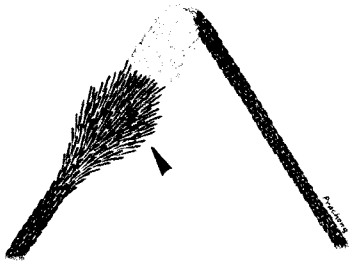
To PLATE 8

[a]*Anopheles aberrans*, *An. bengalensis*, *An. fragilis*, *An. insulaeflorum*, *An. palmatus*, *An. stricklandi*, and *An. tigertti*.

PLATE 4

From PLATE 3: Wing with pale and dark scales; antepronotal lobe with scales

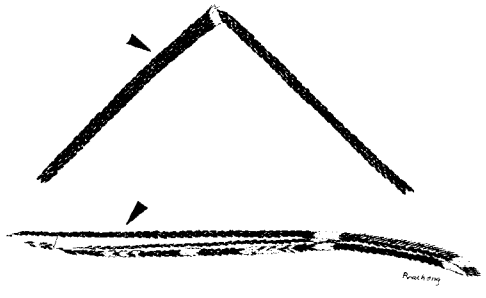
Legs with tuft of dark scales on hindfemur or on tarsomeres of mid- and hindleg



Lophoscelomyia Series
Asiaticus Group and *An.bulkleyi*
(unassociated species)

→ To PLATE 5

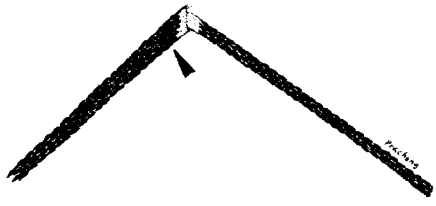
1. Hindfemur without distal broad preapical white band
2. Costa without presector pale (PSP) spot



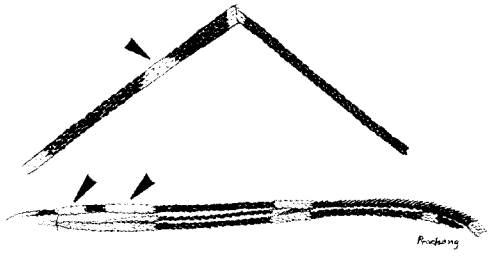
Myzorhynchus Series[a]

→ To PLATE 6

Legs without tuft of dark scales on hindfemur or on tarsomeres of mid- and hindleg



1. Hindfemur with distal broad preapical white band **or**
2. Costa with presector pale (PSP) and humeral pale (HP) spots



Anopheles Series (in part)
Lindesayi Group

→ To PLATE 7

[a]Albotaeniatus, Barbirostris, Hyrcanus, and Umbrosus Groups.

PLATE 5

KEY TO THE SPECIES OF THE LOPHOSCELOMYIA SERIES ADULT FEMALES

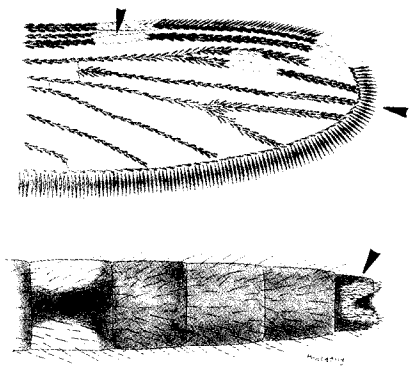
From PLATE 4: Legs with tuft of dark scales on hindfemur or on tarsomeres of mid-and hindlegs

Legs with clusters of erect dark scales on tarsomere 2 of midleg and tarsomeres 1 and 2 of hindleg

No specimens available

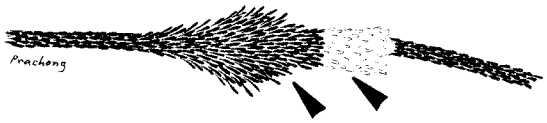
An. bulkleyi[a]
(Unassociated species)

1. Wing apex without pale fringe spot at vein R_{4+5}
2. Subcostal pale (SCP) spot of costa extending onto vein R_1
3. Abdominal tergum VIII with pale golden scales



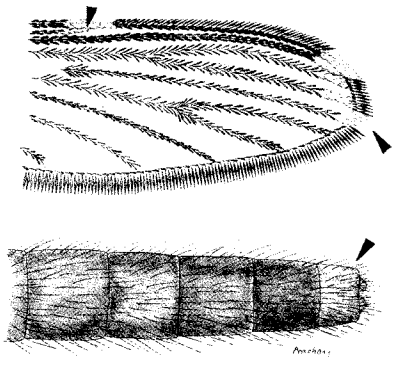
An. asiaticus

Legs with erect scales only on hindfemur, as prominent tuft of scales on apical 0.25- 0.33 (black proximally and white distally)



Asiaticus Group

1. Wing apex with narrow pale fringe spot at vein R_{4+5}
2. Subcostal pale (SCP) spot, when present, confined to costa and tip of subcosta
3. Abdominal tergum VIII without pale scales



An. interruptus

[a]Only known from a single male (type specimen) which was lost.

PLATE 6

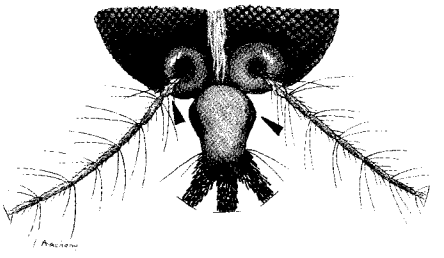
From PLATE 4: Hindfemur without distal broad preapical white band; costa without presector pale (PSP) spot

1. Clypeus with patch of dark scales on each side
2. Basal 4-8 antennal flagellomeres with pale scales

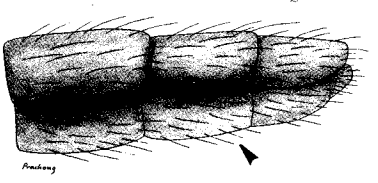
Hyrcanus Group[a]

→ To PLATE 15

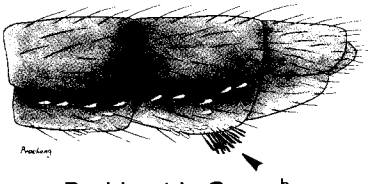
1. Clypeus without patch of dark scales
2. Only antennal flagellomere 1 with pale scales



Sternum VII without tuft of black scales



Sternum VII with tuft of black scales



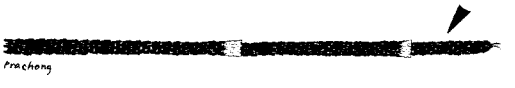
Barbirostris Group[b]

→ To PLATE 12

Hindtarsomere 5 all white

Albotaeniatus Group
An. montanus

Hindtarsomere 5 dark-scaled



Umbrosus Group[c]

→ To PLATE 9

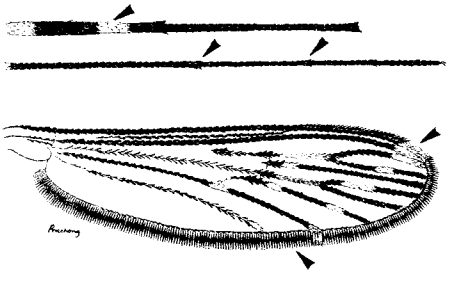
[a] *Anopheles argyropus* A and B, *An. crawfordi* A and B, *An. nigerrimus* A and B, *An. nitidus*, *An. paraliae*, *An. peditaeniatus*, *An. pursati*, and *An. sinensis* A and B.
[b] *Anopheles barbirostris* A, B, and C, *An. barbumbrosus*, *An. campestris*, *An. donaldi*, *An. hodgkini*, and *An. pollicaris*.
[c] *Anopheles baezai*, *An. letifer*, *An. roperi*, *An. separatus*, *An. umbrosus*, and *An. whartoni*.

PLATE 7

KEY TO THE SPECIES OF THE LINDESAYI GROUP ADULT FEMALES

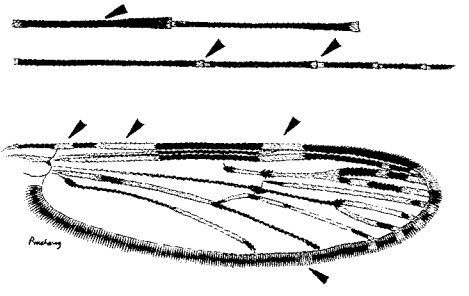
From PLATE 4: Hindfemur with distal broad preapical white band or costa with presector pale (PSP) and humeral pale (HP) spots

1. Hindfemur with broad preapical pale band, tarsi all dark
2. Costa with not more than 2 pale spots, apical pale (AP) **and/or** subcostal pale (SCP) spots
3. Wing usually without pale fringe spot between veins CuA and vein 1A



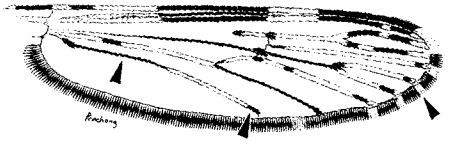
Lindesayi Subgroup
An. lindesayi cameronensis

1. Hindfemur without broad preapical pale band, tarsi with pale bands
2. Costa with 3 or more pale spots including presector pale (PSP) and humeral pale (HP) spots
3. Wing usually with pale fringe spot between veins CuA and vein 1A[a]



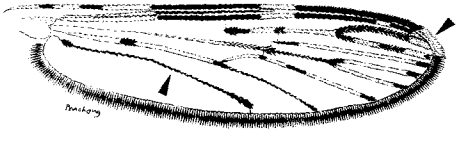
Gigas Subgroup

1. Wing margin with pale fringe spots at veins R_1,R_2, R_{4+5}, M_1, M_2, and M_{3+4}
2. Vein 1A with two dark spots (long spot at base and short spot at apex)



n. sp. near *An. gigas* [b]

1. Wing margin with pale fringe spots at vein R_1 and R_2
2. Vein 1A entirely dark



An. baileyi [c]

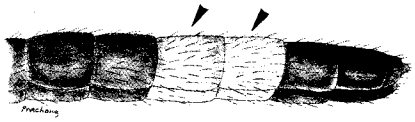
[a]This character is difficult to see on some specimens.
[b]This species found on top of a mountain, Phu Kra Dung, Loei Province.
[c]This species found on top of a mountain, Doi Inthanon, Chiang Mai Province.

PLATE 8

KEY TO THE SPECIES OF THE AITKENII GROUP ADULT FEMALES

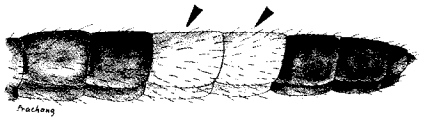
From PLATE 3: Erect head scales long and narrow, only slightly expanded apically; antennal flagellomere 1with or without scales

Abdominal segments IV or IV and V distinctly paler than other segments



All abdominal segments unicolorous

Abdominal segments IV and V pale

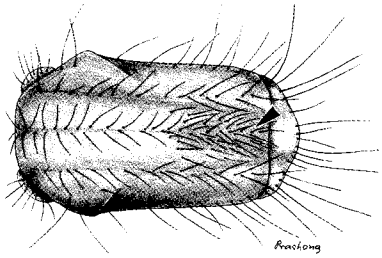


An. aberrans (in part, 75%)

Only abdominal segment IV pale

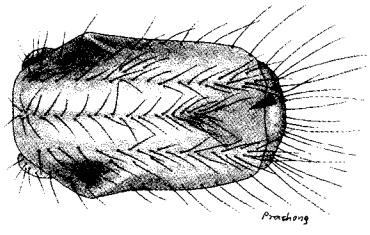
An. palmatus (in part, 75%)

Prescutellar space with short fine setae reaching scutellum



An. insulaeflorum

Prescutellar space with distinct median bare area immediately cephalad of scutellum



An. aberrans (in part, 25 %), *An. bengalensis, An. fragilis*, *An. palmatus* (in part, 25%), *An. stricklandi*, and *An. tigertti*

PLATE 9

KEY TO THE SPECIES OF THE UMBROSUS GROUP ADULT FEMALES

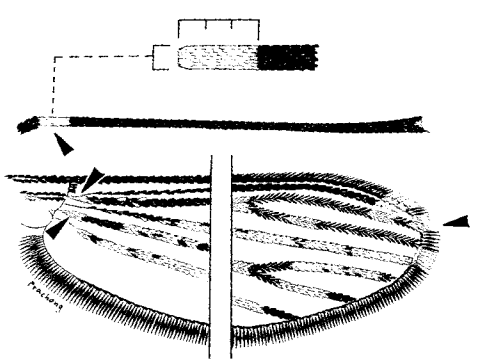
From PLATE 6: Hindtarsomere 5 dark-scaled

Palpus with pale bands, apical segment usually entirely pale-scaled

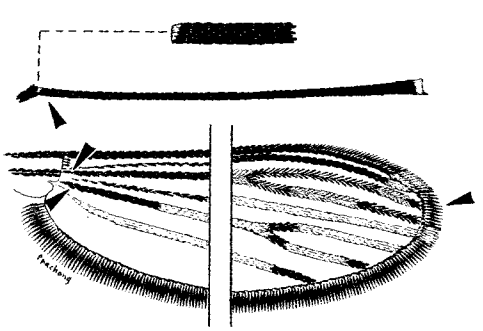
Palpus entirely dark-scaled

An. separatus

1. Base of hindtibia with distinct pale band, usually 1.5-4.0 times as long as segment width
2. Base of veins R and CuA usually with scattered pale scales
3. Wing apex with 3 pale fringe spots, middle pale fringe spot at vein R_2



1. Base of hindtibia dark-scaled or with small pale spot
2. Base of veins R and CuA with dark scales
3. Wing apex with 2 pale fringe spots, without pale fringe spot at vein R_2



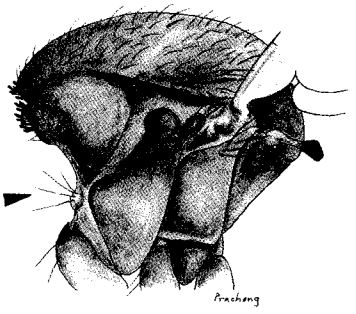
An. roperi

To PLATE 10

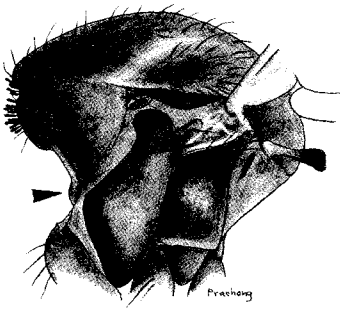
PLATE 10

From PLATE 9: Base of hindtibia dark-scaled or with small pale spot; base of veins R and CuA with dark scales; wing apex with 2 pale fringe spots, without pale fringe spot at vein R_2.

Upper proepisternal setae present on both sides (1-6)

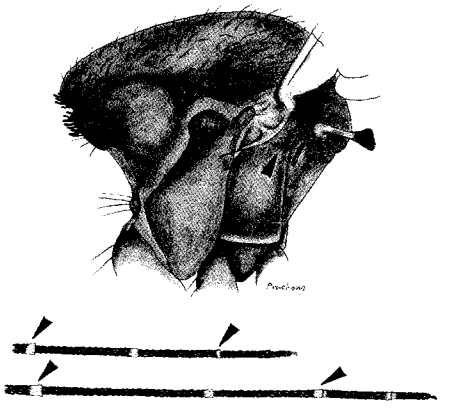


Upper proepisternal setae absent on both sides (rarely with one small seta on one side)



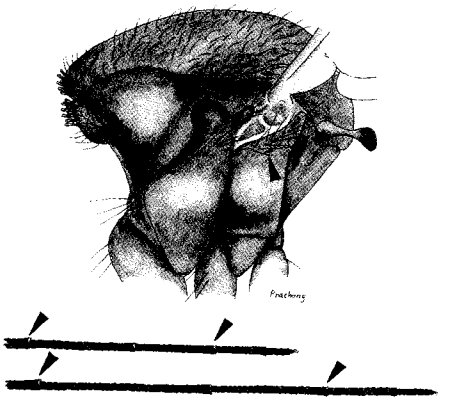
→ To PLATE 11

1. Upper mesepimeron with 1-6 setae and no associated scales
2. Fore- and hindtarsomeres with small apical pale bands



An. umbrosus

1. Upper mesepimeron with 9-19 setae and a few inconspicuous dark scales
2. Fore- and hindtarsomeres all dark or with minute apical dorsal spots at joints

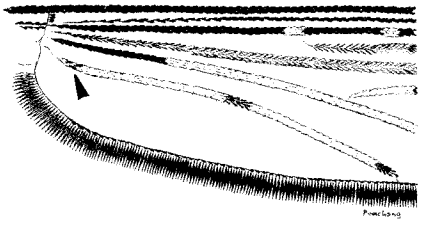


An. baezai

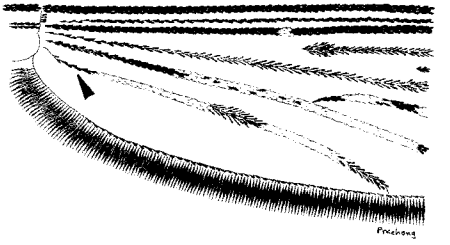
PLATE 11

From PLATE 10: Upper proepisternal setae absent on both sides (rarely with one small seta on one side)

Vein 1A with pale scales proximal to median dark mark, or infrequently with 2 or 3 dark scales near base	Vein 1A with 5 or more dark scales at base, or base infrequently nearly all dark-scaled



An. letifer



An. whartoni

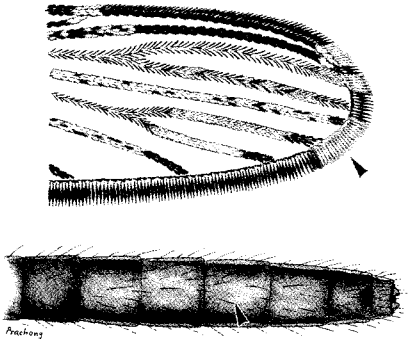
PLATE 12

KEY TO THE SPECIES OF THE BARBIROSTRIS GROUP ADULT FEMALES

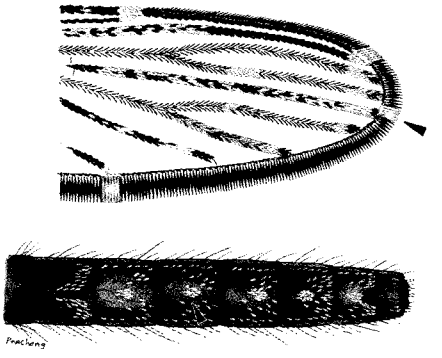
From PLATE 6: Sternum VII with tuft of black scales

1. Wing with broad pale apical fringe spot extending at least from vein R_{4+5} to vein M_1
2. Abdominal sterna without pale scales[a]

1. Wing with narrow pale apical fringe spot at vein R_{4+5}
2. Abdominal sterna with pale scales

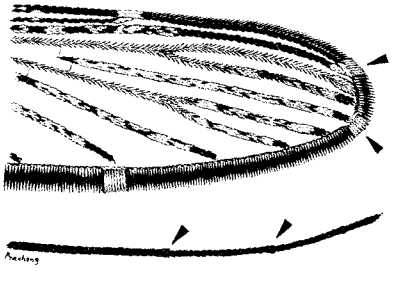


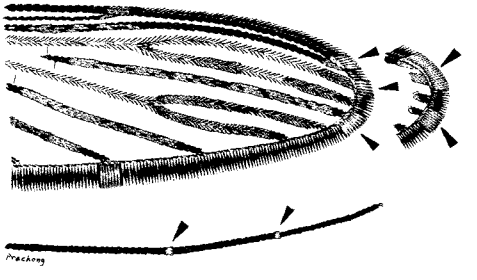
An. barbumbrosus



1. Wing apex with only 2 narrow pale fringe spots, no pale spot at vein R_2
2. Midtarsomeres usually unbanded

1. Wing apex with 3 narrow pale fringe spots, middle spot at vein R_2, or with only 2 pale fringe spots, but upper spot wide with pale scales to include vein R_2
2. Midtarsomeres usually with narrow apical pale bands





→ To PLATE 13 (Above)

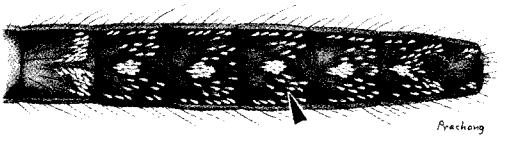
→ To PLATE 13 (Below)

[a] One or two pale scales are rarely found on sternum III.

