

AN ANNOTATED CHECKLIST  
OF THE *ANOPHELES* OF THAILAND

JOHN E. SCANLON  
E. L. PEYTON  
DOUGLAS J. GOULD

THAI NATIONAL SCIENTIFIC PAPERS

FAUNA SERIES NO. 2

APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND

BANGKOK 1968

595.771(593)  
S23

## THAI NATIONAL SCIENTIFIC PAPERS

A medium for the publication of results of original scientific research, issued by the Applied Scientific Research Corporation of Thailand as material becomes available, initially in the following series: Biological Series, Fauna Series, Flora Series, and Physical Sciences Series.

Papers may be submitted for publication in these series by authors irrespective of their institutional affiliations. Acceptance of papers is in the hands of an Editorial Committee consisting of AVM M.R. Sukshom Kashemsanta (Scientific Editor), Dr. Pradisth Cheosakul, Mr. Frank G. Nicholls, Dr. C. Lewis Wrenshall, Dr. Rawi Bhavilai, Mr. Tem Smitinand, Dr. James S. Dinning, and Dr. Siribongse Boon-Long.

Papers are accepted only after seeking the advice of specialist referees.

All enquiries and manuscripts should be forwarded to:

*The Scientific Editor, ASRCT  
196 Phahonyothin Road  
Bang Khen, Bangkok 9, Thailand*

## AVAILABLE PUBLICATION

THONGLONGYA, KITTI: A New Martin of the Genus *Pseudochelidon* from Thailand.  
Thai National Scientific Papers, Fauna Series No. 1.  
Price: 10 baht (foreign US\$0.75 including postage).

AN ANNOTATED CHECKLIST  
OF THE *ANOPHELES* OF THAILAND

JOHN E. SCANLON  
E. L. PEYTON  
DOUGLAS J. GOULD

THAI NATIONAL SCIENTIFIC PAPERS

FAUNA SERIES NO. 2

APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND

BANGKOK 1968



PUBLISHED 16 DECEMBER 1968 BY  
APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND  
BANG KHEN, BANGKOK

037167

595.771 (5937)

S23

PRINTED IN THAILAND AT THE ASRCT PRESS, BANGKOK  
BY GROUP CAPTAIN SORN SATRABHAYA 1968  
PRICE : 20 BAHT

AN ANNOTATED CHECKLIST OF THE *ANOPHELES* OF THAILAND  
(DIPTERA : CULICIDAE)\*

BY JOHN E. SCANLON,† E.L. PEYTON,† AND DOUGLAS J. GOULD‡

[Manuscript received 8 January 1968]

*Summary*

The following checklist contains all of the *Anopheles* known to occur in Thailand as of January 1968. Included are sixty-two species-group taxa, several of which are listed tentatively, pending further investigation. Under each species included are listed the most important collection records and other references for Thailand, as well as pertinent data on their distribution, habitats, and role in malaria transmission.

INTRODUCTION

The Kingdom of Thailand lies on the mainland of south-east Asia, between approximately 6 degrees and 21 degrees north latitude. The country has a particularly rich mosquito fauna, sharing many species with India and Indo-China in its northern and central monsoon areas, and having a large Malayan element in the more southern provinces. From 1961 to 1967 the Department of Medical Entomology of the U.S. Army Medical Component-South-East Asia Treaty Organization (SEATO) has conducted extensive studies on the mosquito fauna of Thailand, and on mosquito-borne diseases in the country. In the course of preparing detailed descriptions of the various *Anopheles* species encountered in these collections and illustrated keys to the species, the authors found it useful to prepare the following checklist of the *Anopheles* species of Thailand. It is anticipated that the list will change during the course of work still in progress, but it may be useful for entomologists and public health workers to have a working list for ready reference until the more detailed work has been completed and published. A number of new records of the country are included (Table 1, p. 5).

\*This is contribution number 76 from the Army Research Program on Malaria. Supported in part by Research Contract No. DA-49-193-MD-2672 from the U.S. Army Medical Research and Development Command, Office of the Surgeon General.

†Southeast Asia Mosquito Project, Smithsonian Institution, Washington, D.C.

‡Department of Medical Entomology, U.S. Army Medical Component—SEATO, Bangkok, Thailand.

In preparing the list, an effort was made to see all published references to the *Anopheles* of Thailand. The appropriate references have been listed for each included species. Several works of general interest (e.g. Brug and Bonne-Wepster 1947; Foote and Cook 1959; Smart 1948; Christophers 1933; and Puri 1949) have been listed in the References as an aid to those interested in the fauna, although they have not been cited in the checklist proper. The most recent complete list of the *Anopheles* of Thailand was published by Thurman (1959). Essentially the same list was given by Thurman in 1957 at the meetings of the Pacific Science Congress, but this was not actually published until 1962. Under each species included in the present list we have listed the most important collection records and other references for Thailand, in addition to the citation in the Thurman (1959) list.

The majority of the distribution records given for the various species are derived from the examination of specimens collected by SEATO personnel and now deposited in the United States National Museum (USNM). Additional specimens in the USNM collections were also examined, particularly those of D. C. and E. B. Thurman, O. R. Causey, and excellent series deposited at the Museum by E. I. Coher and P. F. Beales. More detailed collection records will be given in the taxonomic publications still in preparation for this series, but provincial records are listed for the species given here as a rapid guide to distribution. Distribution records, by provinces, have also been included from the published references to the *Anopheles* of Thailand where it was possible to identify the locality from the published data.

In the past, some difficulty has been encountered in listing distribution records because of the inherent problems of transcribing Thai place names into English. The Romanized versions of provincial names used in the checklist are in accordance with the standardized names proclaimed in the Royal Gazette of the Kingdom of Thailand, number 84, issued on 23 June 1967. A list of the provincial names used in the checklist is given in the Appendix; each province has also been numbered as an aid in locating it on the accompanying map (Figure 1 in the Appendix).

Synonymy, type localities, and distribution outside Thailand will be found in Stone, Knight, and Starcke (1959), and Stone (1961, 1963). Additional synonymy will be found in Reid (1965) for the *aitkenii* group.

Malaria control and eradication programmes have been in progress in Thailand for some years, and excellent results have been obtained in many areas (Ayurakitkosol and Griffith 1956, 1963). In the more difficult jungle areas, or recently cleared agricultural land, malaria still persists (Scanlon and Sandhinand 1965). *Anopheles minimus* Theobald was the first species implicated as a malaria vector in Thailand by dissection (Payung Vejjasatra 1933), and it was long believed to be the only important vector in the country (Griffith 1955). More recently, *balabacensis* Baisas has been implicated in several areas (Ayurakitkosol and Griffith 1963; Scanlon and Sandhinand 1965), and it may be a very important vector in parts of Thailand. *Anopheles aconitus* Dönitz has been implicated in malaria transmission in the central plain of Thailand (Gould *et al.* 1967), and *sundaicus* (Rodenwaldt) may be a locally important malaria vector in coastal areas (Barnes 1923*b*). Anigstein (1932) reported positive dissections for *annularis* Van der Wulp at Nonthaburi near Bangkok, and Griffith (1955) referred to a positive oocyst dissection for *barbirostris* Van der Wulp. As

studies proceed, it is probable that other *Anopheles* species will be found in Thailand with malaria oocysts or sporozoites.

*Anopheles* species have also been implicated in the transmission of human filariasis in Thailand. Iyengar (1953) reported the following species with microfilariae of *Brugia malayi* in southern Thailand: *albotaeniatus* (Theobald), *barbistrostris* Van der Wulp, *nigerrimus* Giles, *sinensis* Wiedemann, and *umbrosus* (Theobald). Harinasuta *et al.* (1964) found no infected *Anopheles* in later investigations in southern Thailand.

The following checklist contains all of the *Anopheles* known to occur in Thailand as of January 1968. Included are fifty-two species-group taxa positively known from Thailand, specimens of which were examined by the authors. In addition, one species, *bulkleyi* Causey, is definitely known from the country, but specimens were not available for study. Five additional species-group taxa have been reported from Thailand previously, but were not seen by the authors. These are: *aitkenii* James, *albotaeniatus* (Theobald), *gigas formosus* Ludlow, *gigas sumatrana* Swellengrebel & Rodenwaldt, and *majidi* Young & Majid. As noted in the species discussions, several species-group taxa are included in the list tentatively, pending further investigation. These are: *maculatus willmori* James, *filipinae* Manalang, *fluviatilis* James, and *varuna* Iyengar.

TABLE 1

## SUMMARY OF ANOPHELES TAXA RECORDED FROM THAILAND

## Valid records

- Anopheles* (*Anopheles*) *annandalei interruptus* Puri  
*A.* (*Anopheles*) *argyropus* (Swellengrebel)  
*A.* (*Anopheles*) *asiaticus* (Leicester)  
*A.* (*Anopheles*) *baezai* Gater  
*A.* (*Anopheles*) *barbistrostris* Van der Wulp  
*A.* (*Anopheles*) *barbumbrosus* Strickland & Choudhury  
*A.* (*Anopheles*) *bengalensis* Puri  
*A.* (*Anopheles*) *bulkleyi* Causey\*  
*A.* (*Anopheles*) *campestris* Reid  
*A.* (*Anopheles*) *crawfordi* Reid  
*A.* (*Anopheles*) *donaldi* Reid  
*A.* (*Anopheles*) *fragilis* (Theobald)  
*A.* (*Anopheles*) *hodgkini* Reid  
*A.* (*Anopheles*) *indiensis* Theobald  
*A.* (*Anopheles*) *insulaeflorum* (Swellengrebel & Swellengrebel de Graaf)  
*A.* (*Anopheles*) *lesteri paraliae* Sandosham  
*A.* (*Anopheles*) *lerifer* Sandosham  
*A.* (*Anopheles*) *montanus* Stanton & Hacker  
*A.* (*Anopheles*) *nigerrimus* Giles  
*A.* (*Anopheles*) *palmatum* (Rodenwaldt)  
*A.* (*Anopheles*) *peditaeniatus* (Leicester)  
*A.* (*Anopheles*) *pollicaris* Reid  
*A.* (*Anopheles*) *pursati* Laveran  
*A.* (*Anopheles*) *roperi* Reid  
*A.* (*Anopheles*) *separatus* Leicester  
*A.* (*Anopheles*) *sinensis* Wiedemann

TABLE 1 (continued)

- A. (Anopheles) sintonoides* Ho  
*A. (Anopheles) tigerti* Scanlon & Peyton  
*A. (Anopheles) umbrosus* (Theobald)  
*A. (Cellia) aconitus* Dönitz  
*A. (Cellia) annularis* Van der Wulp  
*A. (Cellia) balabacensis* Baisas  
*A. (Cellia) balabacensis introlatus* Colless  
*A. (Cellia) culicifacies* Giles  
*A. (Cellia) hackeri* Edwards  
*A. (Cellia) jamesii* Theobald  
*A. (Cellia) jeyporiensis candidiensis* Koizumi  
*A. (Cellia) karwari* (James)  
*A. (Cellia) kochi* Dönitz  
*A. (Cellia) maculatus* Theobald  
*A. (Cellia) minimus* Theobald  
*A. (Cellia) pallidus* Theobald  
*A. (Cellia) pampanai* Büttiker & Beales  
*A. (Cellia) philippinensis* Ludlow  
*A. (Cellia) pujutensis* Colless  
*A. (Cellia) ramsayi* Covell  
*A. (Cellia) riparis macarthuri* Colless  
*A. (Cellia) splendidus* Koizumi  
*A. (Cellia) stephensi* Liston  
*A. (Cellia) subpictus* Grassi  
*A. (Cellia) sundaicus* (Rodewaldt)  
*A. (Cellia) tessellatus* Theobald  
*A. (Cellia) vagus* Dönitz

## Doubtful records

- Anopheles (Anopheles) aitkenii* James\*  
*A. (Anopheles) albotaeniatus* (Theobald)\*  
*A. (Anopheles) gigas formosus* Ludlow\*  
*A. (Anopheles) gigas sumatrana* Swellengrebel & Rodewaldt\*  
*A. (Cellia) filipinae* Manalang  
*A. (Cellia) fluviatilis* James\*  
*A. (Cellia) maculatus willmori* James  
*A. (Cellia) majidi* Young & Majid\*  
*A. (Cellia) varuna* Iyengar

## Misidentifications

- Anopheles (Cellia) jeyporiensis* James

\*No specimens identified as this taxon were seen by the authors.