PLATE 13

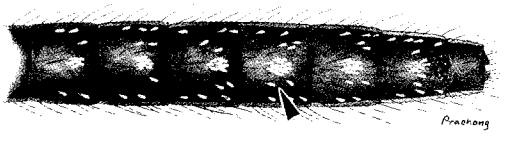
From PLATE 12: Wing apex with only 2 narrow pale fringe spots, no pale fringe spot at vein R_2; midtarsomeres usually unbanded

Abdominal sterna with many white scales scattered between median patch and lateral rows



An. campestris[a]

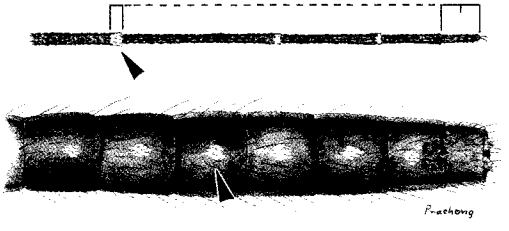
Abdominal sterna with few scattered white scales between median patch and lateral rows



An. barbirostris[a]
(A, B, and C)

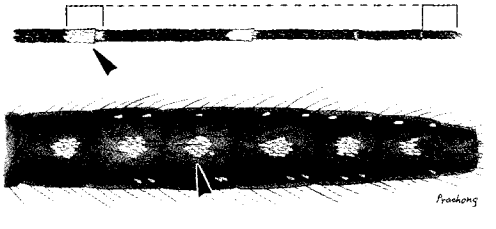
From PLATE 12: Wing apex with 3 narrow pale fringe spots, middle spot at vein R_2, or with only 2 pale fringe spots, but upper spot wide with pale scales to include vein R_2; midtarsomeres usually with narrow apical pale bands

1. First foretarsal pale band short, 0.5 or less as long as tarsomere 5, rarely crossing joint onto tarsomere 2
2. Usually 0-20 median pale scales on abdominal sterna II-VI



An. hodgkini

1. First foretarsal pale band long, more than 0.5 as long as tarsomere 5, usually crossing joint onto tarsomere 2
2. More than 20 median pale scales on abdominal sterna II-VI



To PLATE 14

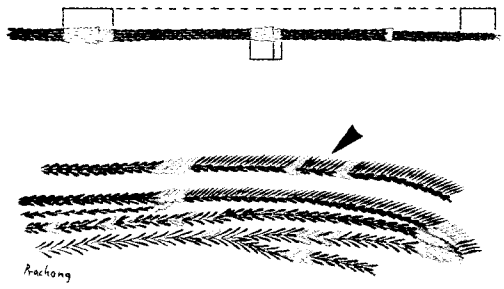
[a]Associated larval and pupal exuviae are best used to identify adult females of these species.

PLATE 14

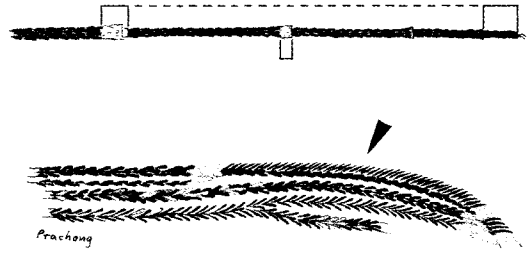
From PLATE 13: First foretarsal pale band long, more than 0.5 as long as tarsomere 5, usually crossing joint onto tarsomere 2; more than 20 median pale scales on abdominal sterna II-VI

1. First pale band of foretarsus longer than tarsomere 5
2. Second pale band of foretarsus extends onto base of tarsomere 3
3. Costa often with dark scales on preapical pale (PP)

1. First pale band of foretarsus seldom longer than tarsomere 5
2. Second pale band of foretarsus rarely extends onto base of tarsomere 3
3. Costa without preapical pale (PP)



An. pollicaris



An. donaldi

PLATE 15

KEY TO THE SPECIES OF THE HYRCANUS GROUP
ADULT FEMALES

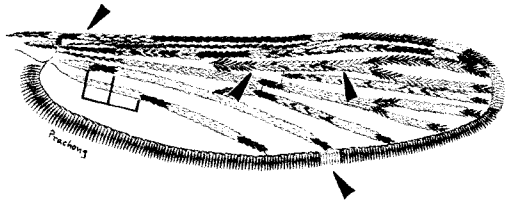
From PLATE 6: Clypeus with patch of dark scales on each side; basal 4-8 antennal flagellomeres with pale scales

Hindtarsomeres with basal and apical pale bands, at least one tarsomere (4) with basal pale band or patch

Hindtarsomeres with apical pale bands only

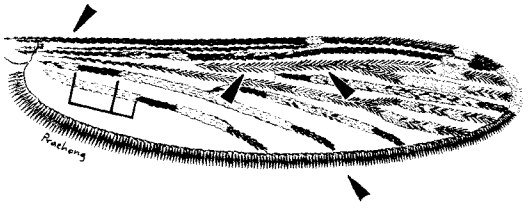
To PLATE 17

1. Basal dark mark[a] on vein CuA short, separated by own length or more from upper dark mark on vein 1A
2. Base of costa just distal to humeral crossvein with scattered pale scales, frequently with small humeral pale (HP) spot
3. Dark mark at origin of vein R_S well defined, scales between dark mark and fork mostly white
4. Vein CuA with pale fringe spot



An. nitidus

1. Basal dark mark[a] on vein CuA long, approaching within own length or less of upper dark mark on vein 1A
2. Base of costa just distal to humeral crossvein dark scaled, or with few scattered pale scales, no humeral pale (HP) spot
3. Dark mark at origin of vein R_S poorly defined, scales between dark mark and fork mostly dark
4. Vein CuA with or without pale fringe spot



To PLATE 16

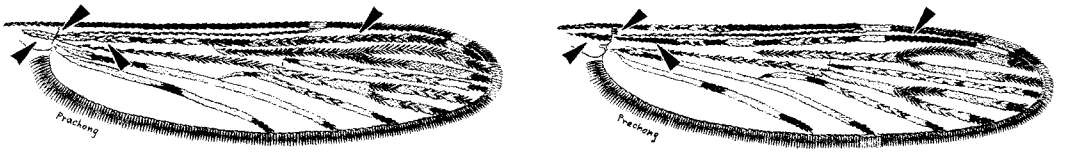
[a]Vein CuA sometimes with several dark scales at very base and then pale scales followed by "short" basal dark mark.

PLATE 16

From PLATE 15: Basal dark mark on vein CuA long, approaching within own length or less of upper dark mark on vein 1A; base of costa just distal to humeral crossvein dark scaled, or with few scattered pale scales, no humeral pale (HP) spot; dark mark at origin of vein R_S poorly defined, scales between dark mark and fork mostly dark; vein CuA with or without pale fringe spot

1. Humeral crossvein without scales
2. Remigium mostly pale-scaled
3. Basal 0.33 and preapical dark (PD) mark on vein R-R_1 usually with many pale scales

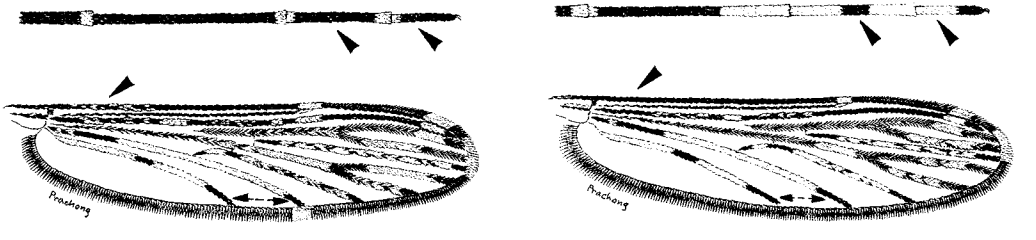
1. Humeral crossvein with patch of dark scales
2. Remigium mostly dark-scaled
3. Basal 0.33 and preapical dark (PD) mark on vein R-R_1 dark-scaled, or with very few pale scales



An. peditaeniatus

1. Hindtarsomere 4 with broad dark band, at least 0.6 length of segment
2. Hindtarsomere 5 with or without very narrow basal pale band (0.25 or less of segment)
3. Costa just distal to humeral crossvein usually with several scattered pale scales
4. Apical dark mark on vein CuA short, rarely as long as apical dark mark on vein 1A

1. Hindtarsomere 4 with narrow dark band, 0.5 or less length of segment
2. Hindtarsomere 5 with basal pale band on 0.6 or more of segment
3. Costa just distal to humeral crossvein usually without pale scales
4. Apical dark mark on vein CuA long, usually as long as apical dark mark on vein 1A



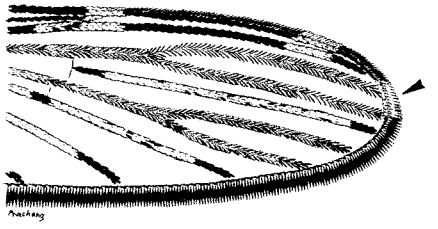
An. nigerrimus
(A and B in part)

An. argyropus
(A and B)

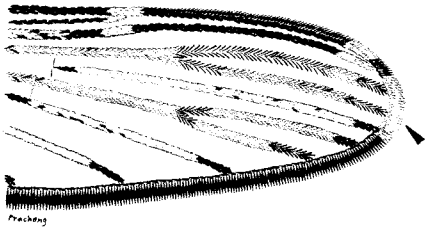
PLATE 17

From PLATE 15: Hindtarsomeres with apical pale bands only

Wing apex with narrow pale fringe spot, not extending beyond veins R_1 to R_3

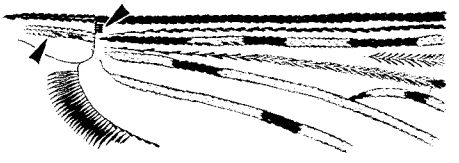


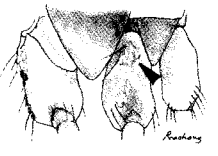
Wing apex with wide pale fringe spot, extending at least from vein R_2 to R_{4+5}



To PLATE 18

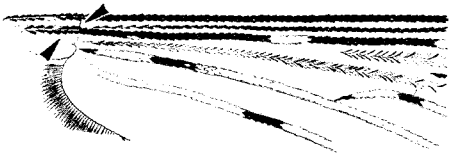
1. Humeral crossvein with dark scales
2. Remigium mostly pale-scaled
3. Midcoxa with pale scales

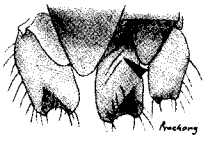




An. pursati

1. Humeral crossvein without scales
2. Remigium mostly dark-scaled
3. Midcoxa without pale scales



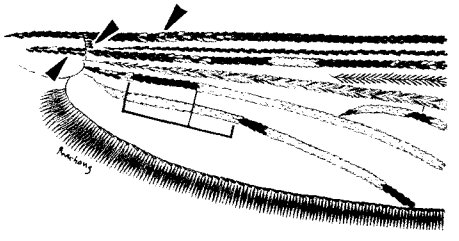


An. paraliae

PLATE 18

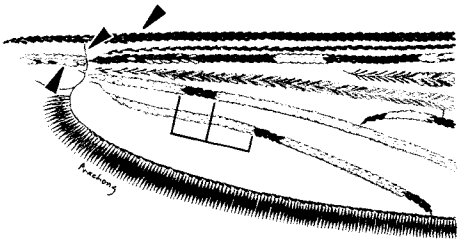
From PLATE 17: Wing apex with wide pale fringe spot, extending at least from vein R_2 to R_{4+5}

1. Vein CuA with long basal dark mark, at least twice as long as most basal pale mark on vein CuA, and approaching within own length or less of upper dark mark on vein 1A
2. Costa usually with several scattered pale-scales on basal 0.33 just distal to humeral crossvein
3. Remigium mostly dark-scaled
4. Humeral crossvein with dense patch of dark scales

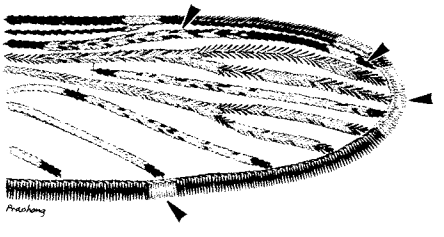


An. nigerrimus
(A and B) in part

1. Vein CuA with short basal dark mark, equal or less length of most basal pale mark on CuA, and usually separated by own length or more from upper dark mark on vein 1A
2. Costa usually entirely dark-scaled on basal 0.33 just distal to humeral crossvein
3. Remigium mostly pale-scaled
4. Humeral crossvein bare or with few scales

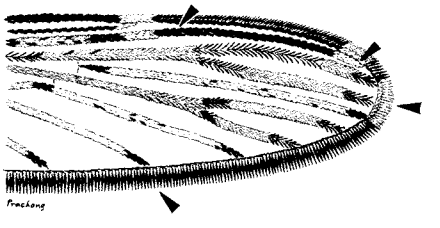


1. Wing pattern blurred
2. Tip of vein R_1 dark-scaled
3. Wing apex with long pale fringe spot, beginning at or above vein R_1
4. Preapical dark (PD) mark on vein R_1 with some pale scales
5. Vein CuA usually with pale fringe spot



*An. sinen*sis
(A and B)

1. Wing pattern sharp, dark marks short and well defined
2. Tip of vein R_1 pale-scaled
3. Wing apex with shorter pale fringe spot, beginning at vein R_2
4. Preapical dark (PD) mark on vein R_1 without pale scales
5. Vein CuA usually without pale fringe spot



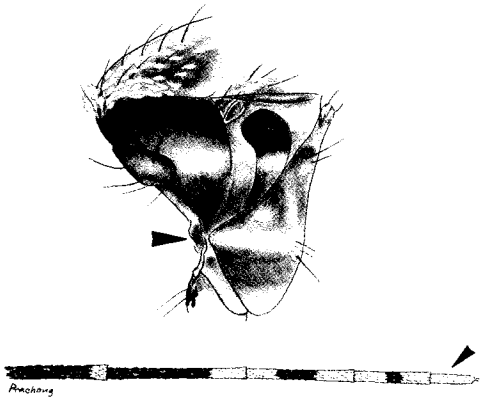
An. crawfordi
(A and B)

PLATE 19

KEY TO THE SERIES OF SUBGENUS *CELLIA* ADULT FEMALES

From PLATE 2: Wing with 4 or more dark marks involving both costa and veins R-R_1, accessary sector pale (ASP) spot present on costa and/or subcosta, and/or R_1

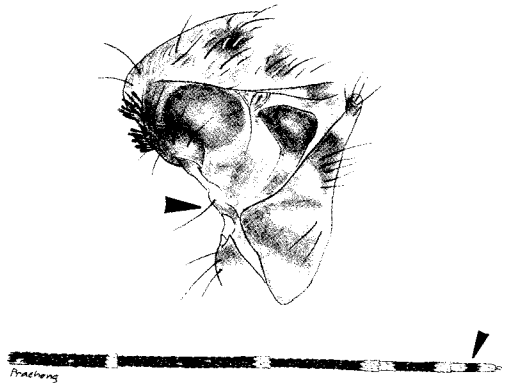
1. Upper proepisternal setae absent
2. Hindtarsomere 5 entirely pale-scaled (except *An. stephensi*)



Neocellia Series[a]

→ To PLATE 21

1. Upper proepisternal setae present
2. Hindtarsomere 5 at least partially dark-scaled



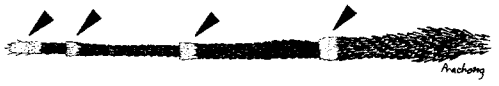
→ To PLATE 20

[a]*Anopheles annularis*, *An. jamesii* A and B, *An. nivipes* A and B, *An. philippinensis*, *An. pseudojamesi*, and *An. splendidus*; *An. karwari* A, B and C, and *An. stephensi*; *An. dravidicus*, *An. maculatus*, *An. maculatus* E and K, *An. notanandai*, *An. pseudowillmori*, *An. sawadwongporni*, and *An. willmori*.

PLATE 20

From PLATE 19: Upper proepisternal setae present; hindtarsomere 5 at least partially dark-scaled

1. Maxillary palpus with 4 or more pale bands
2. Antepronotum with scales

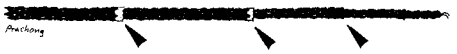


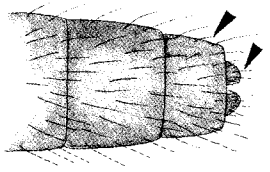
Neomyzomyia Series[a]

To PLATE 28

1. Maxillary palpus with 3 pale bands
2. Antepronotum without scales

1. Legs entirely dark or with narrow apical pale bands or dorsal patches on some tarsomeres
2. Abdominal segments VII and VIII and female cerci without scales

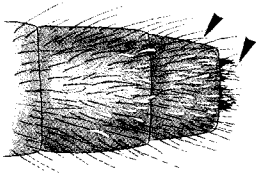




Myzomyia Series[b]

To PLATE 35

1. Legs with basal and apical pale bands on some tarsomeres
2. Abdominal segments VII and VIII and female cerci with at least few scales



Pyretophorus Series[c]

To PLATE 38

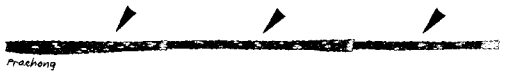
[a]*Anopheles baimaii*, *An. cracens*, *An. dirus*, *An. hackeri*, *An. introlatus*, *An. latens*, *An. macarthuri*, *An. nemophilous*, *An. pujutensis*, and *An. scanloni*: *An. kochi* and *An. tessellatus*.
[b]*Anopheles aconitus* A, B, and C, *An. culicifacies* A and B, *An. jeyporiensis* A, B, C and D, *An. minimus*, *An. minimus* species C, *An. pampanai,* and *An. varuna*.
[c]*Anopheles epiroticus*, *An. indefinitus*, *An. subpictus* B, C, and D, and *An. vagus* A and B.

PLATE 21

KEY TO GROUPS AND SPECIES OF THE NEOCELLIA SERIES ADULT FEMALES

From PLATE 19: Upper proepisternal setae absent; hindtarsomere 5 entirely pale-scaled (except *An. stephensi*)

Hindfemur, tibia, and tarsomere 1 speckled with pale scales



Hindfemur, tibia, and tarsomere 1 dark, not speckled with pale scales

To PLATE 22

Hindtarsomeres 3, 4, and 5 entirely white

Hindtarsomeres 3 and 4 not entirely white, 5 white or dark

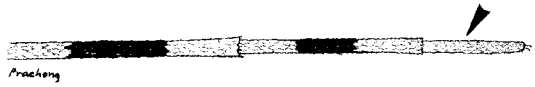
Jamesii Group

To PLATE 23

Hindtarsomere 5 entirely dark

An. stephensi

Hindtarsomere 5 entirely white



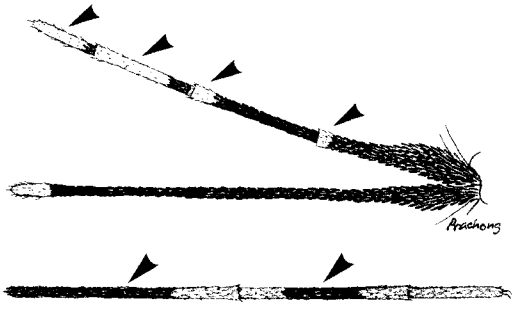
Maculatus Group

To PLATE 24

PLATE 22

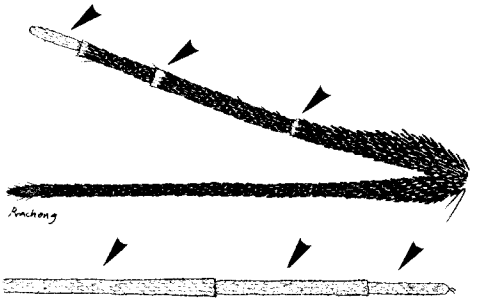
From PLATE 21: Hindfemur, tibia, and tarsomere 1 dark, not speckled with pale scales

1. Maxillary palpus with 4 pale bands
2. Hindtarsomeres 3 and 4 not entirely white



An. karwari
(A, B, and C)

1. Maxillary palpus with 3 pale bands
2. Hindtarsomeres 3, 4 and 5 entirely white



Annularis Group

To PLATE 27

PLATE 23

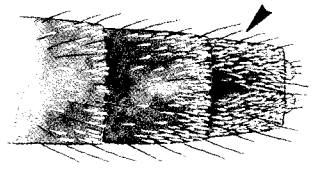
KEY TO THE SPECIES OF THE JAMESII GROUP ADULT FEMALES

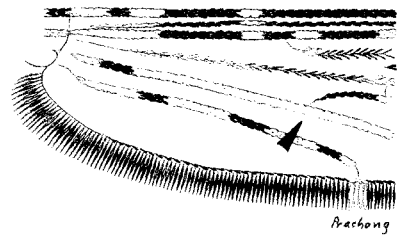
From PLATE 21: Hindtarsomeres 3, 4, and 5 entirely white

Maxillary palpus with dorsal pale spots on palpomeres 2 and/or 3; subapical pale band broad, approximately equal to apical pale band

An. splendidus

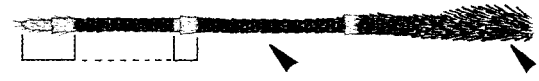
1. Terga VI-VIII with yellow scales
2. Vein CuA without dark spot at fork with vein mcu



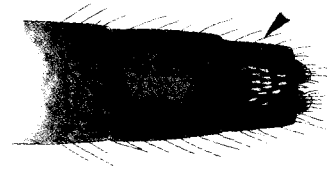


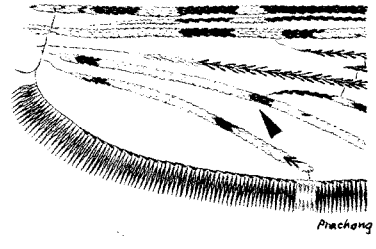
An. jamesii
(A and B)

Maxillary palpus without dorsal pale spots on palpomeres 2 and/or 3; subapical pale band narrow, half length or less of apical pale band



1. Terga VI-VIII without yellow scales
2. Vein CuA with dark spot at fork with vein mcu





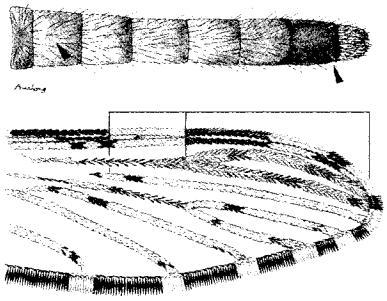
An. pseudojamesi

PLATE 24

KEY TO THE SPECIES OF THE MACULATUS GROUP ADULT FEMALES

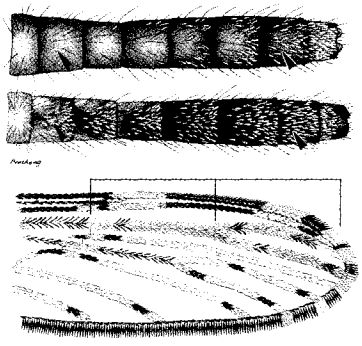
From PLATE 21: Hindtarsomere 5 entirely white

1. Abdominal terga II-VII without scales, tergum VII infrequently with 1-3 narrow pale scales laterally
2. Vein R_2 long, usually longer than twice length of vein R_{2+3}; furcation of vein R_{2+3} at proximal end of preapical dark (PD) spot on vein R_1

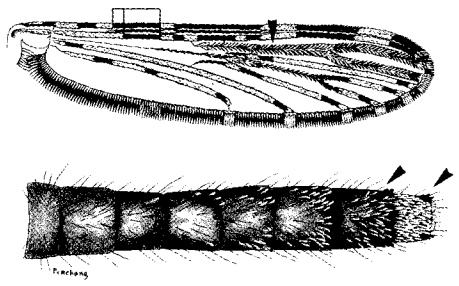


An. pseudowillmori

1. Abdominal terga II-VII usually covered with narrow to broad pale scales
2. Vein R_2 shorter, not longer than twice length of vein R_{2+3}; furcation of vein R_{2+3} usually beyond proximal 0.33 of preapical dark (PD) spot on vein R_1

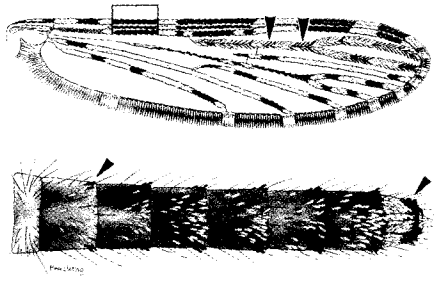


1. Vein R_{2+3} with one dark spot on both wings, and presector dark (PSD) spot on vein R usually shorter than presector dark (PSD) spots on subcosta and costa
2. Posterolateral corners of abdominal terga VII,VIII with dark scales, occasionally on IV-VI



→ To PLATE 25

1. Vein R_{2+3} with two dark spots at least on one wing, if one then presector dark (PSD) spot on vein R usually as long as presector dark (PSD) spots on subcosta and costa
2. Posterolateral corners of abdominal terga II-VIII with dark scales

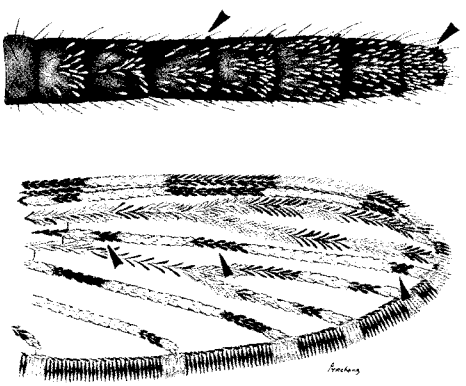


→ To PLATE 26

PLATE 25

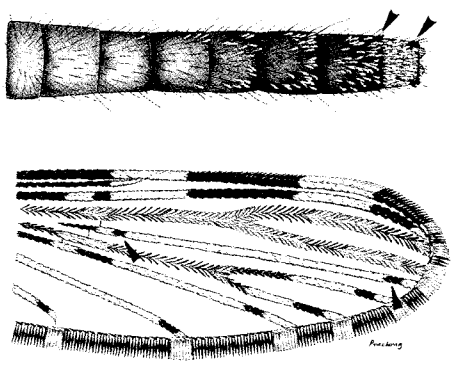
From PLATE 24: Vein R_{2+3} with one dark spot on both wings, and presector dark (PSD) spot on vein R usually shorter than presector dark (PSD) spots on subcosta and costa; postero-lateral corners of abdominal terga VII,VIII with dark scales, occasionally on IV-VI

1. Abdominal terga IV-VIII with dark scales on posterolateral corners, sometimes on III
2. Vein R_{4+5} with 3 dark spots at least on one wing, occasionally with 2 dark spots

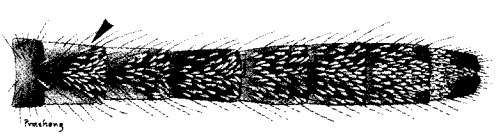


An. dravidicus

1. Abdominal terga VII,VIII with dark scales on posterolateral corners, sometimes on VI
2. Vein R_{4+5} with 2 dark spots

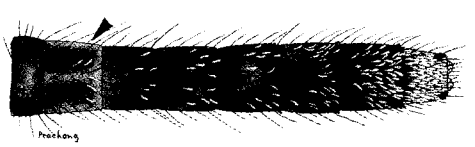


Abdominal terga II-VIII largely covered with broad spatulate pale scales (high mountain species in northern part of Thailand)



An. willmori

Abdominal terga II-VI with or without few pale falcate scales, VII-VIII largely covered with broad spatulate pale scales (high mountain and lowland species)

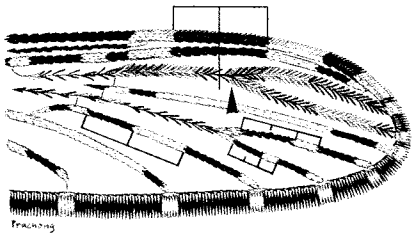


An. maculatus
and *An. maculatus* (E)

PLATE 26

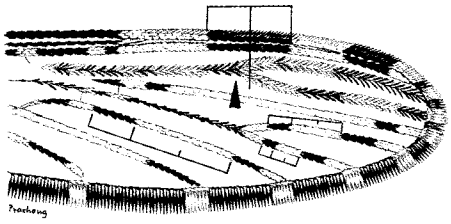
From PLATE 24: Vein R_{2+3} with two dark spots on at least on one wing, if one then presector dark (PSD) spot on vein R usually as long as presector dark (PSD) spots on subcosta and; posterolateral corners of abdominal terga II-VIII dark scales

1. Veins M_1, M_2 and/or M_{3+4} usually with median pale spot equal to or less than twice length of dark spot on either side on both wings
2. Furcation of vein R_{2+3} usually forking beyond proximal 0.5 of preapical dark (PD) spot on vein R_1



An. notanandai [a]

1. Veins M_1, M_2 and M_{3+4} usually with median pale spot more than twice length of dark spot on either side on both wings
2. Furcation of vein R_{2+3} forking within proximal 0.5 of preapical dark (PD) spot on vein R_1



An. sawadwongporni [a] and *An. maculatus* (K)[b]

[a]Eggs are best used to confirm the adult identification (except for *An. notanandai*) (Rattanarithikul and Green, 1986).

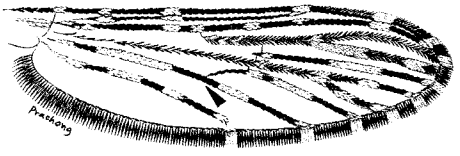
[b]Eggs of *An. maculatus* K (Baimai *et al.*, 1993b) and *An. notanandai* (Rattanarithikul *et al.*,1994a), are inseparable.

PLATE 27

KEY TO THE SPECIES OF THE ANNULARIS GROUP ADULT FEMALES

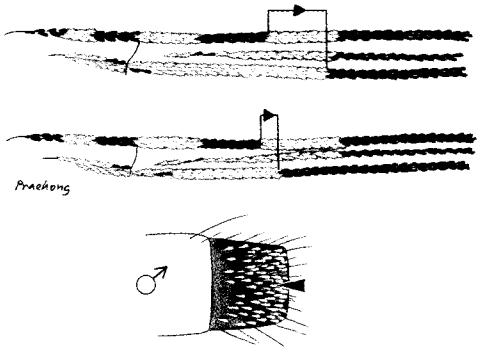
From PLATE 22: Maxillary palpus with 3 pale bands; hindtarsomeres 3, 4 and 5 entirely white

Vein CuA mostly dark-scaled, with dark spot at fork with vein mcu



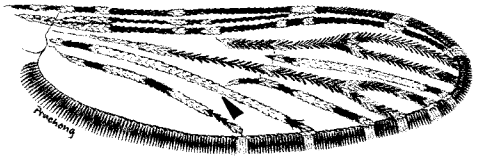
An. annularis

1. Presector dark (PSD) spot on vein R not reaching or overlapping distal end of humeral dark (HD) spot on costa, or only reaching that spot
2. Male with scales on sternum VIII all pale

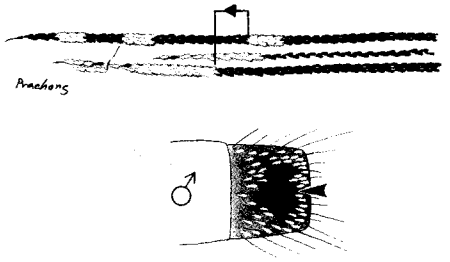


An. philippinensis

Vein CuA mostly pale-scaled, without dark spot at fork with vein mcu



1. Presector dark (PSD) spot on vein R usually reaching or overlapping distal end of humeral dark (HD) spot on costa on both wings
2. Male with median patch of dark scales on sternum VIII



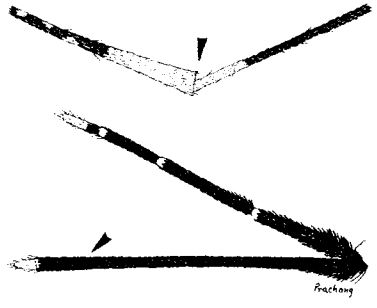
An. nivipes
(A and B)

PLATE 28

KEY TO GROUPS AND SPECIES OF THE NEOMYZOMYIA SERIES ADULT FEMALES

From PLATE 20: Maxillary palpus with 4 or more pale bands; antepronotum with scales

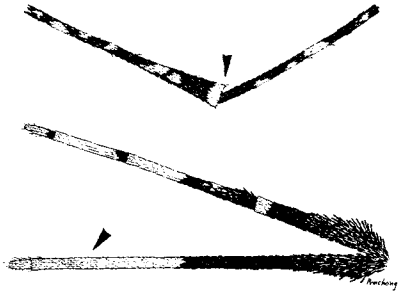
1. Tibio-tarsal joint of hindleg with large white band
2. Proboscis without pale scales on apical half



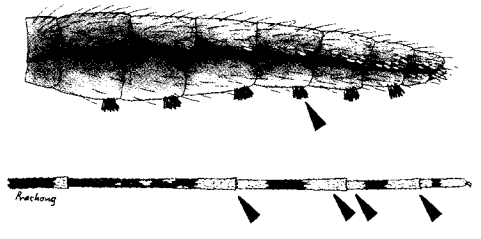
Leucosphyrus Group

→ To PLATE 29

1. Tibio-tarsal joint of hindleg with narrow white band
2. Proboscis with pale scales on apical half

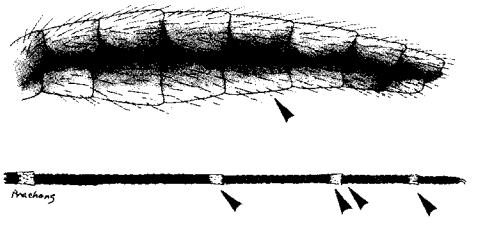


1. Sterna with median tufts of dark scales
2. Hindtarsomeres 3-5 with broad basal and apical pale bands



Kochi Group
An. kochi

1. Sterna without median tufts of dark scales
2. Hindtarsomeres 1-4 with narrow apical pale bands



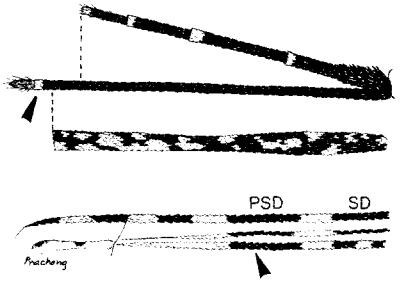
Tessellatus Group
An. tessellatus

PLATE 29

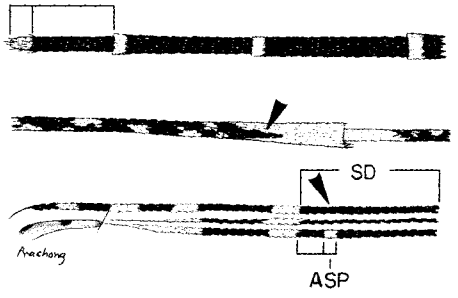
KEY TO THE SPECIES OF THE LEUCOSPHYRUS GROUP ADULT FEMALES[a]

From PLATE 28: Tibio-tarsal joint of hindleg with large white band; proboscis without pale scales on apical half

1. Proboscis distinctly longer than forefemur (ratio 1.16-1.45) and usually much longer than maxillary palpus, often with narrow pale band or patch before labella
2. Presector dark (PSD) spot of vein R without pale interruptions

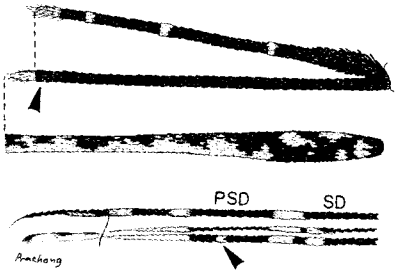


1. Palpomere 5 of maxillary palpus with narrow apical pale band, much narrower than preapical dark band
2. Hindtibia with or without narrow apical extension of dark scales on ventral aspect
3. Accessory sector pale (ASP) spot very small and restricted to vein R, shorter than basal dark spot of sector dark (SD) of vein R and sometimes reduced to 1 or 2 scales



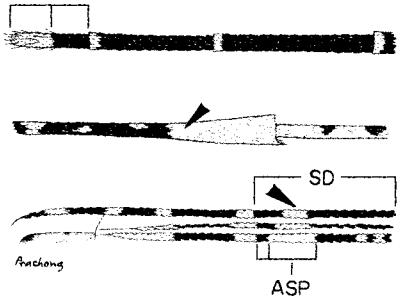
An. hackeri

1. Proboscis shorter or only slightly longer than forefemur (ratio 0.88-1.17) and only slightly longer than maxillary palpus, if longer than forefemur then without pale band or patch before labella
2. Presector dark (PSD) spot of vein R with or without pale interruptions



To PLATE 30

1. Palpomere 5 of maxillary palpus with broad apical pale band approximately as long as preapical dark band
2. Hindtibia without narrow apical extension of dark scales on ventral aspect
3. Accessory sector pale (ASP) spot on vein R longer than basal dark spot of sector dark (SD) of vein R, extending onto subcosta and costa on at least one wing



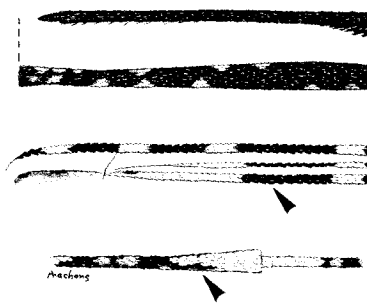
An. pujutensis

[a] Constructed using information provided by Sallum *et al.* (2005) and contained in unpublished keys of EL. Peyton.

PLATE 30

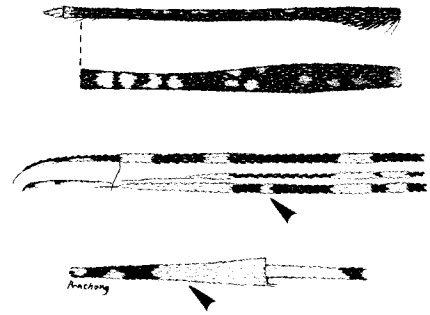
From PLATE 29: Proboscis shorter or only slightly longer than forefemur (ratio 0.88-1.17) and only slightly longer than maxillary palpus, if longer than forefemur then without pale band or patch before labella; presector dark (PSD) spot of vein R with or without pale interruptions

1. Proboscis shorter than forefemur, ratio of proboscis length to forefemur length 0.88-0.99
2. Presector dark (PSD) spot of vein R always without pale interruption in both wings
3. Hindtibia with narrow apical extension of dark scales on ventral surface

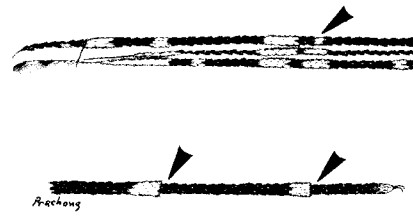


An. macarthuri

1. Proboscis as long as or slightly longer than forefemur, ratio of proboscis length to forefemur length 1.00-1.17
2. Presector dark (PSD) spot of vein R variable with or without pale interruption
3. Hindtibia without narrow apical extension of dark scales on ventral surface[a]

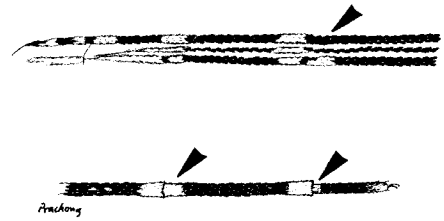


1. Accessory sector pale (ASP) spot usually extending onto subcosta and costa at least on one wing, **and/or**
2. Hindtarsomere 4 without obvious basal pale band or patch
3. Hindtarsomere 5 without basal pale band



→ To PLATE 31 (Above)

1. Accessory sector pale (ASP) spot absent on costa and usually absent on subcosta, **or**
2. Hindtarsomere 4 with obvious basal pale band or patch
3. Hindtarsomere 5 often with minute basal pale band



→ To PLATE 31 (Below)

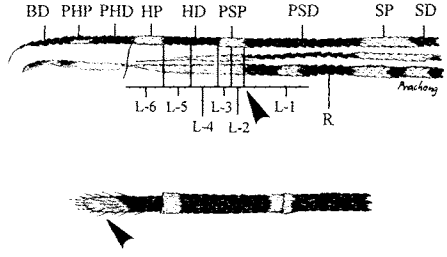
[a]Except *An. scanloni*.

PLATE 31

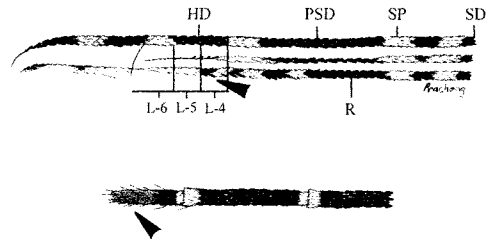
From PLATE 30: Accessory sector pale (ASP) spot usually extending onto subcosta and costa at least on one wing **and/or;** hindtarsomeres 4 without obvious basal pale band or patch; hindtarsomere 5 without basal pale band

1. Presector dark (PSD) spot of vein R often not extending basally beyond level of PSD spot on costa (level 3) and rarely extending onto apical 0.5 of humeral dark (HD) spot on costa, never extending beyond middle of HD (level 4)
2. Apical pale band on palpomere 5 distinctly white or whitish, not strongly contrasting with light bands on palpomeres 2 and 3

1. Presector dark (PSD) spot of vein R usually extending basally well onto level of humeral dark (HD) spot of costa, or beyond middle of HD (levels 4 and 5)
2. Apical pale band on palpomere 5 distinctly cream-colored or yellowish, strongly contrasting with silvery white band on palpomeres 2 and 3



An. introlatus
and *An. nemophilous* (in part)



An. latens

From PLATE 30: Accessory sector pale (ASP) spot absent on costa and usually absent on subcosta, **or** hindtarsomeres 4 with obvious basal pale band or patch; hindtarsomere 5 often with minute basal pale band

All pale scales of wing, cream-colored to golden or yellowish, including those of presector pale (PSP) and sector pale (SP) spots

An. nemophilous (in part)

Pale scales on anterior veins of wing, [especially those on presector pale (PSP) and sector pale (SP) spots of costa] white, contrasting with pale spots on posterior veins

To PLATE 32

PLATE 32

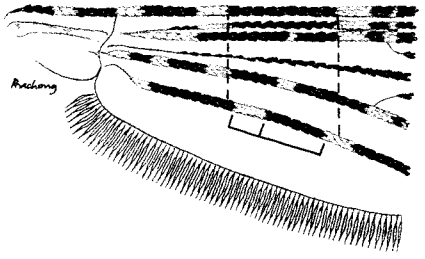
From PLATE 31: Pale scales on anterior veins of wing, [especially those on presector pale (PSP) and sector pale (SP) spots of costa] white, contrasting with pale spots on posterior veins

Apical pale band of hindtibia with short to long, narrow, dark linear extension onto basal portion on ventral surface (specimens from Kanchanaburi only)

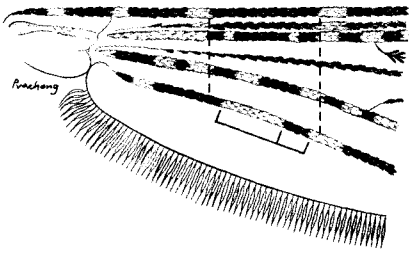
An. scanloni (in part)

Apical pale band of hindtibia without dark extension onto basal portion on ventral surface

Vein 1A without noticeably longer pale spot at level of presector dark (PSD), if long pale spot is present, then usually less than 0.33 length of PSD spot of costa and not noticeably longer than other pale spot on vein 1A, especially most basal spot



Vein 1A with long pale spot at level of presector dark (PSD) of costa at least on one wing, ratio of length to PSD 0.28-1.36, at least 0.4 on one wing, and always longest pale spot on vein 1A



→ To PLATE 33

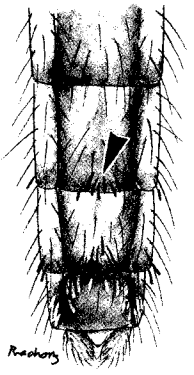
→ To PLATE 34

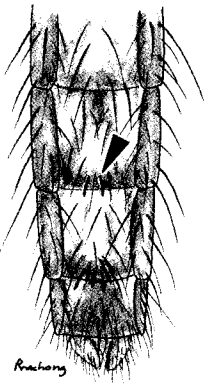
PLATE 33

From PLATE 32: Vein 1A without noticeably longer pale spot at level of PSD, if long pale spot is present, then usually less than 0.33 length of PSD spot of costa and not noticeably longer than other pale spot on vein1A, especially most basal spot