## CHECKLIST

## Subgenus ANOPHELES Meigen, 1818

## ANOPHELES (ANOPHELES) AITKENII James, 1903

*Previous Thailand records:* Wilson and Reid (1947, p. 266); Sandhinand (1951, p. 36); Thurman (1959, p. 121); Reid (1965, p. 109).

*Discussion:* Examination of specimens in the SEATO and USNM collections indicate that the records for this species in Thailand may refer to *bengalensis* Puri, *fragilis* (Theobald), *insulaeflorum* (Swellengrebel & Swellengrebel de Graaf), or *palmatus* (Rodenwaldt). The females of the *aitkenii* group are indistinguishable at present and the males, larvae, or pupae examined from Thailand in the present study were one of the above species. There are a large number of females in the collection from several localities in Thailand identified as *aitkenii*, but for the present these may be taken as referring to the group, rather than *aitkenii, sensu stricto*. In his recent review of the group, Reid (1965) noted that he did not see specimens of *aitkenii* from Thailand, and his record for this country was based on published reports. Therefore, this species is listed for Thailand with reservations, pending further investigation.

## ANOPHELES (ANOPHELES) ALBOTAENIATUS (Theobald), 1903

*Previous Thailand records:* Iyengar (1953, p. 747); Thurman (1959, p. 119).

*Discussion:* Iyengar (1953) reported finding the microfilariae of *Brugia malayi* in one of twenty-five *albotaeniatus* examined in southern Thailand. The precise locality was not indicated, but his studies were carried on in Pattani, Nakhon Si Thammarat, Phatthalung, and Surat Thani Provinces. Harinasuta *et al.* (1964) conducted extensive filariasis studies in Surat Thani Province, but did not report this species. None are present in the SEATO or USNM collections from Thailand. However, the closely related species *montanus* Stanton & Hacker was collected by SEATO at several localities in southern Thailand.

## ANOPHELES (ANOPHELES) ANNANDALEI INTERRUPTUS Puri, 1918

*Previous Thailand records:* Sandhinand (1951, p. 35, as *annandalei*); Thurman (1959, p. 121); Scanlon and Esah (1965, p. 138, as *annandalei*).

*Discussion:* Thurman (1959) indicated that this subspecies was reported from Thailand for the first time between 1950 and 1956. Two larval specimens in the USNM were collected by Thai workers in 1958 on Doi Suthep mountain near Chiang Mai. Additional specimens in the SEATO collection were made by human biting collections, or netted from swarms in the same locality. Larval collections, from tree holes, were made in Trang and Tak Provinces. In Thailand the subspecies appears to be restricted to forested hills. The specimens taken in the human biting collections at Chiang Mai were not permitted to engorge, and the biting habits of the females are still unknown.

*Distribution in Thailand:* Chiang Mai, Nakhon Si Thammarat, Tak, Trang.

## ANOPHELES (ANOPHELES) ARGYROPOUS (Swellengrebel), 1914

*Previous Thailand records:* Stanton (1920, 747, as var. *peditaeniatus*, see Reid 1953); Barraud and Christophers (1931, p. 271, as *hyrcanus* var. *negerrimus* Giles, in part); Reid (1953, p. 39); Thurman (1959, p. 119); Harinasuta *et al.* (1964, p. 323); Scanlon and Esah (1965, p. 138).

*Discussion:* Barraud and Christophers (1931) noted the variability of the white markings on the hind tarsus of *hyrcanus* in Thailand. They specifically mentioned that a form resembling *argyropus* was present and said that they regarded *argyropus* as a synonym of *nigerrimus* Giles. The entire question of the species of the *hyrcanus* group in Thailand is complex and requires additional study, but the following forms, as defined by Reid (1953), appear to be present, in addition to *argyropus*: *sinensis* Wiedemann, *nigerrimus* Giles, *indiensis* Theobald, *peditaeniatus* Leicester, *lesteri paraliae* Sandosham, *crawfordi* Reid, and *pursati* Laveran. Each of these species will be discussed below. Collections by SEATO in the Bangkok area showed that *argyropus* was most abundant there from November to January. It fed infrequently on man, but more readily on large domestic animals. This is a moderately abundant species over much of Thailand. Larvae were collected from rice fields, marches, ditches, seepages, and sumps.

*Distribution in Thailand:* Ayutthaya, Chanthaburi, Chiang Mai, Chon Buri, Phra Nakhon (Bangkok), Nakhon Nayok, Nakhon Ratchasima, Narathiwat, Nonthaburi, Pathum Thani, Prachin Buri, Surat Thani, Satun, Udon Thani.

## ANOPHELES (ANOPHELES) ASIATICUS (Leicester), 1904

*Discussion:* Several lots of immature specimens were collected by SEATO from fallen split bamboo and bamboo stumps in the northern province of Tak in August 1965. The larval sites were in a forested area along streams at an altitude of 460 to 640 metres. It has since been collected several times in two southern provinces under similar conditions, but the altitude in the south was from 150 to 320 metres. This species had previously been known from Malaya. Reid (personal communication) examined a series of the Tak specimens and concurred in the identification. The feeding habits of the species are unknown. *Anopheles asiaticus* is apparently rather rare in Thailand, as large numbers of bamboo stumps and bamboo sections were examined over a period of four years before the first collections were made.

*Distribution in Thailand:* Nakhon Si Thammarat, Phangnga, Tak.

## ANOPHELES (ANOPHELES) BAEZAI Gater, 1933

*Previous Thailand records:* Iyengar (1953, p. 747); Thurman (1959, p. 121).

*Discussion:* Iyengar (1953) listed *baezai* for southern Thailand without further details. In Malaya, *baezai* is a brackish water species, frequently associated with nipa palm groves. It has been found with malaria sporozoites there, presumably of nonhuman origin (Wharton *et al.* 1964). The specimens in the SEATO collection

were collected in a mine pool with brackish water in Ranong Province on the western side of the Isthmus of Kra.

*Distribution in Thailand:* Ranong, "southern Thailand" (Iyengar 1953).

ANOPHELES (ANOPHELES) BARBIROSTRIS Van der Wulp, 1884

*Previous Thailand records:* Theobald (1910, p. 50); Stanton (1920, p. 334); Barnes (1923a, p. 123); Barraud and Christophers (1931, p. 273); Anigstein (1932, p. 251); Causey (1937a, p. 403); Payung Vejjasatra (1933, p. 661); de Fluiter (1948, p. 273); Wilson and Reid (1949, p. 270); Sandhinand (1951, p. 37); Iyengar (1953, p. 747); Griffith (1955, p. 565); Thurman and Thurman (1955, p. 138); Thurman (1959, p. 119); Reid (1962, p. 15); Tansathit *et al.* (1963, p. 138); Harinasuta *et al.* (1964, p. 323); Scanlon and Esah (1965, p. 138); Scanlon and Sandhinand (1965, p. 46).

*Discussion:* *Anopheles barbirostris* is one of the most abundant and widely distributed mosquito species in Thailand. It is found in urban and suburban areas, in agricultural regions, and in forested areas where clearings occur. In the Bangkok area *barbirostris* was most abundant in the month of December, some time after the end of the rainy season, suggesting a rice field habitat for the larvae, since the fields are at their maximum extent at that time. This proved to be the case, although larvae were also found in a wide variety of other habitats, such as surface pools, sumps, streamside pools, chain holes in logs, springs, water jugs, and rock holes. Records for *barbirostris* for the Bangkok area and other coastal plain areas of Thailand may be confused with *campestris*, according to Reid (1962). In Thailand, *barbirostris* seems to be strongly zoophilic, although it does attack man at times. Griffith (1955) reported a single malaria infection in *barbirostris*, but there is no evidence that it is an important malaria vector in Thailand. In southern Thailand, Iyengar (1953) found 11.7% of *barbirostris* infected with microfilariae of *Brugia malayi*.

*Distribution in Thailand:* *Anopheles barbirostris* was found in every province where a reasonable amount of collecting effort was expended. It appears to be absent from heavy forest, but may be encountered almost anywhere else in the country.

ANOPHELES (ANOPHELES) BARBUMBROSUS Strickland & Choundhury, 1927

*Previous Thailand records:* Sandosham (1945); Wilson and Reid (1949, p. 266); Sandhinand (1951, p. 37); Thurman and Thurman (1955, p. 222); Iyengar and Menon (1956, p. 792); Thurman (1959, p. 121); Reid (1962, p. 33); Tansathit *et al.* (1963, p. 138); Scanlon and Esah (1965, p. 138).

*Discussion:* According to Reid (1962), Iyengar and Menon's single specimen from southern Thailand was actually *barbirostris*. Reid examined specimens from Chiang Mai, collected by Coher and Beales, and some specimens from that series are in the USNM. This species appears to be rather widely distributed in Thailand, but not common. It appears to be characteristic of forested foothills, and it does feed on man at times. Larvae were collected from stream pools, rice fields, puddles, ditches, rock pools, and once from water jug.

*Distribution in Thailand:* Chanthaburi, Chiang Mai, Chon Buri, Khon Kaen, Lampang, Nakhon Nayok, Nakhon Ratchasima, Nakhon Si Thammarat, Nan, Phangnga.

ANOPHELES (ANOPHELES) BENGALENSIS Puri, 1930

*Previous Thailand records:* Sandhinand (1951, p. 34, as *aitkenii bengalensis*); Thurman (1959, p. 121, as *aitkenii bengalensis*); Tansathit *et al.* (1963, p. 138, as *bengalensis*); Reid (1965, p. 115); Scanlon and Esah (1965, p. 138, as *aitkenii*).

*Discussion:* Records of members of the *aitkenii* group from Thailand are confused, since females in the group cannot be distinguished at present. Among the male, larval, and pupal specimens examined from Thailand, *bengalensis* appears to be the most abundant member of the group. Taken infrequently in human biting collections, the adult habits are still poorly known. Larvae were collected from stream margins, rock pools, springs, and frequently from pools at the foot of waterfalls, all under forest cover.

*Distribution in Thailand:* Chanthaburi, Chiang Mai, Chon Buri, Lampang, Mae Hong Son, Nan, Narathiwat, Phangnga, Phrae, Songkhla, Trang.

ANOPHELES (ANOPHELES) BULKLEYI Causey, 1937

*Previous Thailand records:* Causey (1937*b*, p. 544); Wilson and Reid (1949, p. 270); Thurman (1959, p. 119).

*Discussion:* The last two records both derive from Causey (1937*b*). This species was described from a single male specimen reared from larvae found in a tree hole near "Chandburi" (Chanthaburi). According to Reid and Knight (1961), this species appears to belong in the *Lophoscelomyia* series with *asiaticus* and *annandalei*. The original description stated that the type male had been deposited in the USNM, but the specimen apparently never was received. Dr. Causey (personal communication, 1966) believes that the type male was lost during shipment, together with other of his specimens. Repeated efforts to find additional specimens in south-eastern Thailand have been unsuccessful to date.

*Distribution in Thailand:* Chanthaburi.

ANOPHELES (ANOPHELES) CAMPESTRIS Reid, 1962

*Previous Thailand records:* Reid (1962, p. 15); Harinasata *et al.* (1964, p. 323); Gould *et al.* (1967, p. 441).

*Discussion:* Reid described this species for the dark-winged form of *Anopheles barbirostris*, which is an important malaria vector in Malaya. He reported *campestris* from Songkhla, Nonthaburi, and Chon Buri Provinces. Specimens fitting the description of *campestris* have been seen from many areas of Thailand, some quite far inland. Reid has noted that *barbirostris* has forms which approach *campestris* where the latter species does not compete with it. The entire question is in need of additional work in Thailand, and will be discussed in detail elsewhere. For purposes

of public health matters it is perhaps best to identify specimens as *Anopheles barbirostris*, *sensu lato*, unless reared series are available. Larvae were found in surface pools of various sizes, marsh, well, hoofprint, ditch, and sump. The species was taken biting man in several localities, but its vector status for either malaria or filariasis in Thailand is problematical at present.

*Distribution in Thailand:* Ayutthaya, Chiang Mai, Chon Buri, Khon Kaen, Nonthaburi, Pathum Thani, Ubon Ratchathani, Udon Thani.

ANOPHELES (ANOPHELES) CRAWFORDI Reid, 1953

*Discussion:* This species was undoubtedly among those listed by the earlier works in the *hyrcanus* group. A number of specimens are in the USNM from the SEATO collections in several areas of Thailand, from light trap, human biting and larval collections. It does not appear to be common anywhere in the country. The peak of the population in Bangkok, measured chiefly by light trap, came in July, somewhat earlier than other *Anopheles* species. Larvae were found in seepage, pond, and marsh. Reid (1953) also found *crawfordi* widely distributed, but not abundant in Malaya, with larvae found in deep or shallow swamps.

*Distribution in Thailand:* Chiang Mai, Chon Buri, Phra Nakhon (Bangkok), Nakhon Nayok, Phangnga.

ANOPHELES (ANOPHELES) DONALDI Reid, 1962

*Discussion:* Reid (1962) noted some specimens sent to him by E. I. Coher from Trang, southern Thailand, which resembled *donaldi*, but which Reid felt were *barbirostris*. Specimens in the USNM from the SEATO collections include a female caught biting man at Waeng in Narathiwat Province and a reared series from Boriphat Waterfall in Songkhla Province. The species appears to be restricted in Thailand to the larvae from swampy areas and pools at the edge of jungle areas. The single SEATO larval collection came from a pool at the edge of the stream below a waterfall.

*Distribution in Thailand:* Narathiwat, Songkhla.

ANOPHELES (ANOPHELES) FRAGILIS (Theobald), 1903

*Discussion:* Larvae resembling *fragilis*, as illustrated by Reid (1965), were found in several sites in southern Thailand, in pools in jungle areas associated with *bengalensis* larvae. Reid (1965) concluded from the distribution of *fragilis* in Malaya and Burma that the species probably occurred also in Thailand, but he did not see specimens from this country. The females are indistinguishable from other females of the *aitkenii* group.

*Distribution in Thailand:* Narathiwat, Songkhla, Yala.

ANOPHELES (ANOPHELES) GIGAS FORMOSUS Ludlow, 1909

*Previous Thailand records:* Barnes (1923a, p. 125, as *formosus*); Barraud and Christophers (1931, p. 271, as *gigas* var. *formosus*); Thurman (1959, p. 119).

*Discussion:* The records listed above all derive from Barnes (1923a), but in his discussion Barnes clearly indicated that his identification was uncertain. Barraud and Christophers also indicate that the identification was uncertain. While it is possible that some member of the *gigas* complex may occur in Thailand, the present record cannot be regarded as justified, and no specimens of *gigas formosus* from Thailand are in the USNM collection.

ANOPHELES (ANOPHELES) GIGAS SUMATRANA Swellengrebel & Rodenwaldt, 1932

*Previous Thailand records:* Thurman (1959, p. 120, as *gigas sumatranus*).

*Discussion:* Thurman (1959) listed this subspecies as having been reported from Thailand for the first time between 1950 and 1956, without additional data. There are no Thailand specimens in the USNM, and Bonne-Wepster and Swellengrebel (1953) indicated that the subspecies was known only from the type locality in Sumatra. At present this subspecies can be listed for Thailand only with considerable reservations.

ANOPHELES (ANOPHELES) HODGKINI Reid, 1962

*Previous Thailand records:* Reid (1962, p. 20).

*Discussion:* Reid (1962) reported *hodgkini* from "La-Mor" (Lamo) in Trang Province. He indicated that in Malaya larvae were generally found in heavily shaded situations along forest margins. Larvae in the SEATO collections were from pools near streams in the forest with many leaves in the water, and from a small pond. As in Malaya, the species does not appear to be abundant in any of the habitats examined in Thailand.

*Distribution in Thailand:* Chon Buri, Nakhon Ratchasima, Phangnga, Ranong, Satun, Trang.

ANOPHELES (ANOPHELES) INDIENSIS Theobald, 1901

*Previous Thailand records:* Thurman (1959, p. 119).

*Discussion:* Thurman (1959) stated that the species was reported from Thailand prior to 1950, but her record appears to be the first one published. Thurman may have been referring to earlier records of *maculipalpis indiensis* (= *splendidus*) by Barnes. Specimens in the SEATO collection include females taken in human and animal biting collections. At times *indiensis* may be a significant species in human biting collections in some areas of Thailand. In recent SEATO studies on mosquito repellents in Rayong Province, *indiensis* was one of the most abundant man-biting species. In most areas, however, it appears to be quite uncommon. Larvae were found in swamp, sump, ditch, and animal footprint. In addition to SEATO specimens, the USNM collection includes Thailand specimens collected by Causey ("SIAM"), Thurman (Chon Buri), and Coher and Beales (Trang).

*Distribution in Thailand:* Chanthaburi, Chon Buri, Nakhon Si Thammarat, Narathiwat, Pathum Thani, Phangnga, Prachin Buri, Prachuap Khiri Khan, Saraburi, Satun, Trat, Trang, Udon Thani.

ANOPHELES (ANOPHELES) INSULAEFLORUM  
(Swellengrebel & Swellengrebel de Graaf), 1919 (1920)

*Previous Thailand records:* Sandosham (1945);\* Thurman (1959, p. 120); Tansathit *et al.* (1963, p. 138); Reid (1965, p. 120).

*Discussion:* A number of collections of larvae were made from stream side pools and rock pools near several waterfalls in Songkhla Province in 1965. The larvae were generally associated with other members of the *aikenii* group, such as *bengalensis* and *fragilis*. Tansathit *et al.* (1963) reported the species from Sattahip Naval Base in Chon Buri Province. A rare and apparently unimportant species in Thailand, *insulaeflorum* appears to be restricted to forested situations, chiefly in the southern part of the country.

*Distribution in Thailand:* Chanthaburi, Chon Buri, Nakhon Ratchasima, Nan, Songkhla, Yala.

ANOPHELES (ANOPHELES) LESTERI PARALIAE Sandosham, 1959

*Previous Thailand records:* Reid (1963, p. 102); Harinasuta *et al.* (1964, p. 323).

*Discussion:* All of the Thailand specimens agree well with the subspecies as described by Sandosham and by Reid (1953), rather than with the nominate form described from the Philippines. Reid (1963) indicated that *lesteri* might be an important malaria and filariasis vector in parts of China. Its status in this respect in Thailand is unknown, but it does not appear to be abundant in any area surveyed. All of the specimens from the extensive Phra Nakhon (Bangkok) studies in 1962-1963 were from light traps. Larvae were taken from rice field, hoofprint, ditch, and well, most abundantly in rice field and ditch.

*Distribution in Thailand:* Ayutthaya, Chiang Mai, Phra Nakhon, (Bangkok, Nonthaburi, Pathum Thani, Prachuap Khiri Khan, Rayong, Surat Thani, Trang.

ANOPHELES (ANOPHELES) LETIFER Sandosham, 1944

*Previous Thailand records:* Iyengar and Menon (1956); Reid (1963, p. 170).

*Discussion:* This species appears to be quite rare in Thailand. It has been taken in a number of localities chiefly in the southern provinces. Larvae were collected in a ditch, and a small number of females were collected biting man. This species is of some importance as a human malaria vector in Malaya, but is present in such small numbers in the areas surveyed in Thailand that it is probably of no importance here.

*Distribution in Thailand:* Chanthaburi, Chon Buri, Prachin Buri, Ranong, Trang, Yala.

\*Cited from *Rev. appl. Ent. Ser. B* 36 : 112 (1948).

## ANOPHELES (ANOPHELES) MONTANUS Stanton &amp; Hacker, 1917

*Discussion:* Another of the species which appear to be restricted to the most southern part of Thailand, clearly related to the Malayan fauna. SEATO collections include specimens from seepage pools in Narathiwat and a pool at the foot of a waterfall in Songkhla. The USNM collection also includes larvae collected by Coher and Beales in Trang, and larvae from the collections of the National Malaria Eradication Project of Thailand from Narathiwat. Adults reared from several of these collections are clearly *montanus*. The finding of this species at several points in southern Thailand raises the question of the identification of the specimens reported as *albotaeniatus* by Iyengar.

*Distribution in Thailand:* Narathiwat, Songkhla, Trang.

## ANOPHELES (ANOPHELES) NIGERRIMUS Giles, 1900

*Previous Thailand records :* Barraud and Christophers (1931, p. 271, as *hyrcanus* var. *nigerrimus*, in part); Sandhinand (1951, p. 35, as *hyrcanus nigerrimus*); Reid (1953, p. 29); Iyengar (1953, p. 747, as *hyrcanus nigerrimus*); Griffith (1955, p. 565); Thurman and Thurman (1955, p. 220); Thurman (1959, p. 119); Tansathit *et al.* (1963, p. 138, as *hyrcanus nigerrimus*); Harinasuta *et al.* (1964, p. 323); Scanlon and Esah (1965, p. 138).

*Discussion:* This is one of the most common and abundant *Anopheles* in Thailand. It was found feeding on man in small numbers at many places surveyed, but appears to feed primarily on large domestic animals. The early records (Barnes 1923a; Anigstein 1932) presumably lump *nigerrimus* under *hyrcanus*, and Reid (1953) noted that one of Barnes's specimens from Thailand was *nigerrimus*. This species has been reported to be a malaria vector in some parts of Asia, but does not appear to be involved in Thailand. Iyengar (1953) found 3.7% of *nigerrimus* with *Brugia malayi* microfilariae in southern Thailand filariasis areas, but Harinasuta *et al.* (1964) found none in their later investigations. *A. nigerrimus* was frequently very abundant in light trap collections in Chiang Mai and Bangkok, and was taken in human and cow biting collections, and in cow- and horse-baited mosquito traps. In Bangkok, the species was most abundant from November to January, in the period following the end of the monsoon season. Larvae were most frequently taken in rice paddies, but other collections were made from marsh, pond, hoofprint, ditch, and sump.

*Distribution in Thailand:* Ayutthaya, Chanthaburi, Chiang Mai, Chiang Rai, Chon Buri, Nakhon Nayok, Nakhon Ratchasima, Nakhon Si Thammarat, Nan, Narathiwat, Nonthaburi, Pathum Thani, Phetchaburi, Ranong, Ratchaburi, Rayong, Trat, Udon Thani.