Abdominal sternum VI with small postero-medial patch of dark scales

Abdominal sternum VI without scales or with at most 1 or 2 dark scales

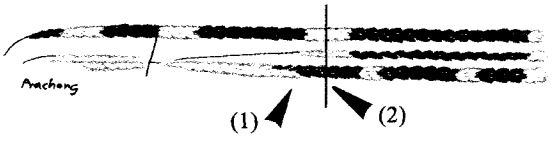


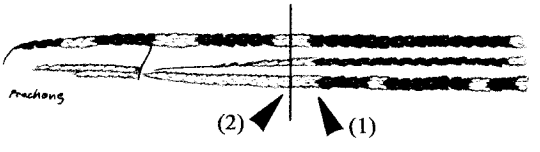


An. cracens

Presector dark (PSD) spot on vein R extending basally beyond PSD spot on costa, at least on one wing, usually reaching humeral dark (HD) of costa (1) or beyond, or at least beyond middle (2) of presector pale (PSP) spot of costa

Presector dark (PSD) spot on vein R usually at level of PSD spot on costa (1), or extending only slightly basally, usually no more than middle (2) of presector pale (PSP) spot of costa





An. dirus

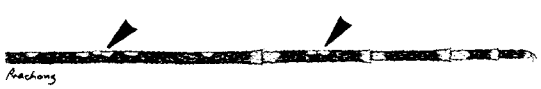
An. baimaii (in part)

PLATE 34

From PLATE 32: Vein 1A with long pale spot at level of PSD of costa at least on one wing, ratio of length to PSD 0.28-0.36, at least 0.4 on one wing, and always longest pale spot on vein 1A

1. Combined pale spots and bands along dorsolateral surface of foretarsomeres 1 and /or 2 dominating the dark portions along this line, often 2 or more of these spots on foretarsomere 1 fused, forming long line or spashes of pale scales along entire length, at least on one leg
2. Foretarsomere 2 often with pale bands and pale spots fused and completely pale dorsally, or spots and bands longer, reducing dark area to narrower median band

1. Combined pale spots and bands along dorsolateral surface of foretarsomeres 1 and /or 2 smaller, more discrete, usually occupying less surface than dark scales along dorsolateral line, pale spots on foretarsomere 1usually not fused, or forming long line or spashes of pale scales along entire length, often restricted to 2-4 spots on basal 0.60
2. Middle dark area of foretarsomere 2 always long, usually without pale spots on dorsal surface, occasionally with 1-3 tiny separate pale spots



An. baimaii (in part)

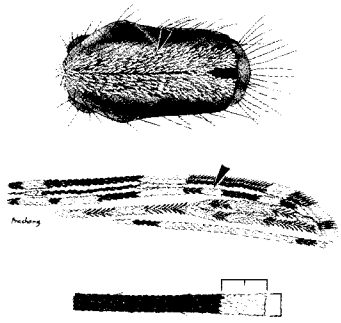
An. scanloni (in part)

PLATE 35

KEY TO THE SPECIES OF THE MYZOMYIA SERIES, FUNESTUS GROUP ADULT FEMALES

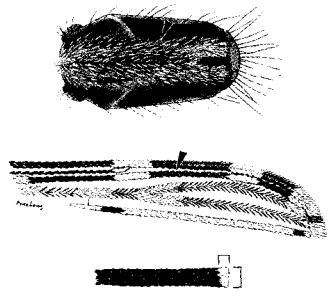
From PLATE 20: Legs entirely dark or with narrow apical pale bands or dorsal patches on some tarsomeres; abdominal segments VII and VIII and female cerci without scales

1. Center of scutum covered with short oblong white scales extending back to scutellum
2. Vein R_1 usually with accessory pale spot on preapical dark (PD) area
3. Foretarsomere 1 with apical pale band nearly 2.0 width of tarsomere diameter

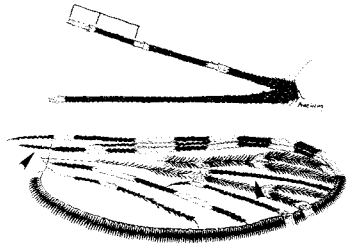


An. jeyporiensis
(A, B, C, and D)

1. Center of scutum without white scales except for setae, or with slender seta-like white scales
2. Vein R_1 usually without accessory pale spot on preapical dark (PD) area
3. Foretarsomere 1 with apical pale band no wider than tarsomere diameter

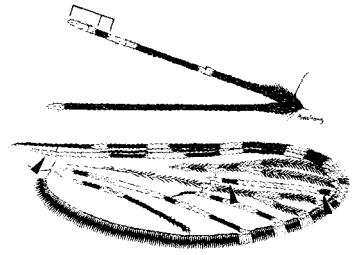


1. Maxillary palpus with preapical dark band much longer than apical pale band
2. Remigium entirely or mostly dark-scaled
3. Vein R_{4+5} usually dark except at base



Culicifacies Subgroup
An. culicifacies
(A and B)

1. Maxillary palpus with preapical dark band equal to or shorter than apical pale band
2. Remigium entirely white or with few gray or black scales at apex
3. Vein R_{4+5} usually with basal and apical dark spots

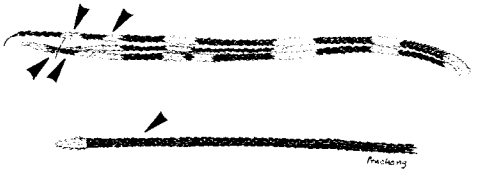


To PLATE 36

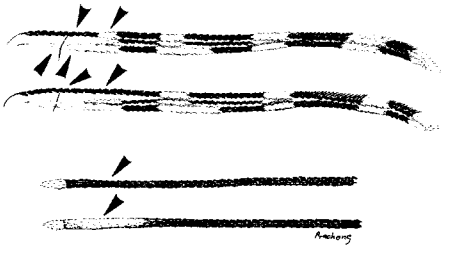
PLATE 36

From PLATE 35: Maxillary palpus with preapical dark band equal to or shorter than apical pale band; remigium entirely white or with few gray or black scales at apex; vein R_{4+5} usually with basal and apical dark spots

1. Apex of remigium and base of vein R with gray to black scales
2. Costa with humeral pale (HP) and presector pale (PSP) spots
3. Proboscis dark-scaled

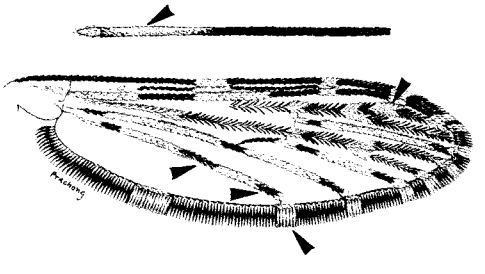


1. Apex of remigium and base of vein R with pale scales
2. Costa usually without humeral pale (HP) and presector pale (PSP) spots or with PSP spot only
3. Proboscis dark or with some pale scales

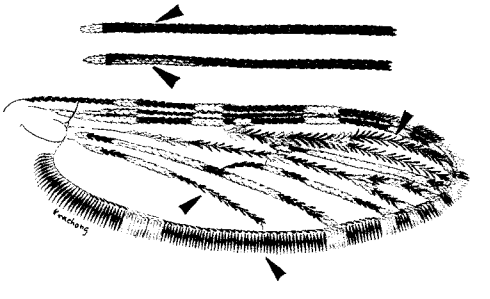


Aconitus Subgroup (in part)
An. pampanai

1. Proboscis with distal pale area on dorsum and venter[a]
2. Vein R_2 with median pale spot
3. Hind margin of wing usually with pale fringe spot at vein 1A[b]
4. Vein 1A with two dark spots on distal half



1. Proboscis usually entirely dark or with ventral pale patch
2. Vein R_2 dark except at base and apex
3. Hind margin of wing usually without pale fringe spot at vein 1A (97-98%)
4. Vein 1A with one long dark spot on distal half



Aconitus Subgroup (in part)
An. aconitus
(A, B, and C)

→ To PLATE 37

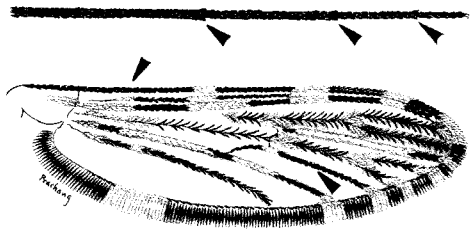
[a]Occasionally confined to small ventral patch.
[b]In southern and central areas, less frequent in the north.

PLATE 37

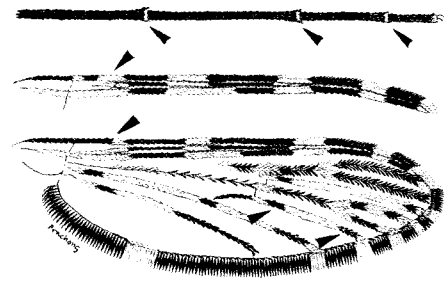
From PLATE 36: Proboscis usually entirely dark or with ventral pale patch; vein R_2 dark except at base and apex; hind margin of wing usually without pale fringe spot at vein 1A (97-98%); vein 1A with one long dark spot on distal half

1. Foretarsomeres entirely dark-scaled
2. Costa without presector pale (PSP) spot
3. Vein M_{3+4} with one long dark spot distal to mcu fork

1. Foretarsomeres 1-4 with very small dorsoapical pale patches
2. Costa with presector pale (PSP) spot[a]
3. Vein M_{3+4} with two dark spots distal to mcu fork



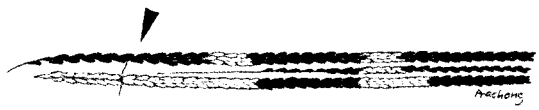
Aconitus Subgroup (in part)
An. varuna



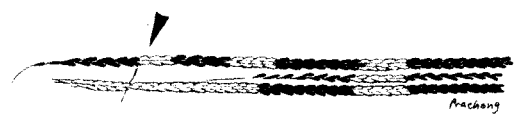
Minimus Subgroup

Costa usually without humeral pale (HP) spot[b]

Costa usually with humeral pale (HP) **and/or** prehumeral (PHP) pale spots[b]



An. minimus



An. minimus
species C

[a] Infrequently, specimens of *An. minimus* have no presector pale spot.
[b]Although this character may be useful in Kanchanaburi Province, Harrison (1980:88) demonstrated that 2.5% of female progeny reared from classic *An. minimus* females collected all over the country had humeral pale (HP) and/or prehumeral pale (PHP) spots. Recent papers (Green *et al.*, 1990, Van Bortel *et al.*, 1999. Chen *et al*, 2002, Sungvornyothin *et al.*, 2006) have determined that the HP spot is not a good character for identifying *An. minimus* C in southeast Asia.

PLATE 38

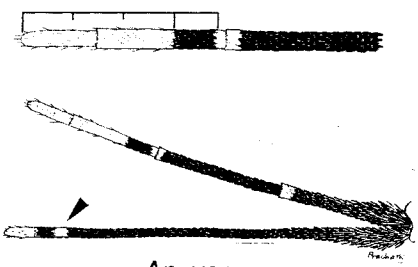
KEY TO THE SPECIES OF THE PYRETOPHORUS SERIES ADULT FEMALES

From PLATE 20: Legs with basal and apical pale bands on some tarsomeres; abdominl segments VII and VIII and female cerci with at least few scales

Hindfemur, tibia, and tarsomere 1 speckled with pale scales

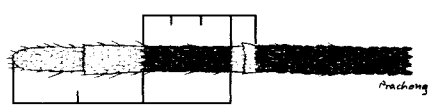
An. epiroticus

1. Maxillary palpus with apical pale band 3-4 times length of preapical dark band
2. Proboscis with well defined pale spot towards the apex



An. vagus
(A and B)

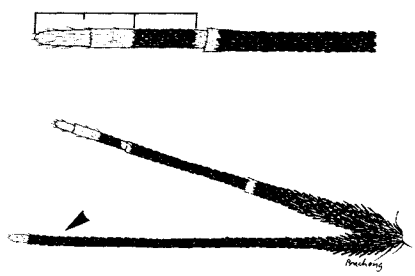
Maxillary palpus with subapical pale band usually 0.33 or less length of preapical dark band, which is 0.5 or more length of apical pale band



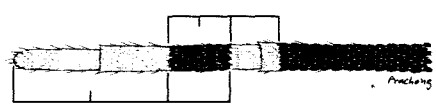
An. subpictus
(B, C, and D)

Hindfemur, tibia, and tarsomere 1 dark, not speckled with pale scales

1. Maxillary palpus with apical pale band 2.5 times or less length of preapical dark band
2. Proboscis without or with faint pale spot towards the apex



Maxillary palpus with subapicàl pale band usually 0.5 or more length of preapical dark band, which is often less than 0.5 length of apical pale band



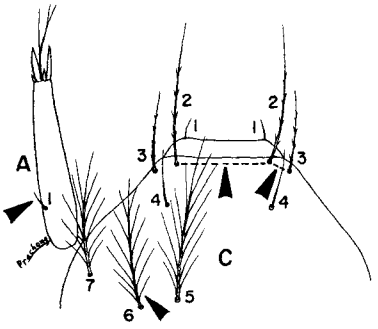
An. indefinitus

PLATE 1

KEY TO THE SUBGENERA OF *ANOPHELES* FOURTH-INSTAR LARVAE

Characters: Siphon absent; abdominal seta 1 palmate, usually with well developed leaflets on most segments

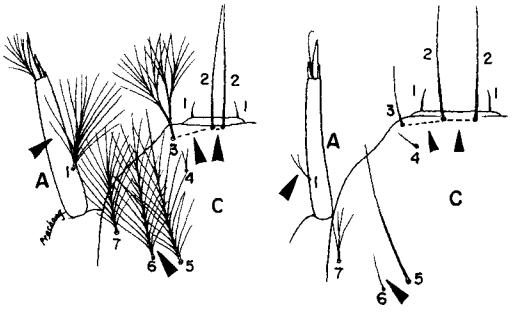
1. Distance between bases of seta 2-C wider than distance between bases of setae 2-C and 3-C on one side
2. Seta 1-A small and simple, rarely bifid or trifid; setae 5-, 6-, and 7-C long and branched



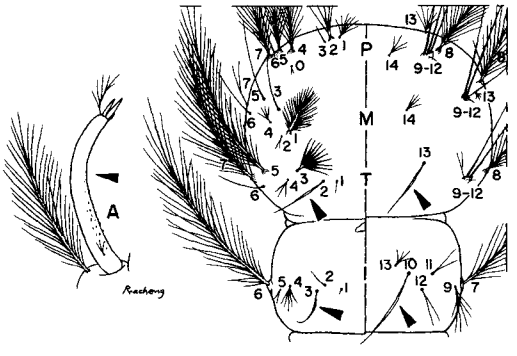
Subgenus *Cellia*

→ To PLATE 21

1. Distance between bases of seta 2-C equal to or less than distance between bases of setae 2-C and 3-C on one side
2. Seta 1-A branched, often large, if simple or small then some of setae 5-, 6-, and 7-C short, simple, or with few branches

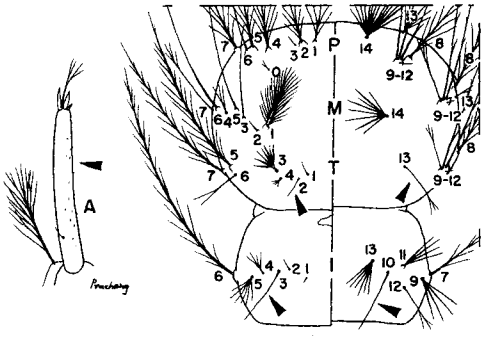


1. Antennal shaft markedly curved inward
2. Some single setae of thorax and abdomen flattened



Subgenus *Baimaia*
An. kyondawensis

1. Antennal shaft straight or only slightly curved
2. Single setae of thorax and abdomen not flattened



Subgenus *Anopheles*

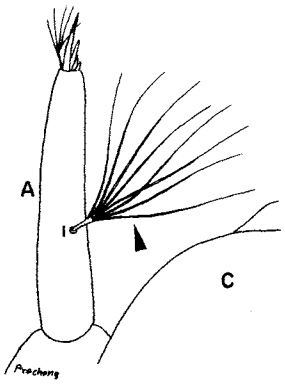
→ To PLATE 2

PLATE 2

KEY TO THE SERIES AND SPECIES GROUPS OF SUBGENUS *ANOPHELES* FOURTH-INSTAR LARVAE[a]

From PLATE 1: Antennal shaft straight or only slightly curved; single setae of thorax and abdomen not flattened

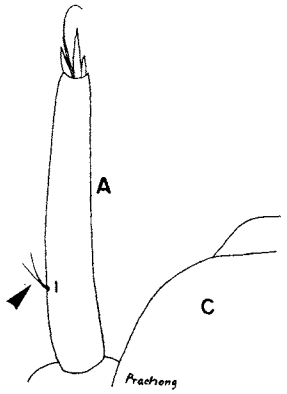
Seta 1-A with branches long, reaching beyond midpoint on antenna



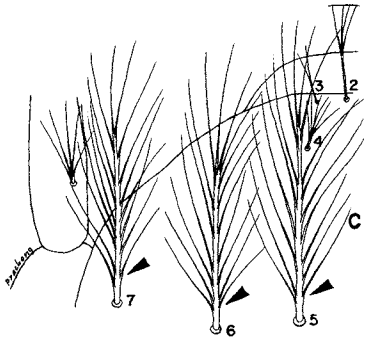
Myzorhynchus Series

→ To PLATE 4

Seta 1-A short, not reaching beyond midpoint on antenna



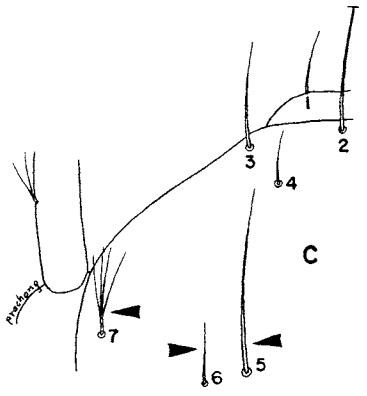
Setae 5-, 6-, and 7-C well developed and plumose



Anopheles Series (in part)

→ To PLATE 3 (Above)

Setae 5-, 6-, and 7-C reduced, some or all, simple or with few short branches



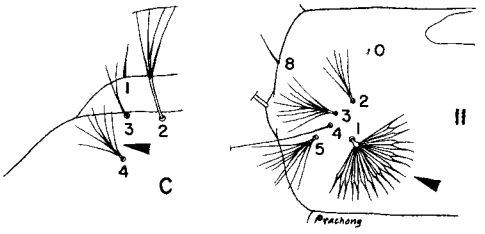
→ To PLATE 3 (Below)

[a]Larva of *An. bulkleyi* is unknown.

PLATE 3

From PLATE 2: Setae 5-,6-, and 7-C well developed and plumose

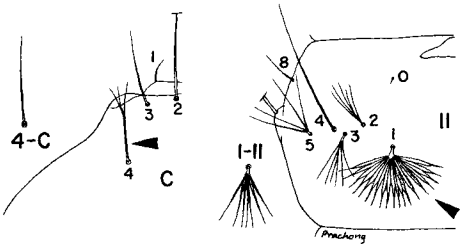
1. Seta 4-C branched from base
2. Abdominal segment II with fully developed palmate setae (small species in mountains and lowlands)



Aitkenii Group

To PLATE 8

1. Seta 4-C simple or branched only on distal half
2. Abdominal segment II with or without fully developed palmate setae (large species on high elevation mountains)

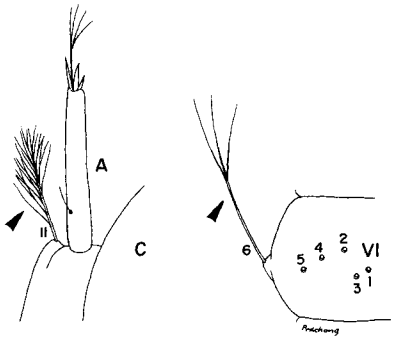


Lindesayi Group

To PLATE 7

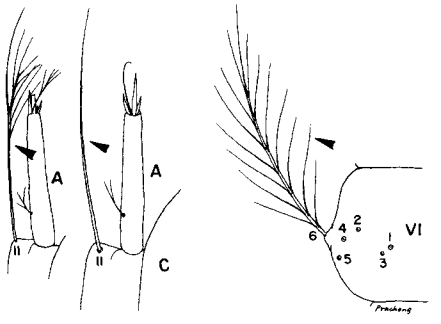
From PLATE 2: Setae 5-, 6-, and 7-C reduced, some or all simple or with few short branches

1. Seta 11-C shorter than antenna
2. Seta 6-VI simple or with 2-4 branches



Culiciformis Group
An. sintonoides

1. Seta 11-C longer than antenna, simple or with 4-8 strong branches arising approximately midway
2. Seta 6-VI with more than 10 branches



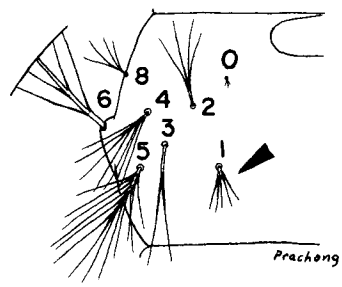
Lophoscelomyia Series
Asiaticus Group

To PLATE 6

PLATE 4

From PLATE 2: Seta 1-A with branches long, reaching beyond midpoint on antenna

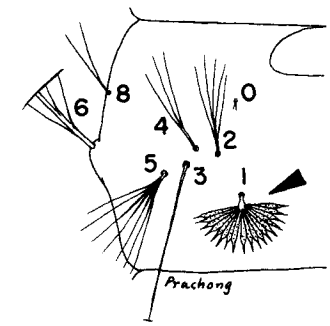
Dorsum of abdomen without palmate setae (seta 1), or only palmate on 2 or 3 segments



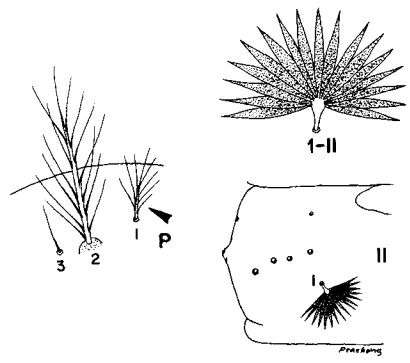
Umbrosus Group

→ To PLATE 11

Dorsum of abdomen with fully developed palmate setae (seta 1) on at least 5 segments



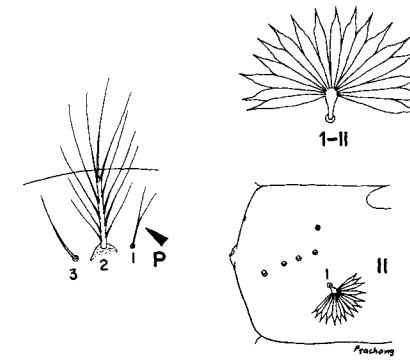
1. Seta 1-P with 4 or more branches spreading from near base
2. Seta 1-II palmate, usually pigmented[a]



Barbirostris Group

→ To PLATE 13

1. Seta 1-P without branches on basal half, simple or with short branches on distal half
2. Seta 1-II palmate, unpigmented



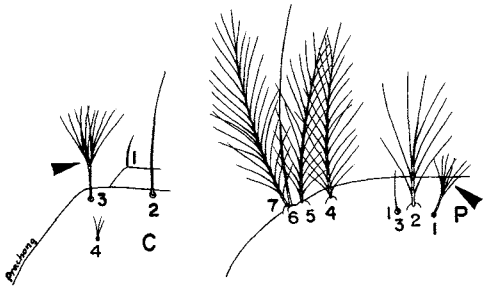
→ To PLATE 5

[a]Except *An. barbumbrosus*.