## ANOPHELES (ANOPHELES) PALMATUS (Rodenwaldt), 1926

*Previous Thailand records:* Sandhinand (1951, p. 36, as *aikenii palmatus*); Thurman (1959, p. 121); Reid (1965, p. 119).



*Discussion:* Larvae were collected from a small stream at Ton Nga Chang waterfall in Songkhla Province. An additional small collection was found at the National Malaria Eradication Project, Thailand, from Chiang Rai, without ecological data; and Sandhinand reported it from Chiang Mai, without additional data. This appears to be a rather rare member of the *aitkenii* group in Thailand, and the habits of the adults are unknown. The records from the northern provinces require further study, since the general distribution of the species in Malaysia and Indonesia would seem to indicate that southern Thailand might mark its northern limit, as is true of a number of primarily Malaysian species (e. g. *riparis*, *balabacensis introlatus*, and *fragilis*). Sandhinand's specimens from Chiang Mai were not seen during this study, and the circumstances under which the specimens from Chiang Rai were obtained make the locality data somewhat doubtful.

*Distribution in Thailand:* Chiang Mai, Chiang Rai, Songkhla.

ANOPHELES (ANOPHELES) PEDITAENIATUS (Leicester), 1908

*Previous Thailand records:* Stanton (1920, p. 334, as *hyrcanus* var. *peditaeniatus*); Barnes (1923a, p. 123, as *sinensis*, in part); Barraud and Christophers (1931, p. 271, as *hyrcanus* var. *nigerrimus*, in part); Thurman (1959, p. 119); Reid (1962, p. 36); Harinasuta *et al.* (1964, p. 323); Scanlon and Esah (1965, p. 138).

*Discussion:* This member of the *hyrcanus* species group is abundant in many areas of Thailand, chiefly in open agricultural land devoted to rice culture. In the SEATO collections it was less abundant than *sinensis* or *nigerrimus*, but was taken by a variety of methods, including human and animal biting collections, light traps, and horse-baited traps. The females feed chiefly on large domestic animals. Larvae were collected chiefly from rice fields, but also from marsh, ditch, well, and rock pools. In the extensive Bangkok collections almost all specimens were taken in light traps, and the population had a clear peak in December, well after the end of the monsoon and shortly after the rice paddies surrounding the city were at their maximum stage of flooding.

*Distribution in Thailand:* Ayutthaya, Chiang Mai, Chon Buri, Narathiwat, Nakhon Nayok, Nakhon Ratchasima, Nan, Nonthaburi, Pathum Thani, Prachin Buri, Prachuap Khiri Khan, Phrae, Rayong, Satun, Surat Thani, Trang, Udon Thani.

ANOPHELES (ANOPHELES) POLLICARIS Reid, 1962

*Discussion:* This relatively rare member of the *barbirostris* group was collected in the larval stage several times in rock pools and pools in the beds of drying streams under forest cover in southern Thailand. The larvae, pupae, and adults agreed well with the original descriptions (Reid 1962). Adult habits are unknown.

*Distribution in Thailand:* Satun, Songkhla.

## ANOPHELES (ANOPHELES) PURSATI Laveran, 1902

*Previous Thailand records:* Thurman (1959, p. 122, as sp. D. Reid); Reid (1963, p. 101).

*Discussion:* Small numbers of *pursati* were collected in Bangkok and surrounding areas on the central plain. Almost all of the collections were by light trap, but a few females were taken in human biting collections. Reid (1963) reported specimens of this species from Thurman's light trap collections in Chiang Mai; so it is probable that the species occurs in small numbers in agricultural areas throughout the country. No larvae of *pursati* were collected in Thailand during this study, but Reid (1953) reported that the larvae were found in ponds with floating vegetation in northern Malaya.

*Distribution in Thailand:* Ayutthaya, Chiang Mai, Phra Nakhon (Bangkok), Nonthaburi.

## ANOPHELES (ANOPHELES) ROPERI Reid, 1950

*Discussion:* Immature forms were collected from several sites in the far southern portion of Thailand, from pools on the margin of streams or in the beds of drying streams in the forest. These are the same types of habitats as described for *A. roperi* in Malaya (Hodgkin 1950). The adult habits of *A. roperi* are relatively poorly known. Hodgkin (1950) indicated it as a possible malaria vector in parts of Malaya where malaria was particularly difficult to control, but more recent information (Wharton *et al.* 1963) suggests that it is a vector of *Plasmodium traguli* of mouse deer, not of human malaria.

*Distribution in Thailand:* Narathiwat, Phangnga, Satun, Songkhla.

## ANOPHELES (ANOPHELES) SEPARATUS Leicester, 1908

*Previous Thailand records:* Barnes (1923a, p. 123, as *sinensis*, in part?); Iyengar (1953, p. 747); Thurman (1959, p. 121); Tansathit *et al.* (1963, p. 138).

*Discussion:* Barnes (1923a) in his discussion of *A. sinensis* stated that "Specimens conforming to the types of *Anopheles peditaeniatus* Leicester, and *Anopheles separatus* Leicester have been found." Since his discussion listed only Bangkok specimens, it seems probable that this was a misidentification. However, Tansathit *et al.* reported the species from Sattahip Naval Base in Chon Buri Province. All specimens in the SEATO collections came from southern Thailand, and additional specimens in the USNM were collected in Trang by Coher and Beales. Immature specimens were collected in swamps, spring-fed bogs, and a nipa swamp. According to Hodgkin (1950) this species is primarily zoophilic in Malaya, and has never been implicated as a malaria vector there on epidemiological grounds. Specimens were collected feeding on man in Chanthaburi Province.

*Distribution in Thailand:* Chanthaburi, Chon Buri, ? Phra Nakhon (Bangkok), Narathiwat, Trang.

## ANOPHELES (ANOPHELES) SINENSIS Wiedemann, 1828

*Previous Thailand records:* Theobald (1910, p. 51); Stanton (1920, p. 334); Barnes (1923a, p. 123); Barraud and Christophers (1931, p. 271, as *A. hyrcanus* var. *nigerrimus*, in part); Sandhinand (1951, p. 35, as *hyrcanus sinensis*); Reid (1953, p. 21); Griffith (1955, p. 565); Iyengar (1953, p. 747, as *hyrcanus sinensis*); Thurman and Thurman (1955, p. 138); Thurman (1959, p. 119); Tansathit *et al.* (1963, p. 138); Harinasuta *et al.* (1964, p. 323); Scanlon and Esah (1965, p. 138).

*Discussion:* *Anopheles sinensis* is one of the most widely distributed and abundant mosquito species in Thailand. It is characteristic of the open agricultural areas, but chiefly in rice producing regions, but it is not limited to such habitats. In comparative biting experiments, it fed principally on large domestic animals, little on man. *Anopheles sinensis* was often abundant in light trap collections and in bait traps containing horses or cows. The immature stages were collected most frequently in rice paddies, but also in surface pools and ponds, seepages, marshes, ditches, wells, and sumps. Although *sinensis* was found resting in homes at times and, as mentioned above, bit man in small numbers, the general impression from a large series of collections is that it is primarily a zoophilic species. There are numerous reports of *sinensis* or other *hyrcanus* group species as vectors of malaria in China, Indo-China, and Malaya, but it is extremely difficult to evaluate some of these reports due to imprecise identification of the species involved. In more recent years it has been established, for instance, that in many parts of China the *sinensis* listed as a malaria and filariasis vector is actually *A. lesteri*. The distribution of malaria in Thailand is such that members of the *hyrcanus* group are not considered as possible vectors, except in small outbreaks which occur from time to time in the central plain. In southern Thailand, Iyengar (1953) found 3.6% of *A. sinensis* with microfilariae of *Brugia malayi*, but Harinasuta *et al.* (1964) did not report positive dissections in Surat Thani.

*Distribution in Thailand:* Ayutthaya, Chanthaburi, Chiang Mai, Chiang Rai, Chon Buri, Khon Kaen, Phra Nakhon, Lampang, Loei, Mae Hong Son, Nakhon Ratchasima, Nakhon Si Thammarat, Nan, Narathiwat, Nonthaburi, Phangnga, Pathum Thani, Phetchaburi, Prachuap Khiri Khan, Ratchaburi, Ranong, Rayong, Surat Thani, Udon Thani.

## ANOPHELES (ANOPHELES) SINTONOIDES Ho, 1938

*Previous Thailand records:* ? Reid (1963, p. 114).

*Discussion:* Originally described from Hainan, this tree-hole breeding species has been found in a number of widely scattered forested areas of Thailand. The habits of the adults are unknown in Thailand, but the females presumably feed on forest animals. The immature stages were taken most frequently from tree holes, but larvae have also been collected from fallen split bamboo, bamboo stumps, and axils of *Pandanus* species. Reid (1963) discusses a record of what is presumed to be this species from southern Thailand collected by Dr. E. I. Coher.

*Distribution in Thailand:* Chanthaburi, Chumphon, Nakhon Nayok, Nakhon Ratchasima, Phatthalung, Ranong, Trang.

## ANOPHELES (ANOPHELES) TIGERTTI Scanlon &amp; Peyton, 1967

*Previous Thailand records:* Scanlon and Peyton (1957, p. 19).

*Discussion:* Larvae and pupae of this species were first collected in Thailand by SEATO from water aspirated from burrows of land crabs along the banks of small streams. Nothing is known of its feeding habits, since the females of this and other members of the *aikenii* group are indistinguishable. All of the known adults of this species were reared from immature stages.

*Distribution in Thailand:* Chanthaburi, Prachin Buri.

## ANOPHELES (ANOPHELES) UMBROSUS (Theobald), 1903

*Previous Thailand records:* Iyengar (1953, p. 747); Thurman (1959, p. 121); Tansathit *et al.* (1963, p. 138, as *umbrosus* and *novumbrosus*).

*Discussion:* Iyengar (1953) reported finding microfilariae of *Brugia malayi* in 3.3% of *umbrosus* examined in southern Thailand, and reported finding the larvae in swamps shaded by tree and bamboo. The SEATO collections included one lot from a ground pool in Ranong Province. In Malaya, *A. umbrosus* was believed to be of some importance as a vector of human and simian malaria in coastal forests. It appears to be uncommon or rare in Thailand.

*Distribution in Thailand:* Chon Buri, Ranong.

## Subgenus CELLIA Theobald, 1902

## ANOPHELES (CELLIS) ACONITUS Dönitz, 1902

*Previous Thailand records:* Barnes (1923a, p. 122); Barraud and Christophers (1931, p. 274); Anigstein (1932, p. 259); Payung Vejjasatra (1933, p. 661); Causey (1937, p. 403); Wilson and Reid (1949, p. 270); Sandhinand (1951, p. 36); Iyengar (1953, p. 747); Griffith (1955, p. 565); Thurman and Thurman (1955, p. 222); Thurman (1959, p. 119); Tansathit *et al.* (1963, p. 138); Harinasuta *et al.* (1964, p. 323); Scanlon and Esah (1965, p. 138); Gould *et al.* (1967, p. 441).

*Discussion:* One of the most abundant *Anopheles* in Thailand, *aconitus* was taken from almost all areas of the country where collections were made, except in heavily forested regions. It has been frequently collected biting man in Thailand by SEATO, and it has been implicated as a vector of malaria in the central plain of Thailand (Gould *et al.* 1967). It has also been taken in large numbers from horse- and cow-baited traps. In Bangkok the population, as measured by light traps, reached a peak in December to January. Larvae were found most abundant in rice fields, and also in surface pools, ditches, and streams, hoofprints, sumps, wells, and one in an artificial container.