PLATE 5

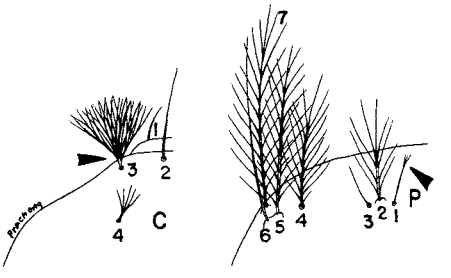
From PLATE 4: Seta 1-P without branches on basal half, simple or with short branches on distal half; seta 1-II palmate, unpigmented

1. Seta 3-C divided about half way from the base into 15 or fewer branches
2. Seta 1-P with 3-7 short, subequal branches arising from the middle to tip of the seta



Albotaeniatus Group
An. montanus

1. Seta 3-C divided from near base into 40 or more branches
2. Seta 1-P simple or with 2-5 short branches on distal half



Hyrcanus Group

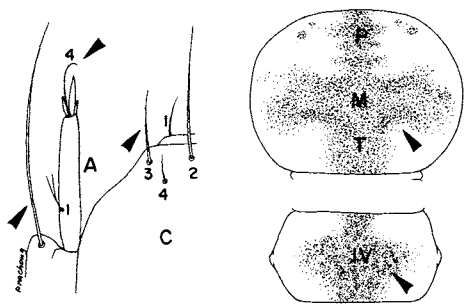
To PLATE 16

PLATE 6

KEY TO THE SPECIES OF THE ASIATICUS GROUP FOURTH-INSTAR LARVAE

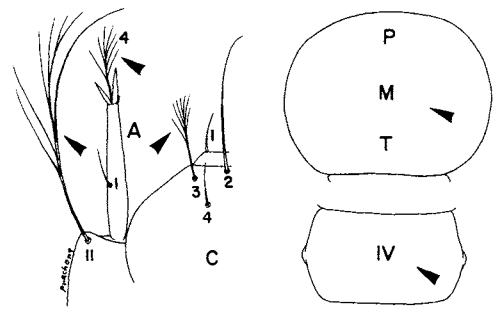
From PLATE 3: Seta 11-C longer than antenna, simple or with 4-8 strong branches arising approximately midway; seta 6-VI with more than 10 branches

1. Setae 4-A, 3-C, and 11-C usually simple
2. Dorsum of thorax and abdominal segments IV-V with large central black marks



An. asiaticus

1. Setae 4-A, 3-C, and 11-C branched
2. Dorsum of thorax and abdominal segments IV-V without central black marks



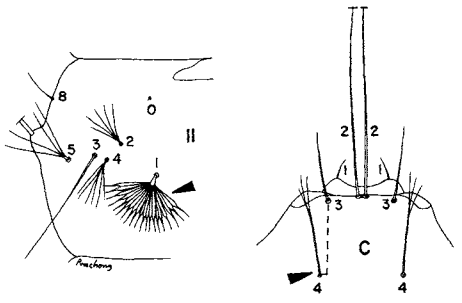
An. interruptus

PLATE 7

KEY TO THE SPECIES OF THE LINDESAYI GROUP FOURTH-INSTAR LARVAE

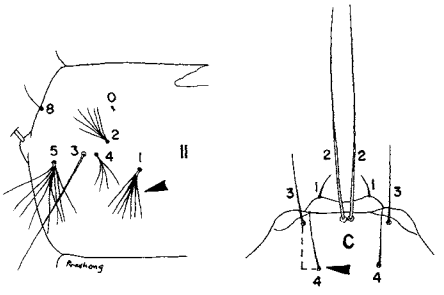
From PLATE 3: Seta 4-C simple or branched only on distal half; abdominal segment II with or without fully developed palmate setae

1. Abdominal segment II with fully developed palmate setae
2. Seta 4-C branched distally and longer than 3-C, inserted far posterior and slightly lateral to insertion of 3-C



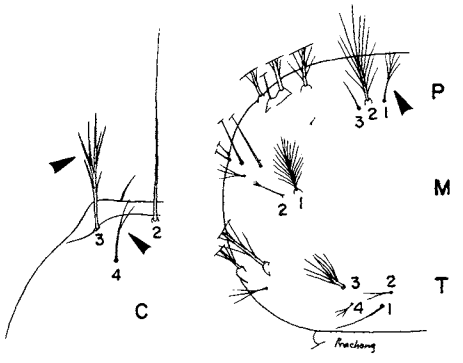
An. lindesayi cameronensis

1. Abdominal segment II with filamentous setae
2. Seta 4-C single or double and shorter than 3-C, inserted closer to and mesal to insertion of 3-C



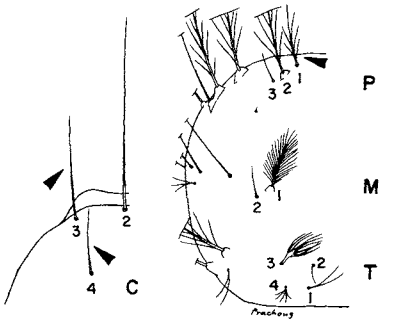
Gigas Subgroup

1. Seta 3-C branched
2. Seta 4-C usually bifid
3. Seta 1-P branched on distal half



n. sp. near *An. gigas*[a]

1. Seta 3-C single
2. Seta 4-C usually single
3. Seta 1-P branched on basal half



An. baileyi

[a]In preparation, from Phu Kra Dung, Loei Province.

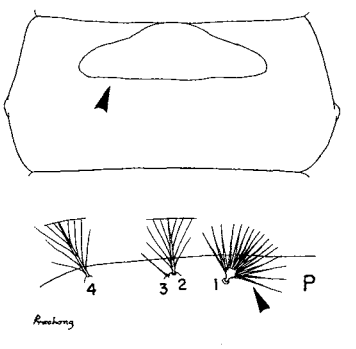
PLATE 8

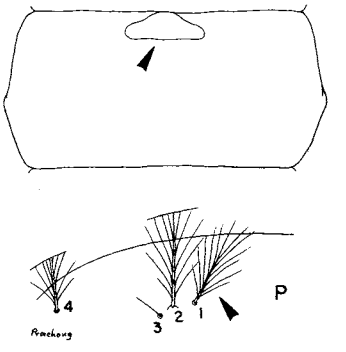
KEY TO THE SPECIES OF THE AITKENII GROUP FOURTH-INSTAR LARVAE

From PLATE 3: Seta 4-C branched from base; abdominal segment II with fully developed palmate setae

1. Anterior tergal plates on segments I-VII large, 0.66-0.75 width of segment
2. Seta 1-P fan-like with single branches and broad basal stem

1. Anterior tergal plates on segments I-VII small, less than 0.50 width of segment
2. Seta 1-P not fan-like

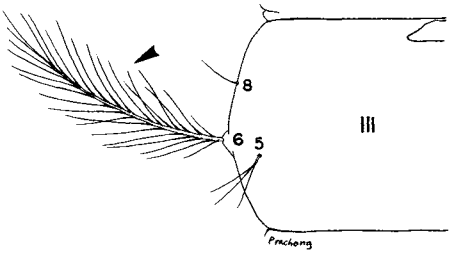


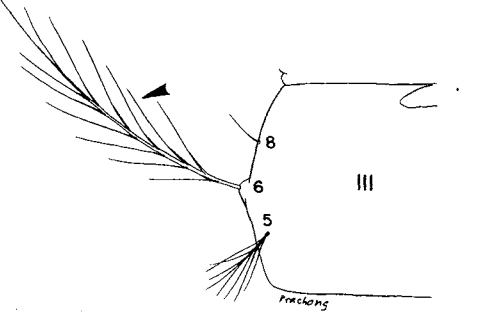


An. palmatus

Seta 6-III with more than 15 branches

Seta 6-III with fewer than 15 branches





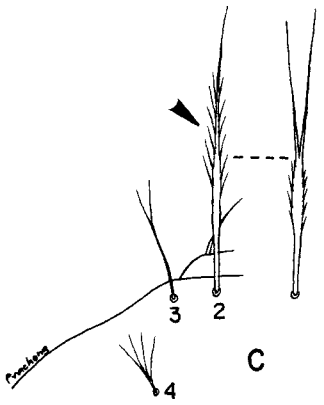
→ To PLATE 9

→ To PLATE 10

PLATE 9

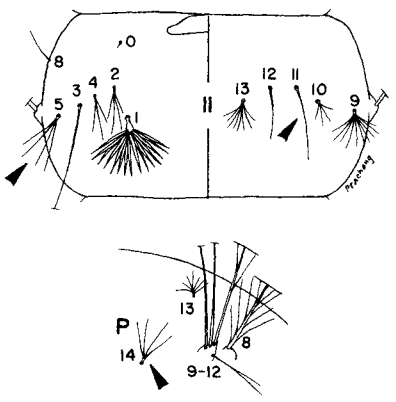
From PLATE 8: Seta 6-III with more than 15 branches

Seta 2-C single or with 2 or 3 distal branches, with short barbs mesally



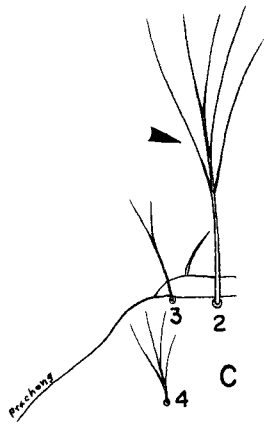
An. fragilis

1. Seta 11-II simple
2. Seta 5-II with 3-6 branches
3. Seta 14-P with 3-5 branches, rarely 5 on both sides[a]



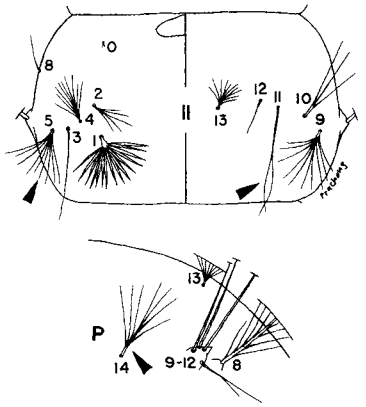
An. aberrans[a]

Seta 2-C with 2-14 distal branches, without short barbs mesally



An. bengalensis

1. Seta 11-II forked or branched beyond base
2. Seta 5-II with 7 or more branches
3. Seta 14-P with 5-8 branches, rarely 5 on both sides



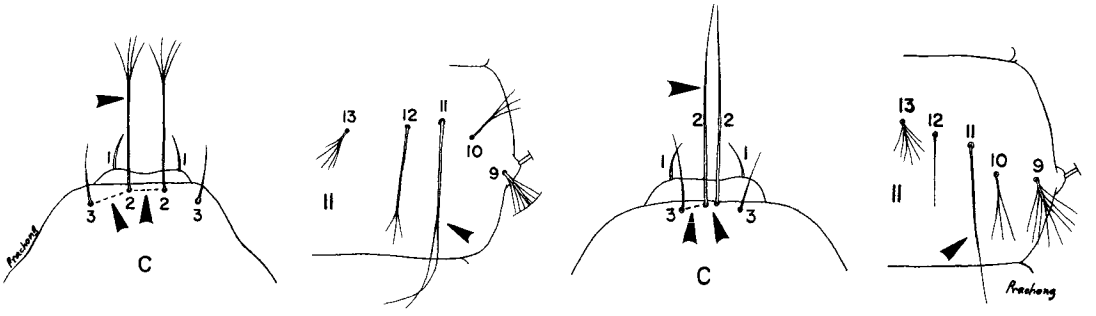
[a]Approximately 50% of larvae have the thorax and abdominal segments IV, V, and X paler than abdominal segments I-III, VI-VIII.

PLATE 10

From PLATE 8: Seta 6-III with fewer than 15 branches

1. Seta 2-C with 2-5 branches originating beyond middle, bases separated by approximately same distance as bases of setae 2-C and 3-C on one side
2. Seta 11-II forked beyond base

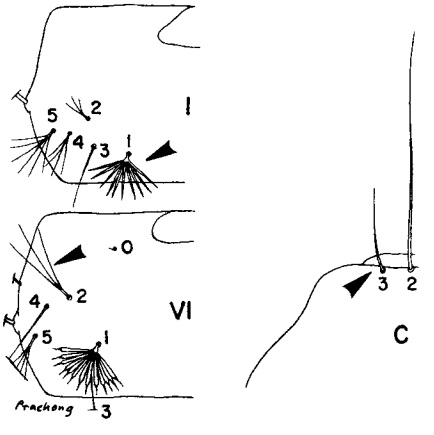
1. Seta 2-C simple, bases much closer than distance between bases of setae 2-C and 3-C on one side
2. Seta 11-II long and simple



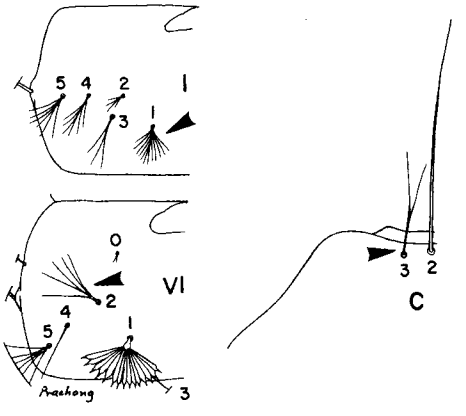
An. tigertti

1. Seta 1-I palmate, with flattened leaflets
2. Seta 2-VI with 1-3 branches
3. Seta 3-C simple, rarely bifid at tip

1. Seta 1-I not palmate, with filamentous branches
2. Seta 2-VI with 4 or 5 branches
3. Seta 3-C with 2-4 branches



An. insulaeflorum



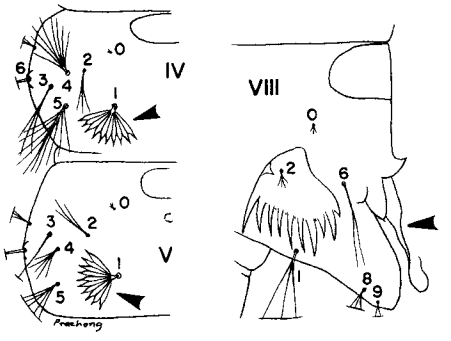
An. stricklandi

PLATE 11

KEY TO THE SPECIES OF THE UMBROSUS GROUP FOURTH-INSTAR LARVAE

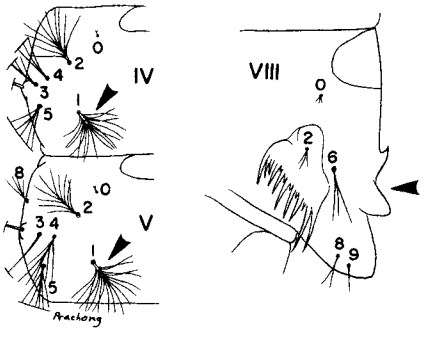
From PLATE 4: Dorsum of abdomen without palmate setae (seta 1), or only palmate on 2 or 3 segments

1. Setae 1-IV and 1-V palmate, with well developed leaflets
2. Median dorsal valve of spiracular apparatus on abdominal segment VIII with stigmal filament

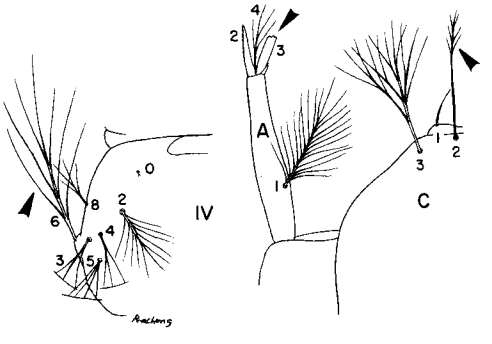


An. umbrosus

1. Setae 1-IV and 1-V not palmate, but with filamentous branches
2. Median dorsal valve of spiracular apparatus on abdominal segment VIII without stigmal filament

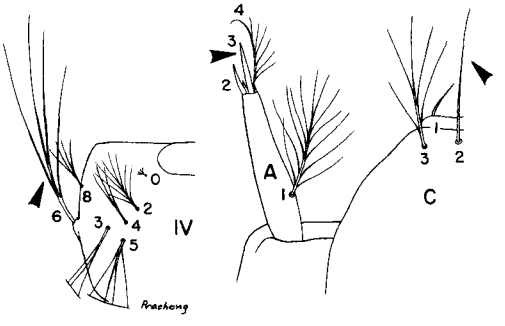


1. Seta 6-IV with 7 or more branches
2. Seta 2-C usually with 5 or more fine branches near tip
3. Seta 3-A with truncate tip



An. baezai

1. Seta 6-IV with fewer than 7 branches
2. Seta 2-C simple or with 4 or fewer branches near tip
3. Seta 3-A with pointed tip

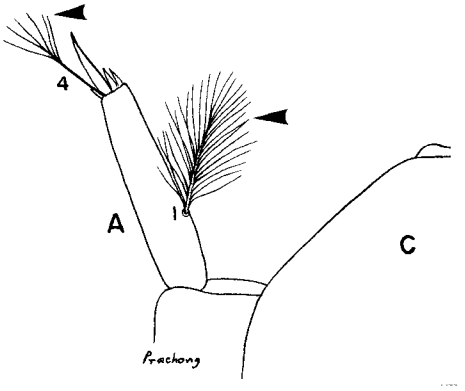


To PLATE 12

PLATE 12

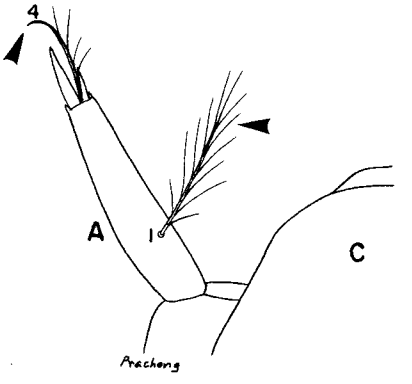
From PLATE 11: Seta 6-IV with fewer than 7 branches; seta 2-C simple or with 4 or fewer branches near tip; seta 3-A with pointed tip

1. Seta 1-A with 25 or more branches
2. Seta 4-A with simple fine branches, not hooked

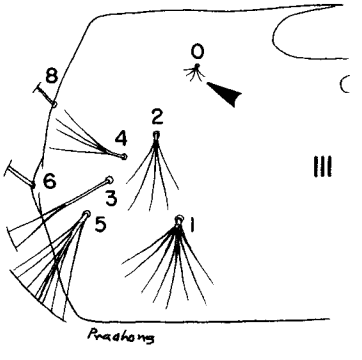


An. separatus

1. Seta 1-A usually with fewer than 20 branches
2. Seta 4-A with 1-2 stout, slightly hooked branches

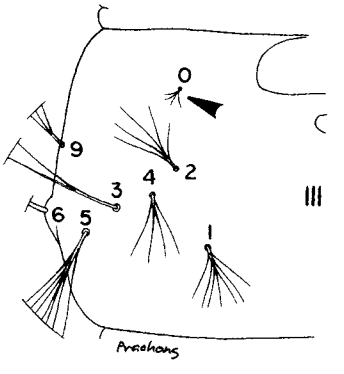


Seta 0-III with 5 or more branches



An. roperi

Seta 0-III usually with fewer than 5 branches, at least on one side



An. letifer and *An. whartoni*

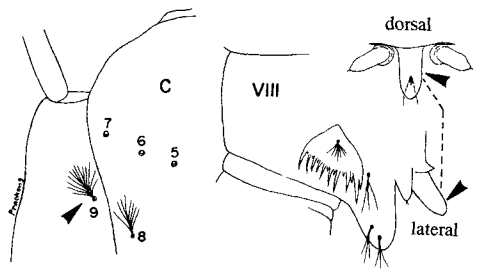
PLATE 13

KEY TO THE SPECIES OF THE BARBIROSTRIS GROUP FOURTH-INSTAR LARVAE

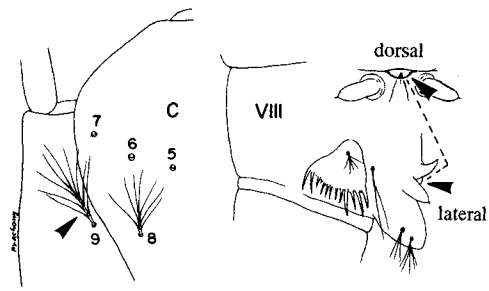
From PLATE 4: Seta 1-P with 4 or more branches spreading from near base; seta 1-II palmate, usually pigmented