*A. aconitus* is a highly variable species. Barraud and Christophers (1931) discussed the variations in palpal and wing markings in some detail and Toumanffo (1936) gave a detailed account of the variations encountered in Indo-China. The

various forms of the species encountered in the SEATO collections in Thailand will be discussed in detail in a later communication.

*Distribution in Thailand:* Ayutthaya, Chanthaburi, Chiang Mai, Chiang Rai, Chon Buri, Khon Kaen, Nakhon Nayok, Nakhon Ratchasima, Nakhon Si Thammarat, Nan, Narathiwat, Nonthaburi, Phangnga, Phetchaburi, Prachin Buri, Phrae, Pathum Thani, Prachuap Khiri Khan, Ratchaburi, Ranong, Rayong, Saraburi, Surat Thani, Trat, Yala. Probably found in agricultural areas throughout the country.

#### ANOPHELES (CELLIA) ANNULARIS Van der Wulp, 1884

*Previous Thailand records:* Stanton (1920, p. 334); Barnes (1923a, p. 124); Barraud and Christophers (1931, p. 276); Anigstein (1932, p. 259) (all as *fuliginosus* Giles, 1900); Causey (1937a, p. 403); Wilson and Reid (1949, p. 270); Sandhinand (1951, p. 36); Iyengar (1953, p. 747); Griffith (1953, p. 565); Thurman (1959, p. 119); Thurman and Thurman (1955, p. 222); Tansathit *et al.* (1963, p. 138); Harinasuta *et al.* (1964, p. 323); Gould *et al.* (1967, p. 441).

*Discussion:* *A. annularis* is a very abundant species over much of the country. It feeds on man in some numbers, and on large domestic animals. Anigstein (1932) reported an outbreak of malaria in a prison in Nonthaburi, in which *annularis* was found infected (two of twenty females examined). There are no other records of positive dissections of *A. annularis* in Thailand, but it is a vector of some importance in India and of lesser importance elsewhere in south-east Asia (Covell 1944). In Bangkok, where the species was particularly abundant in light traps, it was most abundant in November and December. Most larval collections in the SEATO series came from the margins of ponds and reservoirs, but additional collections were made in rice fields and stream margins. Anigstein (1932) referred to tree-hole breeding by *A. annularis* in Thailand, and Borel (1926) reported the species from tree-holes and cut bamboo in Indo-China. However, this habitat was not found in Thailand for *annularis*, although thousands of tree-hole and bamboo collections were made.

*Distribution in Thailand:* Ayutthaya, Chiang Mai, Chanthaburi, Chon Buri, Khon Kaen, Phra Nakhon, Nakhon Ratchasima, Nakhon Si Thammarat, Nan, Narathiwat, Nonthaburi, Pathum Thani, Prachin Buri, Phrae, Ratchaburi, Rayong, Saraburi, Ubon Ratchathani, Udon Thani.

#### ANOPHELES (CELLIA) BALABACENSIS Baisas, 1936

*Previous Thailand records:* Barnes (1923a, p. 122); Barraud and Christophers (1931, p. 274); Causey (1937a, p. 403); Wilson and Reid (1949, p. 266); Sandhinand (1951, p. 37); Ayurakitkosol and Griffith (1963, p. 125); Tansathit *et al.* (1963, p. 138), (all preceding as *leucosphyrus* Dönitz, 1901); Colless (1956, p. 55); Thurman (1959, p. 199), both as *leucosphyrus balabacensis*; Colless (1957, p. 137); Scanlon and Esah (1965, p. 138); Scanlon and Sandhinand (1965, p. 61).

*Discussion:* Although the early records of *A. balabacensis* are given as *leucosphyrus* Dönitz, 1901, they may all be taken to mean *balabacensis*, since all were from

the area north of the Malayan border, where only the latter species occurs (Scanlon and Sandhinand 1965). Ayurakitkosol and Griffith (1963) reported positive dissections for several localities in Thailand, and Scanlon and Sandhinand (1965) reviewed the biology and distribution of *balabacensis* in Thailand. *A. balabacensis* appears to be an efficient vector of malaria in many areas of south-east Asia. It is also a vector of simian malaria (Wharton *et al.* 1964) in Malaya, and feeds readily on monkeys in Thailand. The species is widely distributed in the country, except for the most southern provinces, where it is replaced by *A. balabacensis introlatus* Colless, 1957. Wherever collected the species is typical of forest and forest margins in hilly regions. It has been collected by SEATO personnel at altitude ranging from 4.5 to 1460 metres in the province of Chanthaburi. It is also usually strongly anthropophilic and exophilic. Larvae were collected from small shaded pools and pockets of water in the forest, from elephant and other animal footprints, seepages, rock holes, and the pits dug for gem mining.

*Distribution in Thailand:* Chanthaburi, Chiang Mai, Chon Buri, Kanchanaburi, Lampang, Mae Hong Son, Nakhon Nayok, Nakhon Ratchasima, Nakhon Si Thammarat, Nan, Narathiwat, Phangnga, Phrae, Ranong, Songkhla, Trat, Ubon Ratchathani.

#### ANOPHELES (CELLIA) BALABACENSIS INTROLATUS Colless, 1957

*Discussion:* This subspecies replaces the nominate form in the most southern areas of Thailand, along the Malayan border. The line of demarkation is not clearly defined as yet, and the nominate subspecies is found in northern Malaya on the western side of the Kra Isthmus. It is found in much the same terrain as *balabacensis, sensu stricto*, and the immature forms are found in the same habitats. Habits of the adults in Thailand are unknown at present.

*Distribution in Thailand:* Narathiwat, Ranong.

#### ANOPHELES (CELLIA) CULICIFACIES Giles, 1901

*Previous Thailand records:* Barnes (1923a, p. 122); Barraud and Christophers (1931, p. 274); Anigstein (1932, p. 266); Causey (1937a, p. 403); de Fluiter (1948, p. 273); Wilson and Reid (1949, p. 270); Sandhinand (1951, p. 37); Thurman and Thurman (1955, p. 222); Griffith (1955, p. 565); Thurman (1959, p. 119).

*Discussion:* Most of the records of *culicifacies* from Thailand are from the western area of the country, along the drainage of the Ping River and the Chao Phraya River. The species is reported from Indo-China and southern China (Yunnan), but it is not particularly abundant east of India and Burma. De Fluiter (1944) reported that *culicifacies* might be an important malaria vector in Thailand, with no substantiating data. The species is the most important vector in parts of India (Covell 1944), but is apparently too uncommon to be of any importance in Thailand. There is some evidence that it may be locally abundant at times along the main rivers, and could conceivably be a vector under such conditions.

*Distribution in Thailand:* Ayutthaya, Chiang Mai, Chon Buri, Kanchanaburi, Lamphun, Tak.

ANOPHELES (CELLIA) FILIPINAE Manalang, 1930

*Previous Thailand records:* Thurman (1959, p. 121).

*Discussion:* Thurman (1959) listed this species without additional data other than the fact that it was reported from Thailand for the first time between 1950 and 1956. The SEATO collections have included a small number of females, taken in light traps, resting and biting collections, which appear to be this species. However, the members of the *Myzomyia* group (*aconitus*, *minimus*, *pampanai*, *varuna*, *filipinae*) may be quite variable in Thailand, and *A. filipinae* is listed here tentatively, pending more detailed examination of the group.

*Distribution in Thailand:* Chiang Mai, Chon Buri, Nakhon Ratchasima, Phrae.

ANOPHELES (CELLIA) FLUVIATILIS James, 1902

*Previous Thailand records:* Barnes (1923a, p. 121, as *funestus* Giles); Barraud and Christophers (1931, p. 274, as *listonii* Liston); Anigstein (1932, p. 266, as *listonii*); Wilson and Reid (1949, p. 270); Griffith (1953, p. 565); Thurman (1959, p. 119).

*Discussion:* Barnes (1932a) reported this species from Chiang Mai and from Bangkok, and Barraud and Christophers (1931) merely repeated his record, without comment. Anigstein (1931) expressed great doubt that the Bangkok record could be accurate, due to the breeding habits of *fluviatilis*. Anigstein did report collecting it in northern Thailand in several provinces, and in Phatthalung in the south. It is interesting to note that Causey (1937a) did not include *fluviatilis* in his list of *Anopheles* species for Thailand, nor do there appear to be any other records of additional collections, merely entries in species lists based on previous work. It is apparent that there is considerable confusion surrounding the records of Anigstein and Barnes, and *A. fluviatilis* is listed here for the Thai fauna with some reservations. The species has been reported from Indo-China and from Hong Kong (Covell 1944), but the whole situation should be reviewed, particularly in view of the fact that this is one of the most efficient malaria vectors known.

*Distribution in Thailand:* Chiang Mai, Chiang Rai, Phra Nakhon (Bangkok), Lampang, Patthalung.

ANOPHELES (CELLIA) HACKERI Edwards, 1921

*Discussion:* This species has been studied in detail in Malaya and Borneo. It appears to enter only the southern part of Thailand, and two collections were made from tree hole and one from rock hole in the forest. In Malaya, *hackeri* feeds on monkeys (Wharton *et al.* 1964), but its habits are unknown in Thailand.

*Distribution in Thailand:* Phatthalung, Songkhla.

## ANOPHELES (CELLIA) JAMESII Theobald, 1901

*Previous Thailand records:* Barnes (1923a, p. 124); Barraud and Christophers (1931, p. 278, as *ramsayi* Covell); Thurman (1959, p. 119); Scanlon and Sandhinand (1965, p. 66).

*Discussion:* Barnes (1923a) reported *A. jamesii* from Chiang Mai, as larvae and adults. Barraud and Christophers (1931) held that Barnes's record referred to *ramsayi* Covell, since Sinton found *ramsayi* in Thailand during his short trip there, and since Barnes indicated that his identifications were based on "The Anopheline Mosquitoes of India" by James and Liston, in which *jamesii* is actually *ramsayi*. Neither Anigstein (1932) nor Causey (1937a) give records of *jamesii* for Thailand. However, there are numerous specimens in the SEATO collection from Thailand, and it may actually be locally quite abundant (Scanlon and Sandhinand 1965). Reid (1963) has also reported *jamesii* from Lankawi Island in Malaya, which appears to be the most southern point in its distribution in south-east Asia. Most of the specimens in the SEATO collection were taken in cow biting tests, and the species appears to be strongly zoophilic (Scanlon and Sandhinand 1965). Larvae were collected from ponds and springs. Additional specimens were examined in the USNM from Trang Province, collected by E. I. Coher and P. Beales.

*Distribution in Thailand:* Chanthaburi, Chiang Mai, Chon Buri, Khon Kaen, Nakhon Ratchasima, Prachuap Khiri Khan, Ranong, Saraburi, Trang.

## ANOPHELES (CELLIA) JEYPORIENSIS CANDIDIENSIS Koizumi, 1924

*Previous Thailand records:* Sandhinand (1951, p. 37); Griffith (1955, p. 565); Thurman and Thurman (1955, p. 222); Thurman (1959, p. 121); Thurman (1959, p. 122, as *jeyporiensis*); Scanlon and Esah (1955, p. 138, as *jeyporiensis*).

*Discussion:* All of the records listed are from Chiang Mai Province. Specimens were taken in human biting collections and in light traps in fairly open areas. Thurman's (1959) report of the nominate form from Chiang Mai was apparently based on a personal communication from Dr. V. Notananda. There is a single larva in the USNM collection from Chiang Mai collected by Notananda, and it is *jeyporiensis candidiensis*. There is at present no evidence that the nominate subspecies occurs in Thailand, and it is believed that the records of the nominate form from Indo-China are questionable. Toumanoff and Try (1937) reported a form resembling the nominate form in Tonkin. Since *jeyporiensis candidiensis* appears to be an important malaria vector in parts of Indo-China, the definition of the forms of *jeyporiensis* found in Thailand is of some importance. None of the specimens seen in this study were referable to the nominate subspecies.

*Distribution in Thailand:* Chiang Mai.

## ANOPHELES (CELLIA) KARWARI (James), 1903

*Previous Thailand records:* Barnes (1923a, p. 124); Barraud and Christophers (1931, p. 278); Anigstein (1932, p. 279); Causey (1937a, p. 403); Wilson and Reid



(1949, p. 270); Sandhinand (1951, p. 37); Thurman (1959, p. 119); Tansathit *et al.* (1953, p. 138); Scanlon and Esah (1965, p. 138); Scanlon and Sandhinand (1965, p. 66).

*Discussion:* A fairly common species in many parts of the country, but apparently never extremely abundant, and not a serious pest of man. The specimens reported by Barnes (1923a) and Scanlon and Esah (1965) for Chiang Mai came from areas at 760 metres altitude or greater. Despite the frequent adult collections, few immature forms were found in Thailand. In other areas, such as Malaya, the larvae have been found in pools and seepages with a gentle flow of water. One collection was made in Khao Yai National Park from a rock pool with *A. balabacensis*. This species does not appear to be a malaria vector of any importance anywhere within this range.

*Distribution in Thailand:* Chiang Mai, Chiang Rai, Chanthaburi, Chon Buri, Kanchanaburi, Lampang, Nakhon Nayok, Nakhon Ratchasima, Nakhon Si Thammarat, Nan, Narathiwat, Prachin Buri, Prachuap Khiri Khan, Phrae, Saraburi, Satun, Trat, Trang, Ubon Ratchathani, Udon Thani, Yala.

#### ANOPHELES (CELLIA) KOCHI Dönitz, 1901

*Previous Thailand records:* Barnes (1923a, p. 125); Barraud and Christophers (1931, p. 274); Payung Vejjasatra (1933, p. 661); Causey (1937a, p. 403); de Fluiter (1948, p. 273); Wilson and Reid (1949, p. 266); Sandhinand (1951, p. 37); Thurman and Thurman (1955, p. 222); Thurman (1959, p. 119); Tansathit *et al.* (1963, p. 138); Harinasuta *et al.* (1964, p. 323); Scanlon and Esah (1965, p. 138).

*Discussion:* *Anopheles kochi* may play a minor role in malaria transmission in Indonesia and Indo-China (Covell 1944), but there is no evidence that it does so in Thailand. It may be locally common particularly in agricultural areas, but it is strongly zoophilic. Larvae were found in polluted surface waters, such as buffalo wallows and elephant footprints. Larvae were also found in puddles and pools, marsh, seepage, rice field, and ditch. In the SEATO collections most specimens were from animal biting or light trap collections, but small numbers were taken in human biting collections.

*Distribution in Thailand:* Chiang Mai, Chiang Rai, Chanthaburi, Chon Buri, Kanchanaburi, Khon Kaen, Nakhon Ratchasima, Nakhon Si Thammarat, Nan, Narathiwat, Phangnga, Prachin Buri, Prachuap Khiri Khan, Ranong, Satun, Songkhla, Surat Thani, Trat, Trang, Ubon Ratchathani, Udon Thani, Yala.

#### ANOPHELES (CELLIA) MACULATUS Theobald, 1901

*Previous Thailand records:* Barnes (1923a, p. 124); Barraud and Christophers (1931, p. 227); Anigstein (1932, p. 266); Causey (1937a, p. 403); Wilson and Reid (1949, p. 266); Sandhinand (1951, p. 37); Thurman and Thurman (1955, p. 222); Griffith (1955, p. 565); Thurman (1959, p. 119); Tansathit *et al.* (1963, p. 138); Scanlon and Esah (1965, p. 138); Scanlon and Sandhinand (1965, p. 66).

*Discussion:* The status of *A. maculatus* in Thailand has been of interest since this species is one of the most important vectors of malaria in Malaya, particularly

in clearings in the forested hill areas. While *A. maculatus* is often abundant in such situations in Thailand, it has not been implicated frequently as a malaria vector here. In one hyperendemic area in south-eastern Thailand, Scanlon and Sandhinand (1965) found large numbers feeding on man and on cattle in natural situations, and on man and monkeys in bait traps. Despite the relatively large numbers feeding on man, no positive malaria infections were found in *A. maculatus*, while *A. minimus* Theobald and *A. balabacensis* Baisas from the same collections were positive. It is fairly common in open areas at the edge of forest throughout Thailand, but appears to be primarily zoophilic where cattle are readily available.

In southern Thailand, however, large numbers were found attacking man in several surveys, and one female was found with oocysts. This area is adjacent to Malaysia, and further investigations will be needed to determine the status of *maculatus* as a vector in that area. Larvae were collected chiefly from rock pools and pools and seepages along foot-hill streams. Small numbers were also taken in ditches and rice fields at the edges of forested hills.

*Distribution in Thailand:* Chiang Mai, Chiang Rai, Chanthaburi, Chon Buri, Kanchanaburi, Khon Kaen, Loei, Mae Hong Son, Nakhon Nayok, Nakhon Ratchasima, Nakhon Si Thammarat, Nan, Narathiwat, Prachin Buri, Prachuap Khiri Khan, Phrae, Ranong, Rayong, Satun, Surat Thani, Ubon Ratchathani, Udon Thani, Yala.

#### ANOPHELES (CELLIA) MACULATUS WILLMORI James, 1903

*Previous Thailand records:* Barnes (1923a, as *willmori*); Barraud and Christophers (1931, p. 277, as *maculatus*); Thurman (1959, p. 119).

*Discussion:* Barnes (1923a) listed *maculatus* and *maculatus willmori* from two different foot-hill areas around Chiang Mai. Sinton collected in the area some years later, and Barraud and Christophers (1931) noted that the specimens consisted of some clearly identifiable as *maculatus, sensu stricto*, some indistinguishable from *maculatus willmori* on several characters, and others with intermediate characteristics. The same situation existed wherever reasonably large numbers of *maculatus* were examined in the SEATO collections in Thailand. It would appear that the specimens with heavy scaling of the abdominal tergites and speckling of the palp form one extreme of a series, the opposite extreme corresponding to the *pseudo-willmori* Theobald form of *maculatus*, which lacks any scales on the abdominal tergites. Reid (personal communication) believes that true *willmori* is found only in the Himalayas. Therefore, *maculatus willmori* is listed for Thailand with reservations, pending further examination, including examination of additional sibling series.

*Distribution in Thailand:* Chiang Mai, Chon Buri, Narathiwat.

#### ANOPHELES (CELLIA) MAJIDI Young & Majid, 1928

*Previous Thailand records:* Thurman (1959, p. 121).

*Discussion:* Thurman (1959) reported that this species was recorded from Thailand in the period 1950 to 1956. No further records for the species in Thailand

were found in the literature. In manuscript notes at the USNM by Thurman the following notation was found under *A. majidi*: "Recorded in monthly report for June 1952 from routine survey", with the locality given as "Chiang Mai, Farnag, June, 1952." No specimens are in the USNM collection from Thailand. Therefore, the species is included here very doubtfully.

#### ANOPHELES (CELLIA) MINIMUS Theobald, 1901

*Previous Thailand records:* Barnes (1923a, p. 123); Barraud and Christophers (1931, p. 274); Anigstein (1932, p. 266); Payung Vejjasatra (1933, p. 661); Causey (1937a, p. 403); de Fluiter (1948, p. 273); Wilson and Reid (1949, p. 266); Sandhinand (1951, p. 37); Griffith (1955, p. 565); Thurman (1959, p. 119); Tansathit *et al.* (1963, p. 138); Scanlon and Sandhinand (1965, p. 64).

*Discussion:* *A. minimus* is one of the most important malaria vectors in south-east Asia. It must be suspected as a primary vector wherever found, generally in open agricultural areas at margins of foot-hill forests. It is strongly anthropophilic and endophilic (Covell 1944). Barnes (1923a) reported *A. minimus* from Bangkok, but this is almost certainly a misidentification. Bangkok is essentially malaria-free, as are most of the open plains and deltaic areas of Thailand and neighbouring areas. Anigstein (1932), Wilson and Reid (1949), and de Fluiter (1948) suggested *A. minimus* as a vector of malaria in Thailand on epidemiological grounds, and Payung Vejjasatra (1933) reported positive dissections from southern Thailand. From that time until fairly recently, *A. minimus* was regarded as the only important vector in Thailand. Scanlon and Sandhinand (1965) found *A. balabacensis* infected at a higher rate than *A. minimus* in south-eastern Thailand, and the former species appears to be important in many forested areas in the country. Malaria campaigns based on control of *A. minimus* by residual house spraying have been very successful in many areas of Thailand (Ayurakitkosol and Griffith 1963).

Larvae were collected from streams, ditches, and surface water pools. Covell (1944) noted that the most characteristic breeding place is clear unpolluted slowly-moving water with grassy edges.

*Distribution in Thailand:* Chiang Mai, Chon Buri, Kanchanaburi, Loei, Mae Hong Son, Nakhon Ratchasima, Nan, Phatthalung, Phrae, Saraburi, Ubon Ratchathani, Yala. (Recorded from many other provinces in files of the Ministry of Public Health).

#### ANOPHELES (CELLIA) PALLIDUS Theobald, 1901

*Previous Thailand records:* Barraud and Christophers (1931, p. 277); Causey (1937a, p. 403); Wilson and Reid (1949, p. 270); Sandhinand (1951, p. 37); Thurman and Thurman (1955, p. 222); Thurman (1959, p. 119).

*Discussion:* *A. pallidus* has been taken in a few cow biting collections at several sites in Thailand, but in very small numbers. Barraud and Christophers (1931)

reported larval collections from hoofprints and roadside drain. No larvae were taken in the SEATO collections. The species appears to be generally rare in Thailand.

*Distribution in Thailand:* Ayutthaya, Chiang Mai, Lampang, Rayong.

ANOPHELES (CELLIA) PAMPANAI Büttiker & Beales, 1959

*Discussion:* Büttiker and Beales (1959) described this species from specimens collected near Snoul, Cambodia, near the border of South Vietnam. Specimens in the SEATO collection were collected from streams in Chanthaburi and Nan Provinces, in heavy forest near the Cambodian border town of Pailin, and biting man in Prachin Buri Province. Larvae were also found in the collection of the National Malaria Eradication Project, labeled "Payao" (presumably Phayao in Chiang Rai Province) but without additional data. This appears to be a very rare species in Thailand, but it is possible that some records of *minimus* or closely related species actually refer to *pampanai*.

*Distribution in Thailand:* Chanthaburi, Nan, Prachin Buri.

ANOPHELES (CELLIA) PHILIPPINENSIS Ludlow, 1902

*Previous Thailand records:* Stanton (1920, p. 334, as *fuliginosus nivipes*); Payung Vejjasatra (1933, p. 661); Causey (1937a, p. 403); de Fluiter (1948, p. 273); Wilson and Reid (1949, p. 270); Sandhinand (1951, p. 37); Griffith (1953, p. 565); Iyengar (1953, p. 747); Thurman and Thurman (1955, p. 222); Thurman (1959, p. 119); Tansathit (1963, p. 138); Harinasuta *et al.* (1964, p. 323); Scanlon and Esah (1965, p. 138); Scanlon and Sandhinand (1965, p. 66); Gould *et al.* (1967, p. 441).