1. Median dorsal valve of spiracular apparatus on abdominal segment VIII with caudal, thumb-like stigmal process
2. Seta 9-C with 10-17 branches

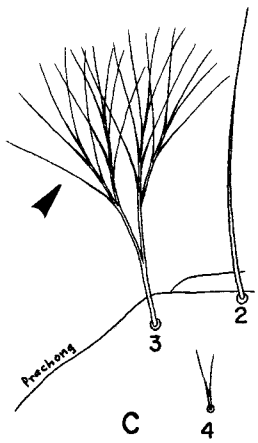
1. Median dorsal valve of spiracular apparatus on abdominal segment VIII with small clear caudal knob, no stigmal process
2. Seta 9-C with 5-11 branches



An. pollicaris

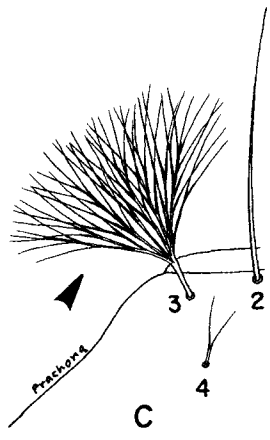


Seta 3-C with 12-36 thin attenuated branches, usually flexible and spread out



An. barbumbrosus

Seta 3-C with thick branches, usually stiff and crowded together (broom-like), and usually more numerous (19-95)



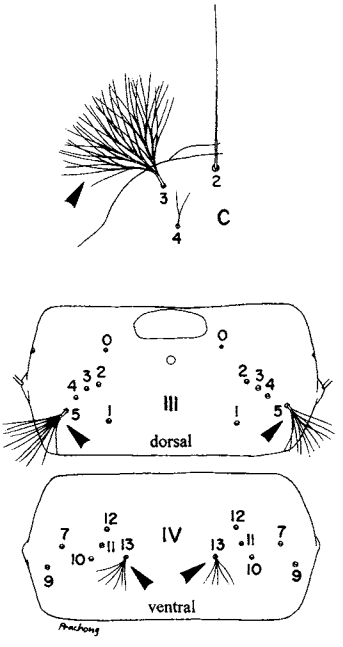
To PLATE 14

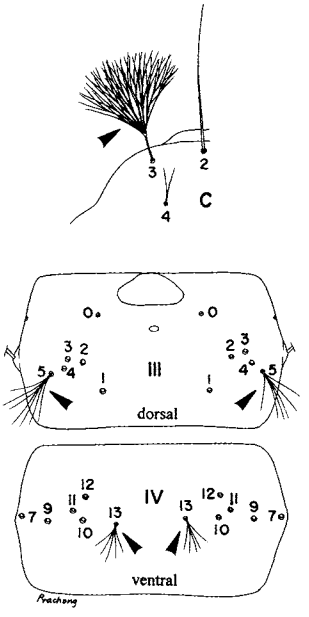
PLATE 14

From PLATE 13: Seta 3-C with thick branches, usually stiff and crowded together (broom-like), and usually more numerous (19-95)

1. Seta 3-C with 19-44 branches, rarely more than 40
2. Sum of branches of both seta 5-III plus those of both seta 13-IV usually total 25-38 (5-III+5-III) + (13-IV+13-IV) = 25-38 branches

1. Seta 3-C with 30-95 branches, rarely fewer than 40
2. Sum of branches of both seta 5-III plus those of both seta 13-IV rarely more than 24 (5-III+5-III) + (13-IV+13-IV) = fewer than 25 branches





An. hodgkini

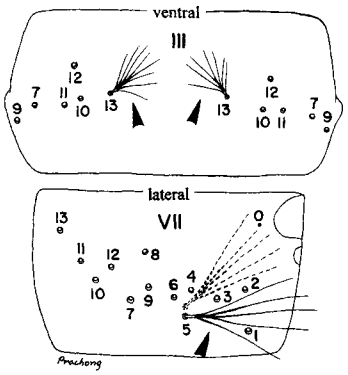
To PLATE 15

PLATE 15

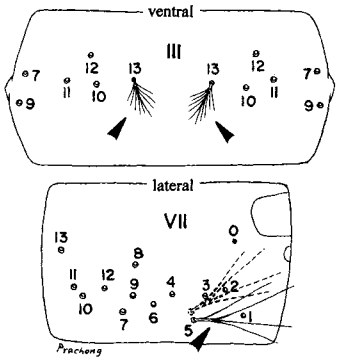
From PLATE 14: Seta 3-C with 30-95 branches, rarely fewer than 40; sum of branches of both seta 5-III plus those of both seta 13-IV rarely more than 24

Difference between sum of branches on both seta 13-III and that of both seta 5-VII is 0-10
(13-III+13-III) - (5-VII+5-VII) = 0-10 branches

Difference between sum of branches of both seta 13-III and that of both seta 5-VII is 9-23
(13-III + 13-III) - (5-VII+5-VII) = 9-23 branches

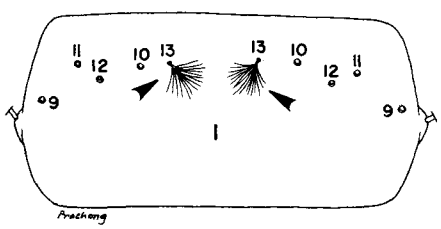


An. barbirostris[a]
(A, B, and C)

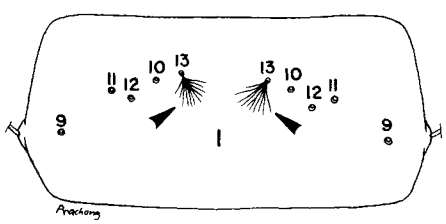


Sum of branches of both seta 13-I is 27-45
[(13-I + 13-I) = 27-45 branches]

Sum of branches of both seta 13-I is 18-27
[(13-I + 13-I) = 18-27 branches]



An. campestris[a]



An. donaldi [a]

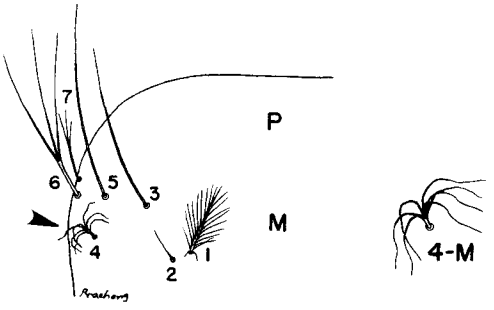
[a]The larval stage is less reliable than the pupal stage for distinguishing these 3 species.

PLATE 16

KEY TO THE SPECIES OF THE HYRCANUS GROUP FOURTH-INSTAR LARVAE

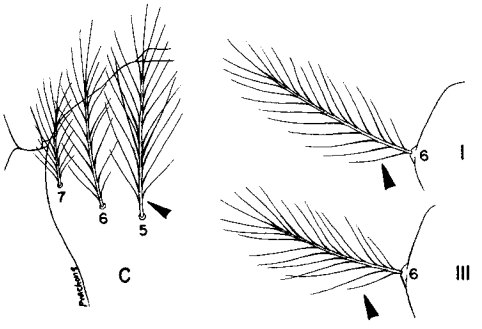
From PLATE 5: Seta 3-C divided from near base into 40 or more branches; seta 1-P simple or with 2-5 short branches on distal half

Seta 4-M small, with thin sinuate spreading branches arising close together at base



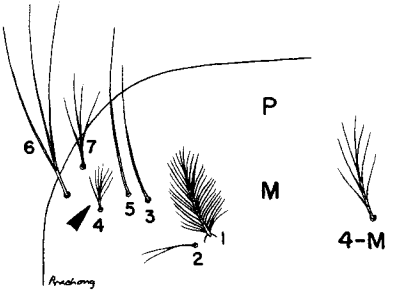
An. peditaeniatus

1. Seta 5-C with 17 or more branches
2. Seta 6-III usually with more than 20 branches
3. Seta 6-I usually with more than 21 branches

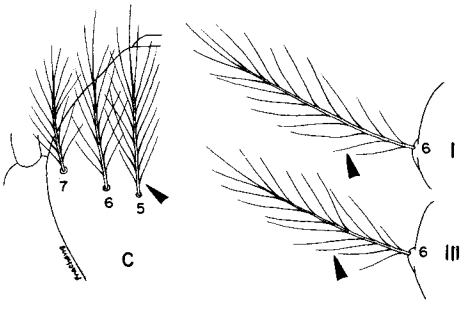


An. sinensis
(A and B)

Seta 4-M with stiff more erect branches arising along central stem or close together near base



1. Seta 5-C with 11-18 branches
2. Seta 6-III rarely with more than 20 branches
3. Seta 6-I usually with fewer than 21 branches

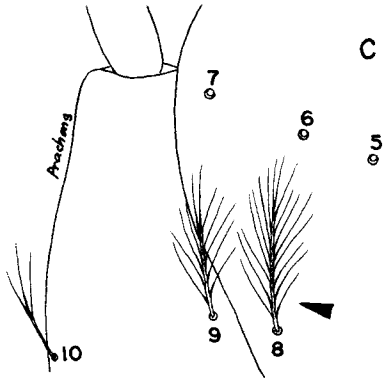


To PLATE 17

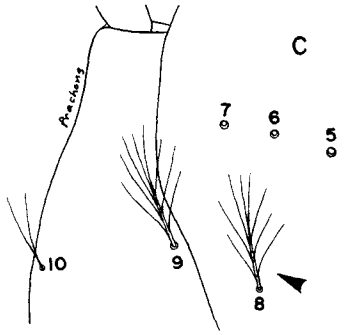
PLATE 17

From PLATE 16: Seta 5-C with 11-18 branches; seta 6-III rarely with more than 20 branches; seta 6-I usually with fewer than 21 branches

Seta 8-C with 12-24 branches (rarely 11 branches on *An. nitidus*)

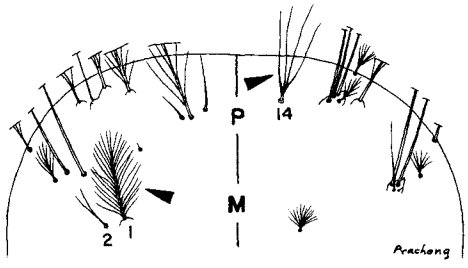


Seta 8-C with 5-11 branches



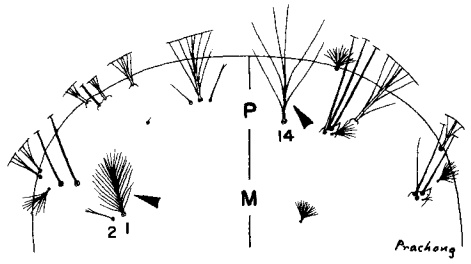
To PLATE 18

1. Seta 14-P with 3-5, usually 3 or 4 branches
2. Seta 1-M with 26-38 branches, usually 28 or more



An. pursati

1. Seta 14-P with 5 or more (rarely 5) branches
2. Seta 1-M with fewer than 28 branches

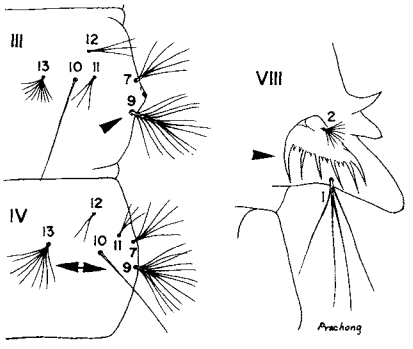


To PLATE 19

PLATE 18

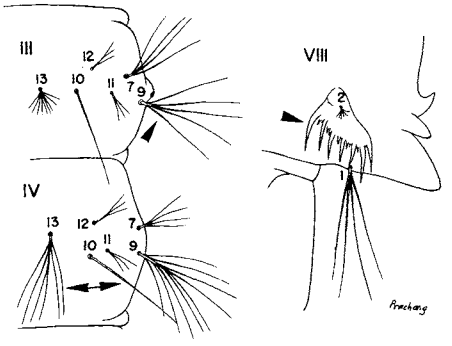
From PLATE 17: Seta 8-C with 5-11 branches

1. Seta 9-III with 10-16 branches
2. Pecten seldom with more than 6 long teeth
3. Seta 13-IV short, with 6-12 branches, approximately 0.5 length of seta 10-IV

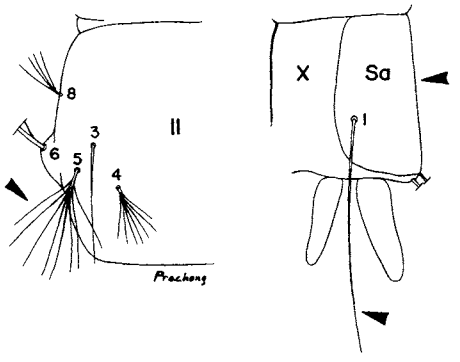


An. nitidus (in part)

1. Seta 9-III with fewer than 10 branches
2. Pecten rarely with fewer than 7 long teeth
3. Seta 13-IV long, with 4-9 branches, approximately equal to or slightly less length of seta 10-IV

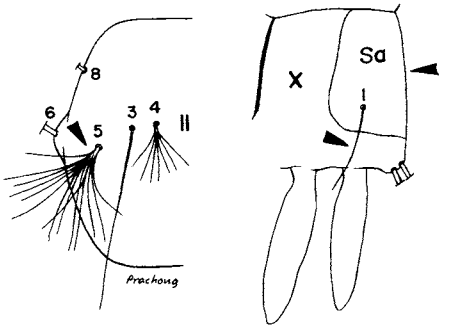


1. Seta 5-II with 6-10 branches
2. Seta 1-X strong, longer than saddle



An. paraliae

1. Seta 5-II seldom with fewer than 12 branches
2. Seta 1-X usually weak and shorter than saddle



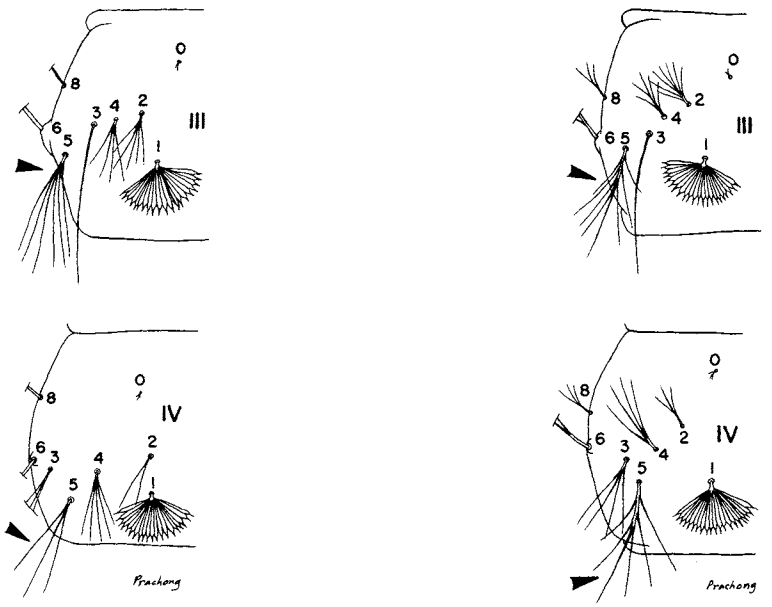
An. crawfordi
(A and B)

PLATE 19

From PLATE 17: Seta 14-P with 5 or more (rarely 5) branches; seta 1-M with fewer than 28 branches

1. Seta 5-III with 4-8 branches
2. Seta 5-IV with 2-4 branches, usually 3

1. Seta 5-III with 7-17 branches
2. Seta 5-IV seldom with fewer than 5 branches



An. nigerrimus
(A and B)

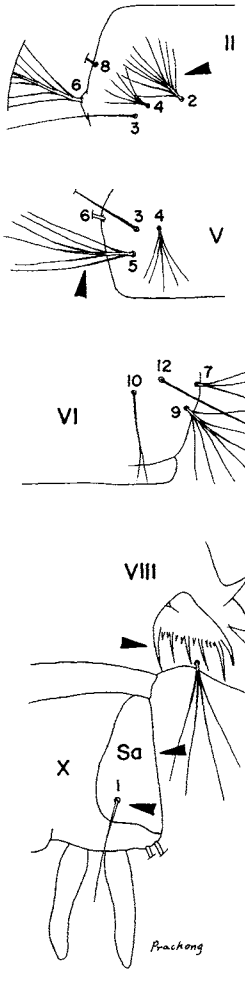
To PLATE 20

PLATE 20

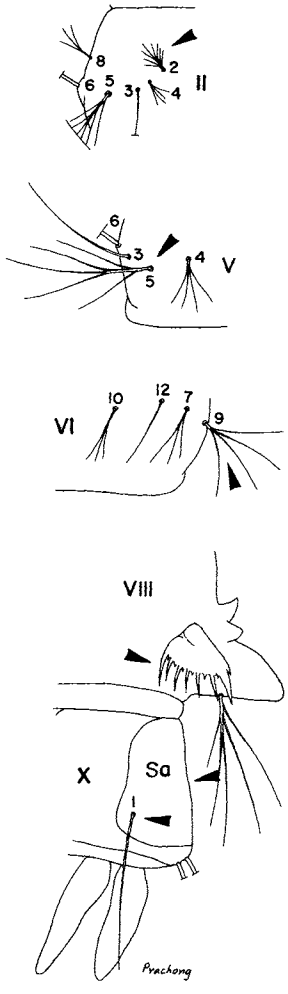
From PLATE 19: Seta 5-III with 7-17 branches; seta 5-IV seldom with fewer than 5 branches

1. Seta 2-II with 8-14 branches
2. Seta 5-V with 5-9 branches
3. Seta 9-VI with 5-9 branches
4. Pecten seldom with more than 6 long teeth
5. Seta 1-X weak, rarely longer than saddle

1. Seta 2-II with 6-9 branches
2. Seta 5-V with 4-6 branches
3. Seta 9-VI with 4 or 5 branches
4. Pecten usually with 7 or 8 long teeth
5. Seta 1-X strong, longer than saddle



An. nitidus (in part)



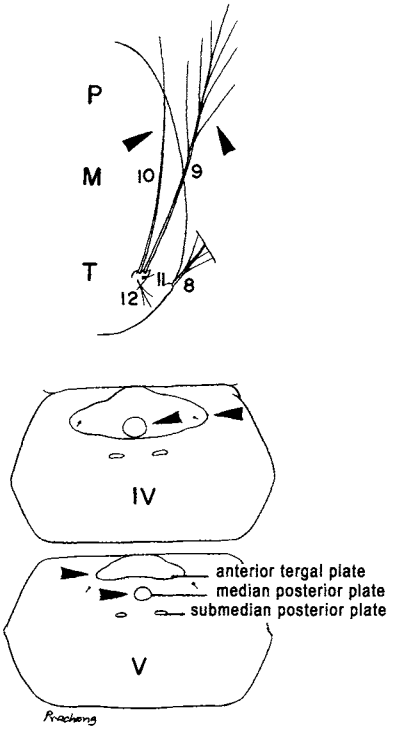
An. argyropus (A and B)

PLATE 21

KEY TO THE SERIES OF SUBGENUS *CELLIA* FOURTH-INSTAR LARVAE

From PLATE 1: Distance between bases of seta 2-C wider than distance between bases of setae 2-C and 3-C on one side; seta 1-A small and simple, rarely bifid or trifid; setae 5-, 6-, and 7-C long and branched

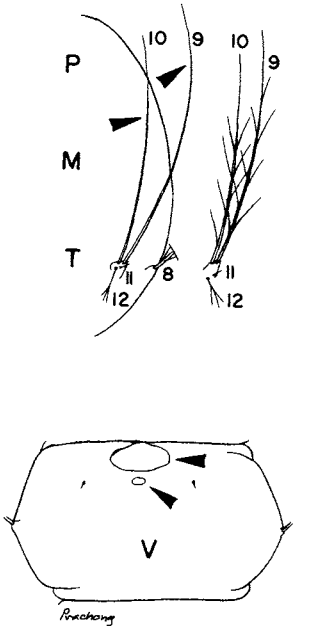
1. Setae 9,10-T with only one seta simple
2. Abdominal segments IV-VII with very large tergal plates[a] enclosing small median posterior plates, but not small oval submedian posterior plates, **if small**, not enclosing small median posterior plates and pair of small oval submedian posterior plates



Myzomyia Series

To PLATE 23

1. Setae 9,10-T both branched or both simple
2. Abdominal segments IV-VII with small tergal plates not enclosing small median posterior plates



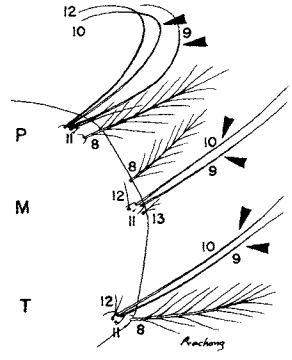
To PLATE 22

[a]As wide as or wider than distance between the bases of pair of palmate setae.