*Discussion:* *A. philippinensis* is one of the more abundant *Anopheles* species in Thailand, occurring chiefly in agricultural areas in the central plain around Bangkok, and in similar situations in upland areas. In Bangkok itself only a small number of specimens were collected in light traps, but adults were captured from cattle baits on the outskirts of the city. This species has been frequently taken in human biting collections in several areas, but *A. philippinensis* is probably primarily a zoophilic species. Harinasuta *et al.* (1964) showed large numbers of *A. philippinensis* biting man in a filariasis endemic area in southern Thailand, but none were found infected. There is no indication that the species is a malaria vector in Thailand. Most larvae in the SEATO collection were from rice fields; other larval sites included surface pools, rock pools, wagon ruts, and stream margins.

*Distribution in Thailand:* Collected in all urban or agricultural areas of Thailand wherever adequate swamps exist, except heavily forested areas.

ANOPHELES (CELLIA) PUJUTENSIS Colless, 1948

*Discussion:* This member of the *leucosphyrus* group was originally described from Borneo, and has subsequently been found in Sumatra and Malaya. Colless (1956) indicated that the larvae were found in the same breeding sites as *balabacensis*,

frequently with this species. The Thailand specimens in the SEATO collection came from rock pools along streams under forest cover, with *balabacensis* and *riparis macarthuri* Colless. The species appears to be one of those restricted to the most southern areas in Thailand where tropical rain forest occurs. The habits of the adults in Thailand are unknown, but in Malaya *pujutensis* feeds on monkeys.

*Distribution in Thailand:* Narathiwat, Songkhla.

#### ANOPHELES (CELLIA) RAMSAYI Covell, 1927

*Previous Thailand records:* Barraud and Christophers (1931, p. 278); Causey (1937a, p. 403); Wilson and Reid (1949, p. 270); Sandhinand (1951, p. 37); Thurman and Thurman (1955, p. 222); Thurman (1959, p. 119); Scanlon and Sandhinand (1965, p. 66).

*Discussion:* *A. ramsayi* was found in a number of areas of Thailand, not in large numbers, chiefly feeding on domestic animals. Larvae were collected in blocked ditches and pond margins, similar to the habitats described elsewhere (Covell 1944). This species appears to be of no importance as a malaria vector in Thailand.

*Distribution in Thailand:* Ayutthaya, Chiang Mai, Chon Buri, Lop Buri, Nonthaburi, Pathum Thani, Trat, Udon Thani, Uttaradit.

#### ANOPHELES (CELLIA) RIPARIS MACARTHURI Colless, 1956

*Discussion:* This subspecies of *A. riparis* King & Baisas, 1936 was described from Borneo, and occurs widely in Malaya. The larvae are generally found in pools along streams in the forest, but the habits of the adults are largely unknown. Numerous collections were made by SEATO in rock pools, seepages and pools near stream margins in areas near the Malayan border. Numbers of adults were reared, but adults were not collected in the field. The females do not appear to feed on man in Thailand, presumably feeding on some jungle animals. Other members of the *leucosphyrus* group feed on simians in the jungle.

*Distribution in Thailand:* Nakhon Si Thammarat, Narathiwat, Phatthalung, Trang.

#### ANOPHELES (CELLIA) SPLENDIDUS Koizumi, 1920

*Previous Thailand records:* Barnes (1923a, p. 124, as *maculipalpis*); Barraud and Christophers (1931, p. 278, as *maculipalpis* var. *indiensis*); Wilson and Reid (1949, p. 270); Sandhinand (1951, p. 37); Thurman (1959, p. 119); Tansathit *et al.* (1963, p. 138); Harinasuta *et al.* (1964, p. 323); Scanlon and Esah (1965, p. 138); Scanlon and Sandhinand (1965, p. 66).

*Discussion:* This is another of the species which occurs widely in Thailand, but does not seem to occur in large numbers. Scanlon and Sandhinand (1965) found that it fed on man in Chon Buri Province, but fed to a greater extent on cattle. Ha-

rinasuta *et al.* (1964) and Tansathit *et al.* (1963) reported very small numbers in human biting collections. *Anopheles splendidus* does not appear to play any role in the transmission of malaria in Thailand. Larvae were collected in a surface pool, stream, and marsh at Chiang Mai and Mae Hong Son.

*Distribution in Thailand:* Chiang Mai, Chon Buri, Mae Hong Son, Nakhon Ratchasima, Saraburi, Ubon Ratchathani, Udon Thani.

ANOPHELES (CELLIA) STEPHENSI Liston, 1901,

*Previous Thailand records:* Griffith (1955, p. 565); Thurman (1959, p. 121)

*Discussion:* The mountains of north-western Thailand appear to mark the eastern limit of distribution of *A. stephensi*. Specimens are in the USNM collection from Chiang Rai and Chiang Mai Provinces (Thurman and Thurman 1955). Additional larval collections were made by SEATO personnel from two localities in Chiang Mai Province (Fang and Mae Rim). The rarity of the species in Thailand makes it unlikely that it plays any role in malaria transmission here, although it is a very important vector in parts of India and the Middle East. Larvae are found in a wide variety of surface waters, including artificial containers in urban areas. In Thailand larvae were found in surface pools and once in a tree hole.

*Distribution in Thailand:* Chiang Mai, Chiang Rai.

ANOPHELES (CELLIA) SUBPICTUS Grassi, 1899

(Including *A. subpictus* var. *malayensis* Hacker, 1921)

*Previous Thailand records:* Stanton (1920, p. 334, *rossii* var. *indefinitus*, in part?); Barnes (1923a, p. 121, *A. rossii*, in part?); Barraud and Christophers (1931, p. 275, 276, as *rossii* and *subpictus malayensis*); Anigstein (1932, p. 259); Causey (1937a, p. 403); Wilson and Reid (1949, p. 270); Iyengar (1953, p. 747); Thurman (1959, p. 119); Tansathit *et al.* (1963, p. 138); Harinasuta *et al.* (1964, p. 323); Scanlon and Esah (1965, p. 138).

*Discussion:* The early records of this very abundant and widespread species are impossible to separate from those for *A. vagus* Dönitz. Both of these species are locally abundant at about the same season in Thailand, although *A. vagus* appears to be more abundant under most circumstances. In addition, many of the references cited above list both *subpictus* and *subpictus malayensis*. The latter form is treated by Stone *et al.* (1959) as a variety. This is undoubtedly the correct interpretation, since both forms, and intermediate forms, were frequently reared from larvae collected from the same site, and the several forms of adults were taken together frequently. This subject will be discussed in more detail elsewhere.

*A. subpictus* is strongly zoophilic in Thailand, although small numbers do feed on man and rest in dwellings. In the Bangkok area, *subpictus* was most abundant in July, just after the onset of the rainy season. Larvae were found in surface water, particularly polluted water or water fouled by animals. Large numbers were also

taken in mangrove swamps and other brackish water habitats together with *A. sundaicus* (Rodenwaldt), 1925. Other habitats were boat bottoms, wells and sumps, ponds, ditches, and artificial containers. There is considerable evidence of an epidemiological nature that *A. subpictus* is never a malaria vector in Thailand.

*Distribution in Thailand:* Common throughout the country. Collected wherever reasonably large numbers of mosquitoes were examined, except in forested areas.

#### ANOPHELES (CELLIA) SUNDAICUS (Rodenwaldt), 1925

*Previous Thailand records:* Barnes (1923a, p. 122, as *ludlowi*); Barraud and Christophers (1931, p. 276, as *ludlowi*); Wilson and Reid (1949, p. 270); Iyengar (1953, p. 747); Griffith (1955, p. 565); Ayurakitkosol and Griffith (1963, p. 122); Thurman (1959, p. 119, as *sundanicus* and *ludlowi*); Tansathit *et al.* (1963, p. 138).

*Discussion:* Barnes (1923a) reported finding oocysts in one of twenty-five *sundanicus* dissected on the island of Ko Phra in the Gulf of Thailand where a malaria epidemic was in progress. The files of the National Malaria Eradication Project in Thailand indicate that the species may be locally abundant in coastal areas, and may be an important vector of local malaria outbreaks. Tansathit *et al.* (1963) found that the severe malaria outbreak at Sattahip Naval Base in Chon Buri Province was, however, due to *A. minimus*. breeding in hill streams near the coast. In the SEATO collections larvae were found in ponds behind beaches in coastal areas, and in mine pools. Adults were taken in human biting collections in several coastal areas, and were found resting in houses, but more detailed study is required on the adult habits in Thailand. A number of specimens in the USNM collection were taken at Songkhla by Coher and Beales.

*Distribution in Thailand:* Chanthaburi, Chon Buri, Ranong, Rayong, Songkhla.

#### ANOPHELES (CELLIA) TESSELLATUS Theobald, 1901

*Previous Thailand records:* Stanton (1920, p. 334); Barnes (1923a, p. 122, as *punctulatus*); Barraud and Christophers (1931, p. 273); Anigstein (1932, p. 253); Payung Vejjasatra (1933, p. 661); Causey (1937a, p. 403); de Fluiter (1948, p. 273); Wilson and Reid (1949, p. 270); Sandhinand (1951, p. 37); Iyengar (1953, p. 747); Thurman and Thurman (1955, p. 222); Thurman (1959, p. 119); Tansathit *et al.* (1963, p. 138); Harinasuta *et al.* (1964, p. 323); Scanlon and Esah (1965, p. 138); Scanlon and Sandhinand (1965, p. 66); Gould *et al.* (1967, p. 441).

*Discussion:* This species is apparently primarily a zoophilic species, but it has been collected biting man at many points in Thailand. Scanlon and Sandhinand (1965) collected small numbers from cattle, none from humans. It has been taken in human biting or house resting collections by Harinasuta *et al.* (1964), Tansathit *et al.* (1963), Scanlon and Esah (1965), and Gould *et al.* (1967). Larvae were collected from various surface water sources, such as rice fields, ponds, ditches, sumps, and springs.

*Distribution in Thailand* : Ayutthaya, Chanthaburi, Chiang Mai, Chiang Rai, Chon Buri, Phra Nakhon (Bangkok), Nakhon Si Thammarat, Narathiwat, Nakhon Ratchasima, Nan, Nonthaburi, Kanchanaburi, Pathum Thani, Ranong, Rayong, Saraburi, Satun, Trang, Udon Thani.

ANOPHELES (CELLIA) VAGUS Dönitz, 1902

*Previous Thailand records*: Theobald (1910, p. 19, as *rossii*); Stanton (1920, p. 334, as *rossii* var. *indefinitus*, in part?); Anigstein (1932, p. 251); Payung Vejjasatra (1933, p. 661); Causey (1937a, p. 403); de Fluiter (1947, p. 273); Wilson and Reid (1949, p. 266); Sandhinand (1951, p. 37); Iyengar (1953, p. 747); Thurman and Thurman (1955, p. 222); Thurman (1959, p.119); Tansathit *et al.* (1963, p. 138); Harinasuta *et al.* (1964, p. 323); Scanlon and Esah (1965, p. 138); Scanlon and Sandhinand (1956, p. 66); Gould *et al.* (1967, p. 441).

*Discussion*: In most urban and agricultural areas of Thailand this is the most abundant *Anopheles* species encountered. The larvae are found in wide variety of surface waters, from rice paddies to small puddles, including heavily polluted hoof-prints and wallows in animal enclosures. They were occasionally found in somewhat more unusual habitats, such as wells, water jugs, chain holes in logs, rock holes, and boat bottoms. The species is often found in abundance in light trap and animal biting collections. Fair numbers of *vagus* have been caught on some occasions (Gould *et al.* 1967) in human biting collections in Thailand, but the species is apparently highly zoophilic. These observations agree well with those reported by Covell (1944) from other areas in south-east Asia. The early records of *A. vagus* in Thailand are confused with those of *A. subpictus*, and these two species occur together very frequently in collections in all parts of the country. Despite its abundance there is no evidence that this species plays any role in the transmission of human disease in Thailand.