PLATE 22

From PLATE 21: Setae 9,10-T both branched or both simple; abdominal segments IV-VII with small tergal plates not enclosing small median posterior plates

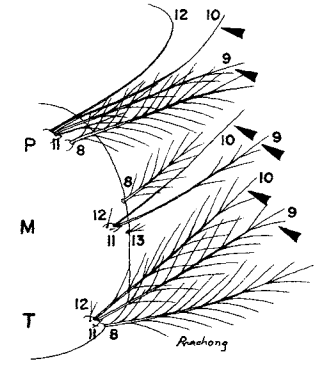
1. Setae 9,10-T simple
2. Setae 9,10-P and 9,10-M all simple



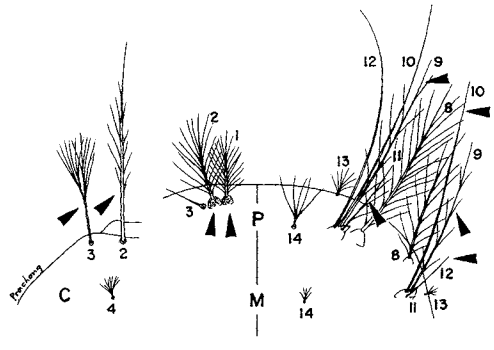
Neomyzomyia Series

→ To PLATE 26

1. Setae 9,10-T branched
2. Setae 9,10-P and 9,10-M not all simple



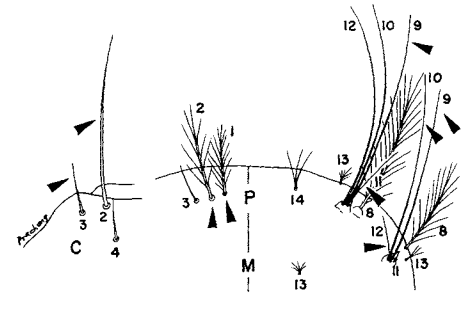
1. Setae 2, 3-C with lateral barbs or branches (both simple in *An. stephensi*)
2. Setae 1, 2-P with darkly sclerotized bases
3. Seta 9-P long, branched, and 11-P short, branched, except *An. stephensi*
4. Seta 9-M plumose, branched from base, setae 10-12-M simple



Neocellia Series

→ To PLATE 32

1. Setae 2, 3-C simple
2. Setae 1, 2-P with lightly sclerotized bases
3. Setae 9-12-P all simple, or one with 2 or 3 distal branches
4. Setae 9,10-M simple, or 9-M with 2 or 3 distal branches



Pyretophorus Series

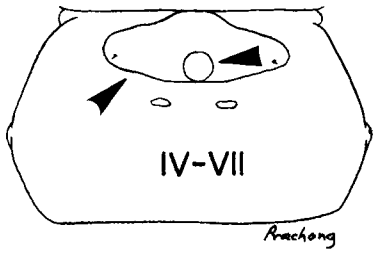
→ To PLATE 38

PLATE 23

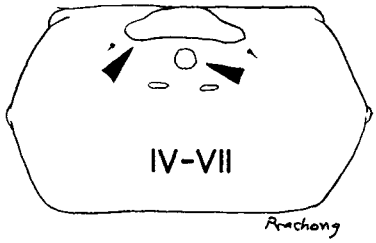
KEY TO THE SPECIES OF THE MYZOMYIA SERIES, FUNESTUS GROUP FOURTH-INSTAR LARVAE

From PLATE 21: Setae 9,10-T with only one seta simple; abdominal segments IV-VII with very large tergal plates enclosing small median posterior plates, but not small oval submedian posterior plates, **if small**, not enclosing small median posterior plates and pair of small oval submedian posterior plates

Anterior tergal plates on IV-VII large, enclosing small median posterior tergal plates

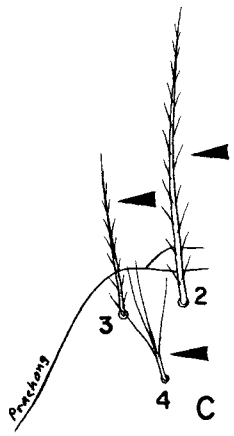


Anterior tergal plates on IV-VII smaller, not enclosing small median posterior tergal plates



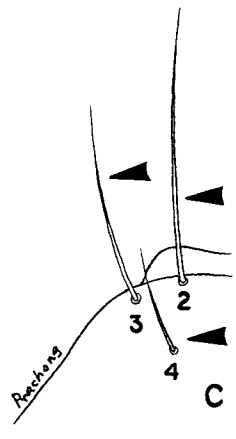
To PLATE 24

1. Setae 2, 3-C with numerous short lateral barbs
2. Seta 4-C with 2-5 branches



An. jeyporiensis
(A, B, C, and D)

1. Setae 2, 3-C simple
2. Seta 4-C simple

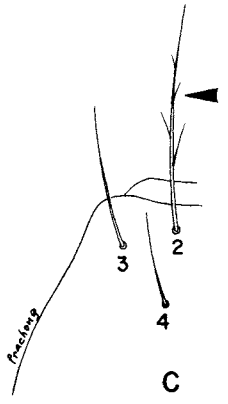


Culicifacies Subgroup
An. culicifacies
(A and B)

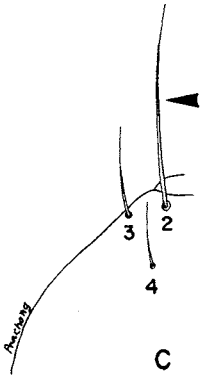
PLATE 24

From PLATE 23: Anterior tergal plates on IV-VII large, enclosing small median posterior tergal plates

Seta 2-C rarely simple, with one to many fine or stout, short lateral barbs[a]



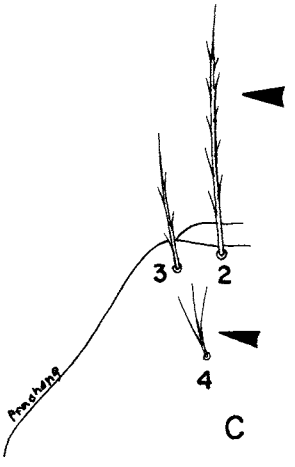
Seta 2-C simple



Aconitus Subgroup (in part)

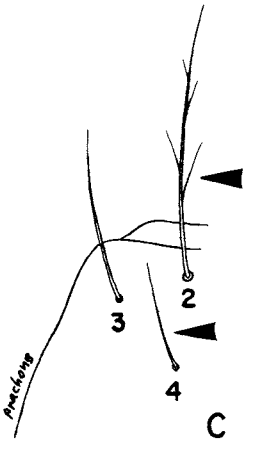
→ To PLATE 25

1. Seta 2-C with 9-18 short lateral barbs
2. Seta 4-C with 2-5 branches



An. aconitus
(A, B, and C)

1. Seta 2-C with 1-4 short lateral barbs
2. Seta 4-C simple



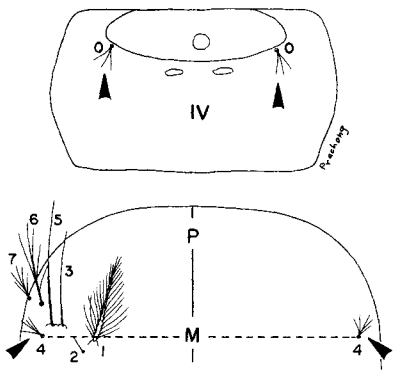
An. varuna

[a]Occasional *An. varuna* have both setae 2-C simple, but they can be identified by having seta 3-T leaflets with long slender filaments.

PLATE 25

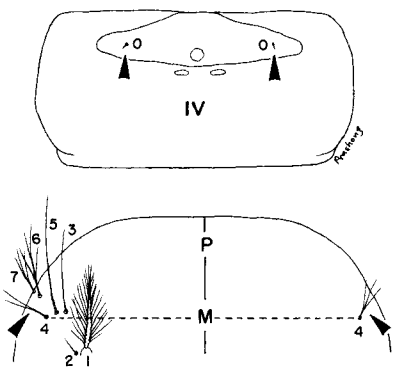
From PLATE 24: Seta 2-C simple

1. Seta 0-IV, V with 2-6 branches arising on segmental membrane
2. Sum of branches on both seta 4-M is 8-11



Minimus Subgroup
An. minimus and *An. minimus* species C

1. Seta 0-IV, V small, simple, arising on anterior tergal plate
2. Sum of branches on both setae 4-M is 4-6



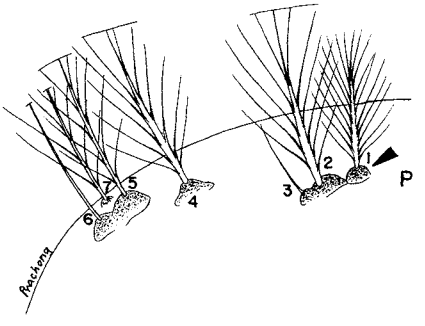
Aconitus Subgroup (in part)
An. pampanai

PLATE 26

KEY TO THE SPECIES OF THE NEOMYZOMYIA SERIES FOURTH-INSTAR LARVAE

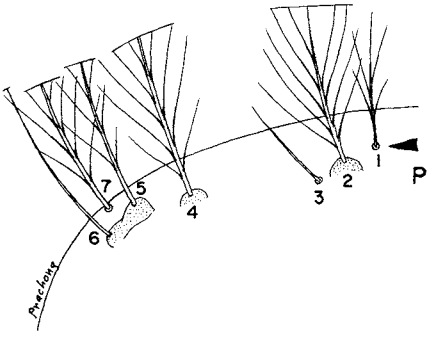
From PLATE 22: Setae 9,10-T simple; setae 9,10-P and 9,10-M all simple

Seta 1-P with more than 10 branches arising from large, darkly pigmented basal tubercle, often joined with median tubercle



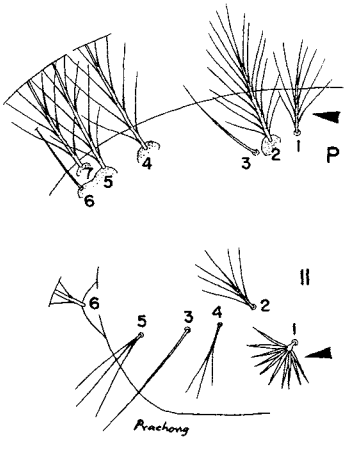
Leucosphyrus Group

Seta 1-P with 2-10 branches arising from small, lightly pigmented basal tubercle



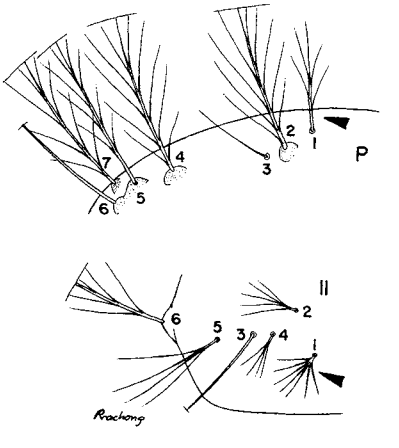
To PLATE 27

1. Seta 1-P usually with 7-10 branches
2. Abdominal seta 1-II palmate, with flattened leaflets



Kochi Group
An. kochi

1. Seta 1-P usually with 2-5 branches
2. Abdominal seta 1-II not palmate, with filamentous branches



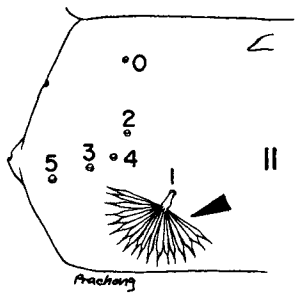
Tessellatus Group
An. tessellatus

PLATE 27

KEY TO THE SPECIES OF THE LEUCOSPHYRUS GROUP FOURTH-INSTAR LARVAE

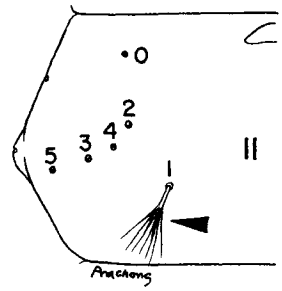
From PLATE 26: Seta 1-P with more than 10 branches arising from large, darkly pigmented basal tubercle, often joined with median tubercle

Abdominal seta 1-II palmate with clearly differentiated filamentous tips

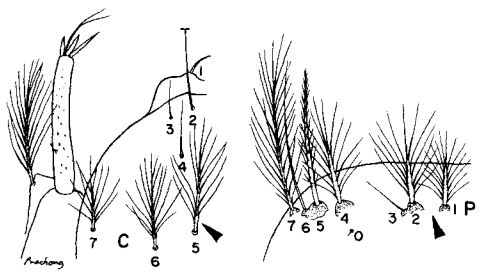


An. hackeri

Abdominal seta 1-II not fully developed, with at most lanceolate tips

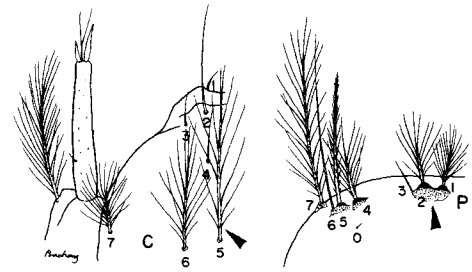


1. Seta 5-C shorter, as long as or slightly longer than antenna
2. Basal sclerotized tubercle of seta 1-P usually separated from tubercle of 2, 3-P at least on one side, usually both



An. scanloni

1. Seta 5-C conspicuously longer than antenna
2. Basal sclerotized tubercle of seta 1-P joined or separated from tubercle of 2, 3-P

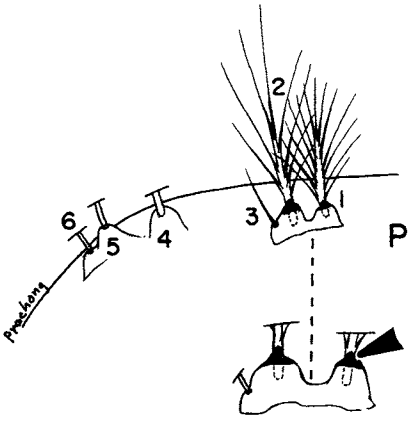


To PLATE 28

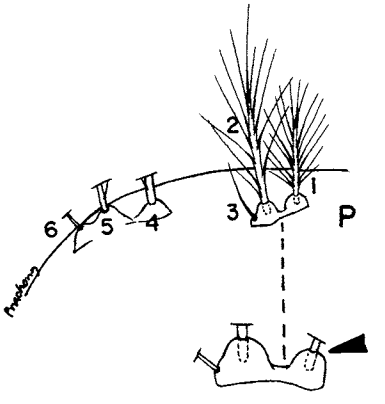
PLATE 28

From PLATE 27: Seta 5-C conspicuously longer than antenna; basal sclerotized tubercle of seta 1-P joined or separated from tubercle of 2, 3-P

Basal sclerotized tubercle of seta 1-P and usually 2-P with prominent tooth or spine arising from posterodorsal margin

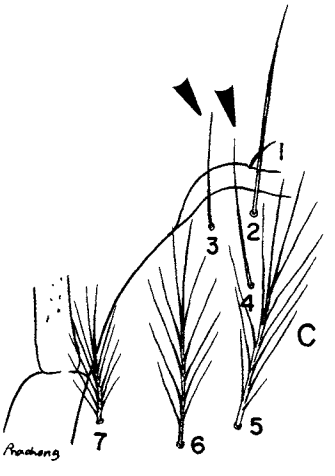


Basal sclerotized tubercle of setae 1,2-P without prominent tooth or spine arising from posterodorsal margin, usually with broad, short, apically rounded lip, or occasionally with small short pointed tooth



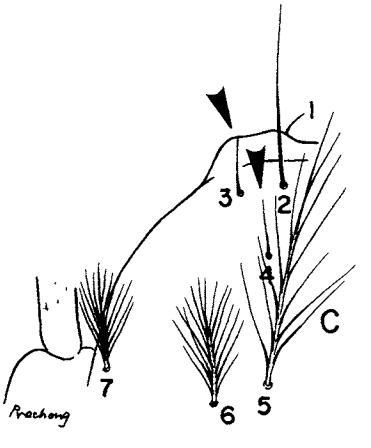
To PLATE 29

Setae 3, 4-C long, 4-C always extending noticeable beyond base of 2-C, seta 3-C extending well beyond anterior margin of head



To PLATE 30

Setae 3, 4-C short, 4-C extending to point before or slightly beyond base of 2-C, seta 3-C extending to or only slightly beyond anterior margin of head

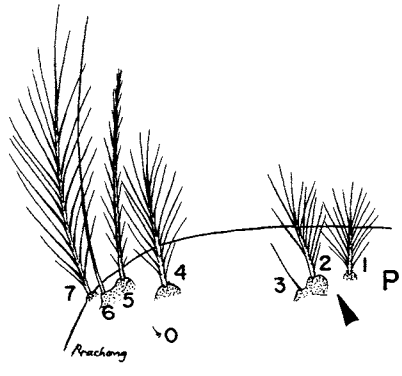


To PLATE 31

PLATE 29

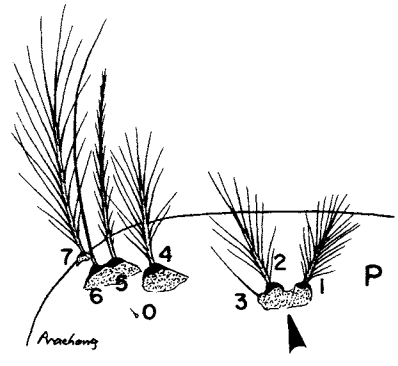
From PLATE 28: Basal sclerotized tubercle of seta 1-P without prominent tooth or spine arising from posterodorsal margin, usually with broad, short, apically rounded lip, or occasionally with small short pointed tooth

Basal tubercles of setae 1, 2-P usually separated, with base of seta 1-P much smaller than base of seta 2-P, distance between bases wide, equal to or greater than basal width of tubercle of 1-P

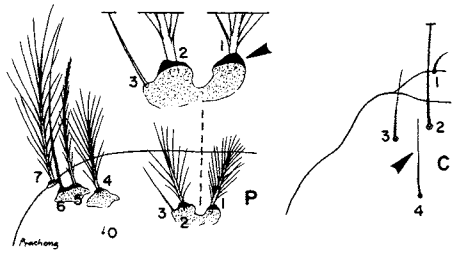


An. latens

Basal tubercles of setae 1, 2-P broadly joined, rarely separate on one side, if bases not joined, then separated by less than basal width of tubicle of seta 1-P

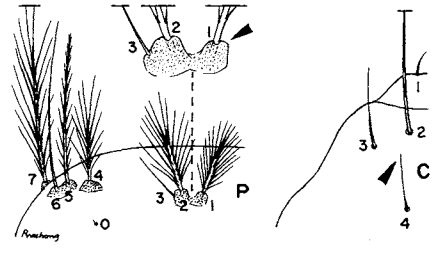


1. Basal scleotized tubercle of seta 1-P with prominent, broad, apically rounded, posteroapical process or lip
2. Seta 4-C long, extending to or slightly beyond base of seta 2-C



An. macarthuri

1. Basal scleotized tubercle of seta 1-P with at most very small, short, pointed tooth or none
2. Seta 4-C short, not extending to base of seta 2-C, usually only reaching 0.75 distance to base of seta 2-C



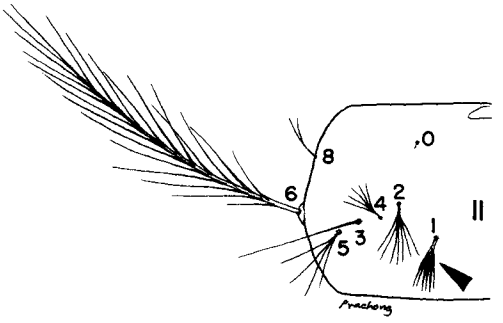
An. pujutensis[a]

[a] Occasional specimens of *An. pujutensis* with the basal tubercles separated have seta 14-P with more than 4 branches.

PLATE 30

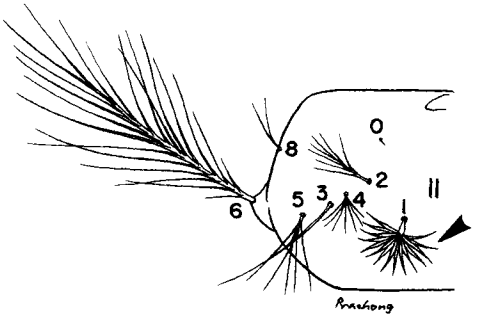
From PLATE 28: Setae 3, 4-C long, 4-C always extending noticeable beyond base of 2-C, seta 3-C extending well beyond anterior margin of head

Seta 1-II weakly developed, with very narrow, translucent, or very lightly pigmented leaflets, basal stem weak, not inflated

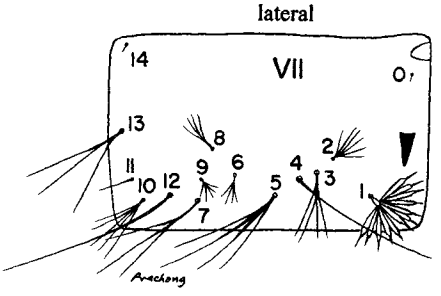


An. baimaii (in part)

Seta 1- II moderately developed, with distinct, moderately broad leaflets, light to brown pigmented, and basal stem usually stout and distinctly inflated

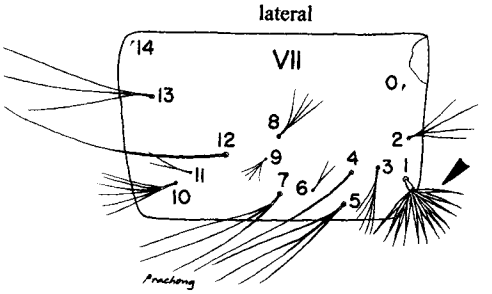


Individual leaflets of seta 1-VII with clearly differentiated apicolateral serrations and apical filament



An. introlatus

Individual leaflets of seta 1-VII without apicolateral serrations or rarely few leaflets may exhibit weak apical serrations, apical filament not clearly differentiated

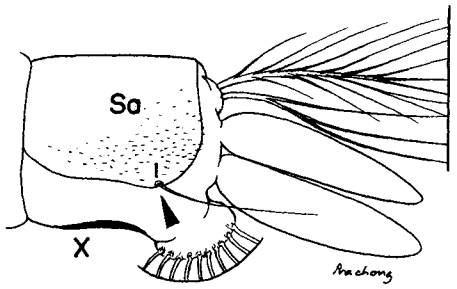


An. nemophilous

PLATE 31

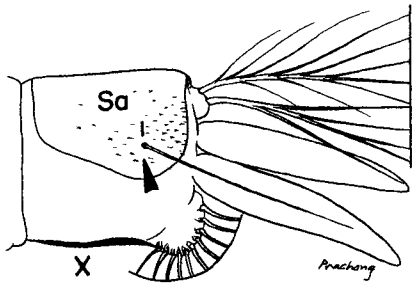
From PLATE 28: Setae 3, 4-C short, 4-C extending to point before or slightly beyond base of 2-C, seta 3-C extending to or only slightly beyond anterior margin of head

Seta 1-X inserted in marginal notch or beside edge of saddle



An. cracens
and *An. baimaii* (in part)

Seta 1-X clearly inserted on saddle, sometimes near margin



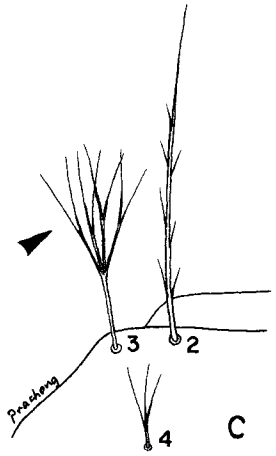
An. dirus

PLATE 32

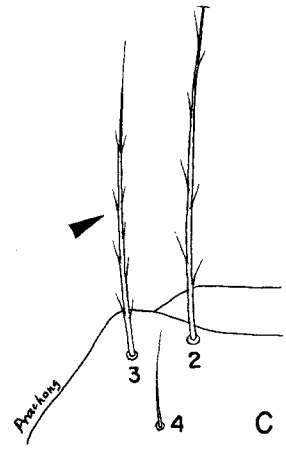
KEY TO THE SPECIES OF THE NEOCELLIA SERIES[a] FOURTH-INSTAR LARVAE

From PLATE 22: Setae 2,3-C with lateral barbs or branches (both simple in *An. stephensi*); setae 1,2-P with darkly sclerotized bases; seta 9-P long, branched, and 11-P short, branched, except *An. stephensi*; seta 9-M plumose, branched from base, setae 10-12-M simple

Seta 3-C with brush-like branches

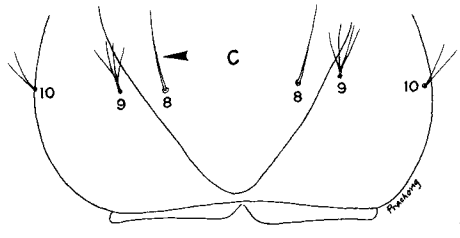


Seta 3-C simple or with short barbs



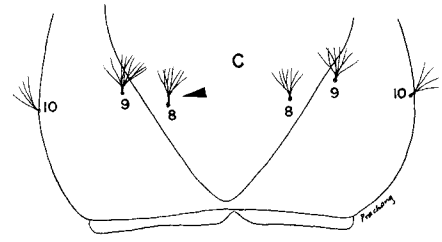
→ To PLATE 34

Seta 8-C simple or bifid at tip



→ To PLATE 33 (Above)

Seta 8-C split near base into 2-8 branches



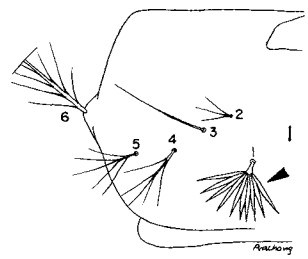
→ To PLATE 33 (Below)

[a]Because of overlapping larval characters group notations are not used in this key. (see Table 3)

PLATE 33

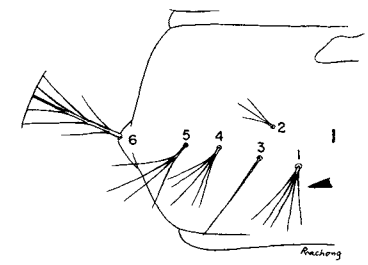
From PLATE 32: Seta 8-C simple or bifid at tip

Abdominal seta 1-I palmate, with well developed leaflets



Annularis Group (in part)
An. annularis

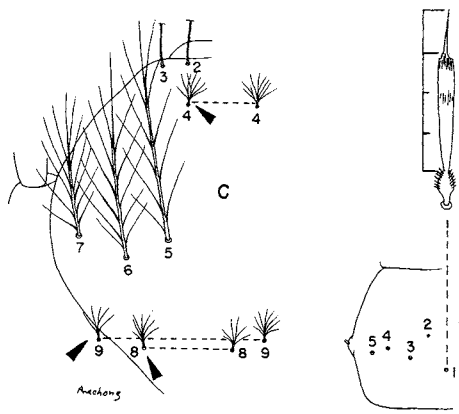
Abdominal seta 1-I not palmate, with filamentous branches



Jamesii Group (in part)
An. jamesii
(A and B)

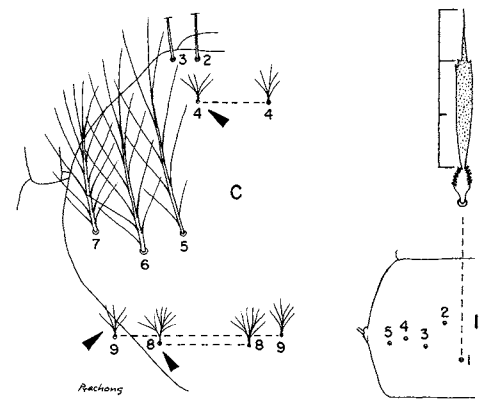
From PLATE 32: Seta 8-C split near base into 2-8 branches

1. Sum of branches on both seta 8-C, plus both seta 9-C, minus sum of both seta 4-C usually fewer than 15 (8-C+8-C)+(9-C+9-C)-(4-C+4-C)}= fewer than 15 branches)
2. Leaflets of abdominal seta 1 often with mottled pattern and slender filaments about 1/3 as long as blades



An. philippinensis[a]

1. Sum of branches on both seta 8-C plus both seta 9-C minus sum of both seta 4-C usually 15 or more {(8-C+8-C)+(9-C+9-C)-(4-C+4-C)} = 15 or more branches
2. Leaflets of abdominal seta 1 usually lightly pigmented and slender filaments about 1/2 as long as blades



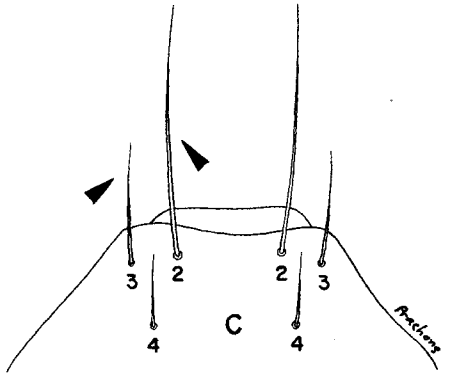
An. nivipes[a]
(A and B)

[a] Differences between *An. philippinensis* and *An. nivipes* are clearest in the pupal stage. Only about 80% of the larvae can be identified by the above characters.

PLATE 34

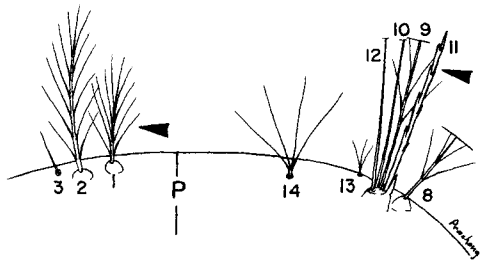
From PLATE 32: Seta 3-C simple or with short barbs

Setae 2,3-C simple



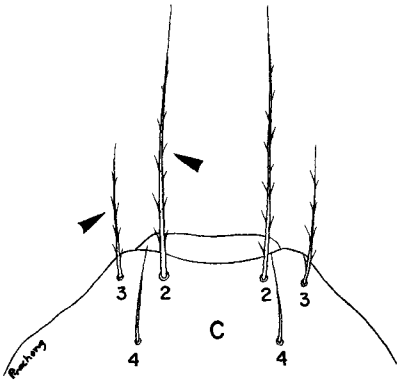
An. stephensi

1. Seta 1-P with fewer than 15 branches
2. Seta 11-P stout, spinulate with short blunt spines

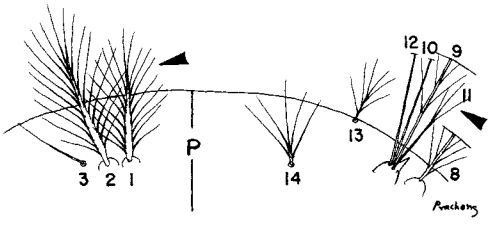


Jamesii Group
An. pseudojamesi

Setae 2,3-C with short barbs



1. Seta 1-P with 15 or more branches
2. Seta 11-P slender with fine branches

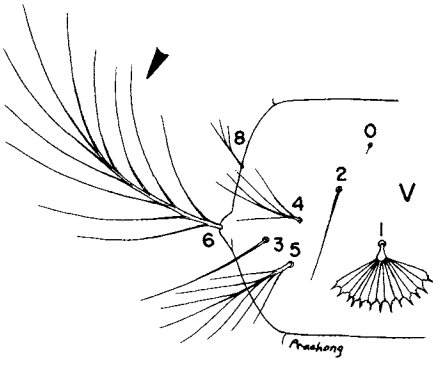


To PLATE 35

PLATE 35

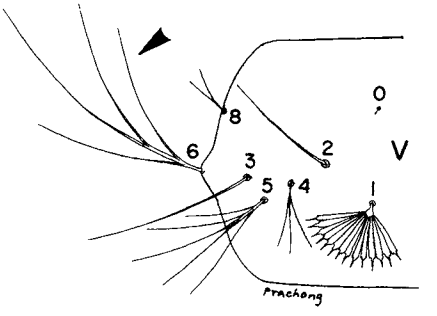
From PLATE 34: Seta 1-P with 15 or more branches; seta 11-P slender with fine branches

Abdominal seta 6-V,VI with 6-16 branches

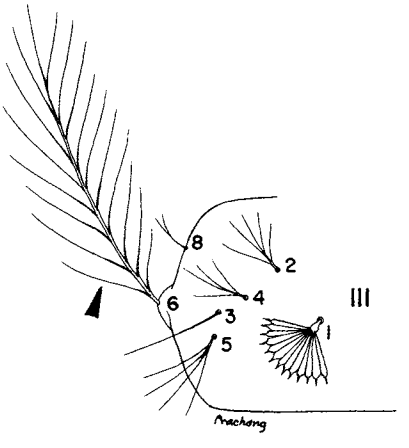


An. karwari
(A, B, and C)

Abdominal seta 6-V,VI with 3-6 branches[a]

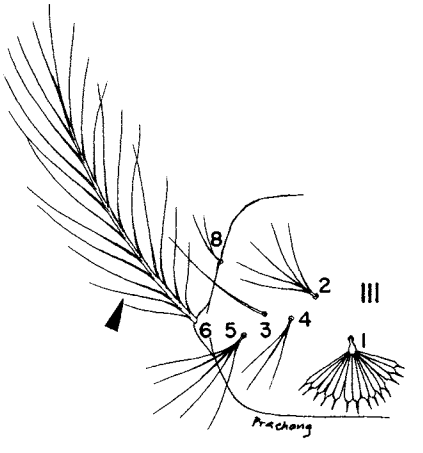


Abdominal seta 6-III usually with 15-19 branches, rarely more than 20



Jamesii Group (in part)
An. splendidus

Abdominal seta 6-III usually with 20 or more branches



Maculatus Group[a]

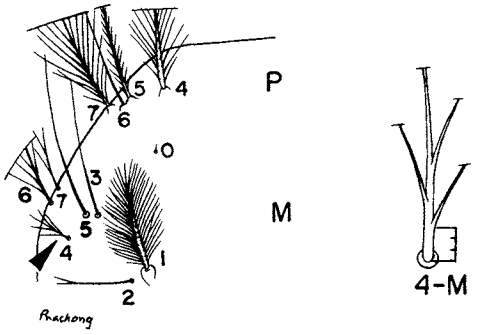
To PLATE 36

[a]Infrequent specimens of the Maculatus Group have seta 6-V, VI with up to 9 branches. Normally *An. karwari* larvae that have seta 6-V,VI with only 6-9 branches on one side will have more than 9 branches on these setae on the other side. However, reared adults with associated laval and pupal exuviae are the best means of identification.

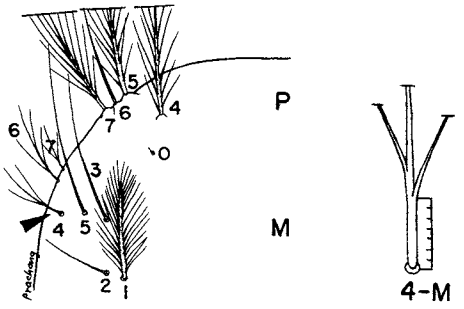
PLATE 36

From PLATE 35: Abdominal seta 6-III usually with 20 or more branches

Basal stem of seta 4-M no longer than 4 times its width[a]

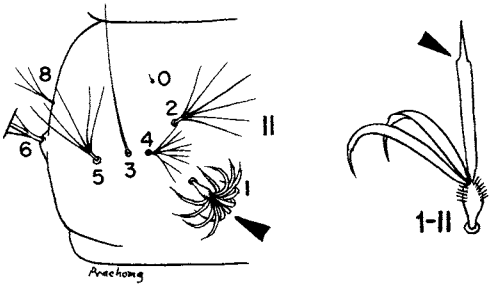


Basal stem of seta 4-M 5 times or more its width[a]

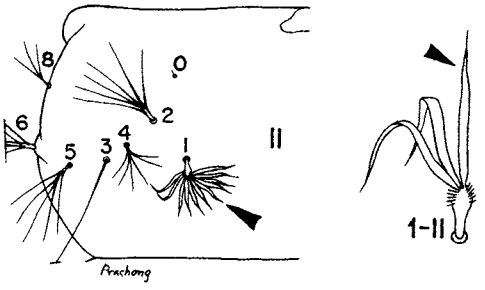


Sawadwongporni Subgroup[b]

Abdominal seta 1-II palmate, most leaflets with distinct serrated shoulders and short filament



Abdominal seta 1-II palmate, leaflets lanceolate, rarely with weakly serrated shoulders and distinct filament



An. pseudowillmori (in part)

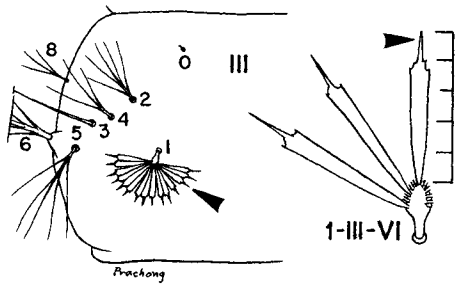
To PLATE 37

[a]Measure seta when it is in the same focal plane.
[b]*Anopheles sawadwongporni, An. notanandai,* and *An. maculatus* (K).

PLATE 37

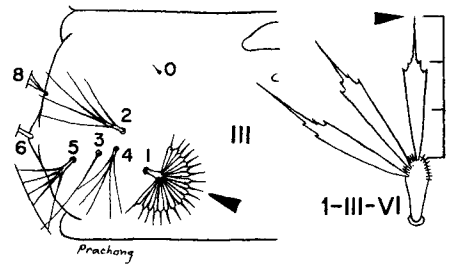
From PLATE 36: Abdominal seta 1-II palmate, leaflets lanceolate, rarely with weakly serrated shoulders and distinct filament

Leaflets of abdominal seta 1-III-VI with short slender filaments, about 1/4 as long as blade



An. maculatus, An. maculatus (E), and *An. dravidicus*

Leaflets of abdominal seta 1-III-VI with long slender filaments, very sharply pointed, 1/3-1/2 as long as blade (species on high elevation mountains)



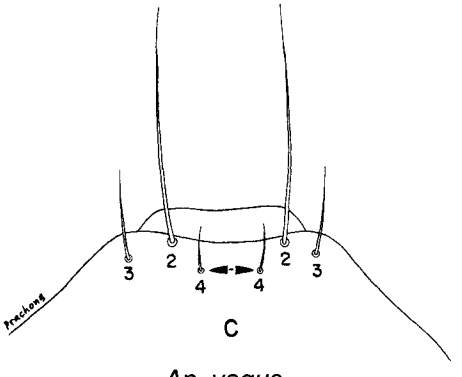
An. willmori and *An. pseudowillmori* (in part)

PLATE 38

KEY TO THE SPECIES OF THE PYRETOPHORUS SERIES FOURTH-INSTAR LARVAE

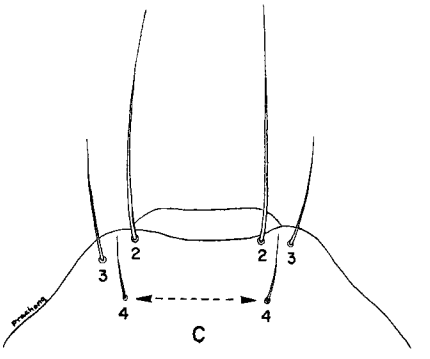
From PLATE 22: Setae 2,3-C simple; setae 1,2-P with lightly sclerotized bases; setae 9-12-P all simple, or one with 2 or 3 distal branches; setae 9,10-M simple, or 9-M with 2 or 3 distal branches

Seta 4-C short, arising near seta 2-C and with bases closer together than bases of seta 2-C

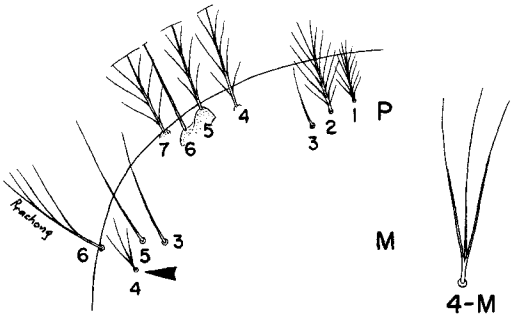


An. vagus
(A and B)

Seta 4-C usually long, arising far back from seta 2-C and with bases wide apart

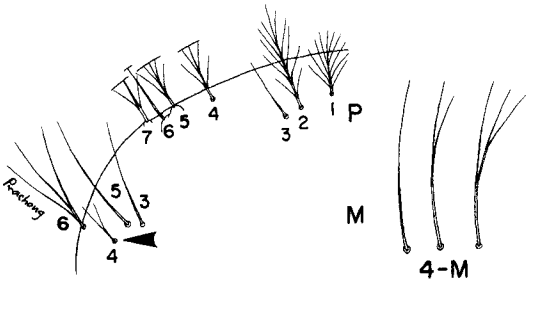


Seta 4-M split into 3 or 4 branches from near base



Sundaicus Complex
An. epiroticus

Seta 4-M with 1or 2 branches, if third branch present, it arises about half way along one of other branches



Subpictus Complex

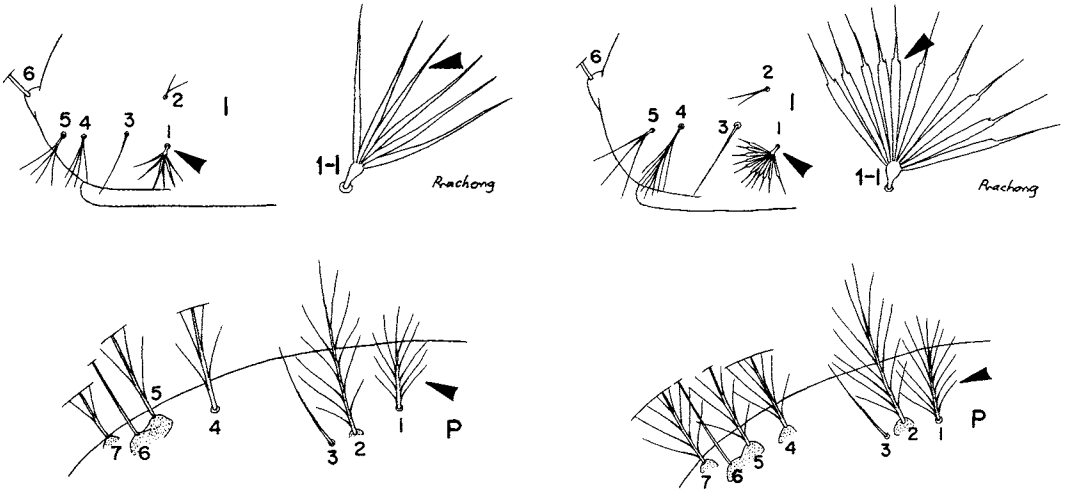
To PLATE 39

PLATE 39

From PLATE 38: Seta 4-M with 1 or 2 branches, if third branch present, it arises about half way along one of other branches

1. Abdominal seta 1-I palmate, usually with 6 or fewer leaflets, leaflets lanceolate without distinct serrated shoulders
2. Seta 1-P usually with fewer than13 branches

1. Abdominal seta 1-I palmate, seldom with fewer than 7 leaflets, **or** most leaflets with distinct serrated shoulders
2. Seta 1-P usually with13 or more branches



An. subpictus
(B, C, and D)

An. indefinitus