*Distribution in Thailand*: *A. vagus* was taken in every province of Thailand where more than cursory collections were made. It was generally not found in the primary forests, but may penetrate wherever small agricultural communities have been established in the forest.

ANOPHELES (CELLIA) VARUNA Iyengar, 1924

*Previous Thailand records*: Thurman (1959, p. 121).

*Discussion*: Thurman (1959) reported that this species was recorded for the first time in Thailand between 1950 and 1956, without additional details. Several specimens in the SEATO collections from Chiang Mai from light trap and human biting collections seem to be this species. However, the entire question of the presence of this species and other members of the *Myzomyia* group in northern Thailand (*aconitus*, *filipinae*, *minimus*, etc.) requires additional study. No larvae were collected in Thailand in the SEATO collections.

*Distribution in Thailand*: Chiang Mai.



## ACKNOWLEDGEMENTS

A large number of technicians of the Department of Medical Entomology, U.S. Army Medical Component - SEATO, contributed to the collections which formed the principal basis of this report. Chief among these were: Mr. Sahem Esah, Mr. Samarn Maneewongse, Mr. Sumeth Chunchulcherm, Mr. Kol Mongkolpanya, Mr. Somboon Maneechai and Mr. Chaliou Diraphat. Mrs. Rampa Rattana-rithikul assisted greatly in the determination of the material collected, as did Miss Supanee Sandhinand and Miss Pacharee Nawarat. Additional unpublished notes on the *Anopheles* of Thailand were furnished by Dr. Udaya Sandhinand and Mr. Manop Rattana-rithikul. Dr. Alan Stone and Dr. John Reid assisted in the identification of some of the more difficult specimens. We also wish to acknowledge the technical assistance of Miss Calesta Lipscomb, Miss Theresa Houck, and Mr. Ashton Uter of the Southeast Asia Mosquito Project, Smithsonian Institution.

## REFERENCES

- ANIGSTEIN, L. (1932).—Malaria and anophelines in Siam. *Q.Bull. Hlth Org. L of N.* 1 (2) : 233-308.
- AYURAKITKOSOL, Luang, and GRIFFITH, M.E. (1956).—The developing antimalaria vigilance program in Thailand. *Bull. Wld Hlth Org.* 15 : 799-805.
- AYURAKITKOSOL, Luang, and GRIFFITH, M.E. (1963).—Progress toward malaria eradication in Thailand. *Proc. Pacif. Sci. Congr.* IX, Bangkok, 1957. 17 : 122-136
- BARNES, M.E. (1923a).—Notes on the anopheline mosquitoes of Siam. *Am. J. Hyg.* 3 (2) : 121-126
- BARNES, M.E. (1923b).—Anopheline mosquitoes with special reference to the species found in Siam. *J. nat. Hist. Soc. Siam* 6 (1) : 65-79.
- BARRAUD, P.J., and CHRISTOPHERS, S.R. (1931).—On a collection of anopheline and culicine mosquitoes from Siam. *Rec. Malar. Surv. India* 2 (2) : 269-285.
- BONNE-WEPSTER, J., and SWELLENGREBEL, N.H. (1953).—"The Anopheline Mosquitoes of the Indo-Australian Region." (de Bussey : Amsterdam.)
- BOREI, E. (1926).—Anopheles et paludisme dans la region de Chaudoc (Cochin-Chine). *Bull. Soc. Path. exot.* 19 : 806-811.
- BRUG, S.L., and BONNE-WEPSTER, J. (1947).—The geographical distribution of the mosquitoes of the Malay Archipelago. *Chronica Nat.* 103 (10-11) : 179-197.
- BÜTTIKER, W., and BEALES, P. (1959).—*Anopheles pampanae*, a new species of mosquito from Cambodia. *Acta Trop.* 16 (1) : 63-69.
- CAUSEY, O.R. (1937a).—Some anopheline and culicine mosquitoes of Siam with remarks on malarial control in Bangkok. *Am. J. Hyg. Monogr. Ser.* 25 (2) : 400-420.
- CAUSEY, O.R. (1937b).—New anopheline and culicine mosquitoes from Siam. *J. Parasit.* 23 (5) : 543-545.
- CHRISTOPHERS, S.R. (1933).—"The Fauna of British India. Diptera." vol. IV. Anophelini. (Taylor and Francis : London.)
- COLLESS, D.H. (1957).—Further notes on the systematics of the *Anopheles leucosphyrus* group (Diptera : Culicidae). *Proc. R. ent. Soc. Lond.* 26 (7-8) : 131-139.
- COVELL, G. (1944).—Notes on the distribution, breeding places, adult habits and relation to malaria of the anopheline mosquitoes of India and the Far East. *J. Malar. Inst. India* 5 : 399-434.
- DE FLUITER, H.J. (1948).—Malaria en malaria-overbrengers in de krijgsgevangenkampen Chungkai en Tamuang (W. Thailand). *Ent. Ber. Amst.* 12 : 271-275
- FOOTE, R.H., and COOK, D.R. (1959).—"Mosquitoes of Medical Importance." Agriculture Handbook. (U.S. Department of Agriculture : Washington.)
- GOULD, D.J., ESAH, Sahem, and PRANITH, Udom (1967).—Relation of *Anopheles aconitus* to malaria transmission in the central plain of Thailand. *Trans. R. Soc. trop. Med. Hyg.* 59 (1) : 441-442.

- GRIFFITH, M.E. (1955).—A note on *Anopheles minimus* Theobald as a malaria vector in Thailand. Estratto dagli Atti del VI Congresso Internazionale di Microbiologia Roma (1953). 5 (26) : 565-567.
- HARINASUTA, Chamlong, CHAROENLARP, Pricha, GUPTAVANI, Pensri, and SUCHARIT, Supat (1964).—A Pilot project for the control of filariasis in Thailand. *Ann. trop. Med. Parasit.* 58 (3) : 315-327.
- HODGKIN, E.P. (1950).—The *Anopheles umbrosus* group (Diptera : Culicidae). II. Biology and transmission of malaria. *Trans. R. ent. Soc. Lond.* 101 (9) : 319-334.
- IYENGAR, M.O.T. (1953).—Filariasis in Thailand. *Bull. Wld Hlth Org.* 9 (6) : 731-766.
- IYENGAR, M.O.T., and MENON, M.A.U. (1956).—The mosquitoes of south Thailand. *Bull. ent. Res.* 47 (4) : 785-795.
- PAYUNG VEJASASTRA, Luang (1933).—(Malaria survey at Tung Song, Nakhon Si Thammarat.) Department of Health (Thailand) Public Health Bulletin No 11. (In Thai.)
- PURI, I.M. (1949).—Anophelines of the oriental region. In : Boyd, M.F., ed. "Malariology." pp. 483-505. (W.B. Saunders Co. : Philadelphia.)
- REID, J.A. (1950).—The *Anopheles umbrosus* group (Diptera : Culicidae). I. Systematics, with descriptions of two new species. *Trans. R. ent. Soc. Lond.* 101 (9) : 281-318
- REID, J.A. (1953).—The *Anopheles hyrcanus* group in south-east Asia (Diptera : Culicidae). *Bull. ent. Res.* 44 (1) : 5-76.
- REID, J.A. (1962).—The *Anopheles barbirostris* group (Diptera : Culicidae). *Bull. ent. Res.* 53 (1) : 1-57.
- REID, J.A. (1963).—Notes on anopheline mosquitoes from Malaya, with descriptions of three new species. *Ann. trop. Med. Parasit.* 57 (1) : 97-116.
- REID, J.A. (1965).—A revision of the *Anopheles aikenii* group in Malaya and Borneo. *Ann. trop. Med. Parasit.* 59 (1) : 106-125.
- REID, J.A., and KNIGHT, K.L. (1961).—Classification within the subgenus *Anopheles* (Diptera, Culicidae). *Ann. trop. Med. Parasit.* 55 (4) : 474-488.
- SANDHINAND, Udaya (1951).—Anophelines of Chiangmai Province, Thailand. *J. med. Ass. Thailand* 34 (3) : 33-38.
- SANDOSHAM, A.A (1945).— "The Identification of the Common Anophelines of Malai and Thailand." (Syonan Tokubetu-Si : Singapore.)\*
- SCANLON, J.E., and ESAH, Sahem (1965).—Distribution in altitude of mosquitoes in northern Thailand *Mosquito News* 25 (2) : 137-144.
- SCANLON, J.E., and PEYTON, E.L. (1967).—*Anopheles (Anopheles) tigertti* a new species of the *aikenii* group from Thailand. *Proc. ent. Soc. Wash.* 69 (1) : 18-23.
- SCANLON, J.E., and SANDHINAND, Udaya (1965).—The distribution and biology of *Anopheles balabacensis* in Thailand (Diptera : Culicidae). *J. med. Ent.* 2 (1) : 61-69
- SMART, J. (1948).—"A Handbook for the Identification of Insects of Medical Importance." (British Museum (Natural History) : London.)
- STANTON, A.T. (1920).—The mosquitoes of the Far Eastern ports with special reference to the prevalence of *Stegomyia fasciata*. *Bull. ent. Res.* 10 : 333-344.
- STONE, A. (1961).—A synoptic catalog of the mosquitoes of the world, supplement I. *Proc. ent. Soc. Wash.* 63 (1) : 29-52.
- STONE, A (1963).—A synoptic catalog of the mosquitoes of the world, supplement II. *Proc. ent. Soc. Wash.* 65 (2) : 117-140.
- STONE, A., KNIGHT, K.L., and STARCKE, H. (1959).—"A Synoptic Catalog of the Mosquitoes of the World." (Thomas Say Foundation, vol. VI.) (Entomological Society of America : Washington.)
- TANSATHIT, Prasit, THAVARAMARA, Banyong, CHALAWYOO, Skol, and KAMPANARDAENYAKARA, Chaiyan (1962).—Malaria in Sattahib Naval Base, Thailand. *Proc. Pacif. Sci. Congr.* IX, Bangkok, 1957. 17 : 137-143.
- THEOBALD, F.V. (1910).—"Monograph of the Culicidae or Mosquitoes." vol. V. (British Museum (Natural History) : London.)
- THURMAN, D.C., and THURMAN, Ernestine B. (1955).—Report of the initial operation of a mosquito light trap in northern Thailand. *Mosquito News* 15 (4) : 218-224.
- THURMAN, Ernestine B. (1959).—A contribution to a revision of the Culicidae of northern Thailand. Univ. Maryland Agric. Exp. Stn Bull. A-100.

- THURMAN, Ernestine B. (1963).—The mosquito fauna of Thailand (Diptera : Culicidae). *Proc. Pacif. Sci. Congr.* IX, Bangkok, 1957. **9** : 47-57.
- TOUMANOFF, C. (1936).—"L'Anophelisme en Extrême-Orient." (Masson et Cie. : Paris.)
- TOUMANOFF, C. and TRY, H.T. (1937).—Nouvelle contribution à la connaissance de la faune anophelienne de la haute altitude du Tonkin. *Bull. Soc. med.chir. Indochine* **15** : 980-991.
- WILSON, T., and REID, J.A. (1949).—Malaria among prisoners of war in Siam ("F" Force). *Trans. R. Soc. trop. Med. Hyg.* **43** (3) : 257-272.
- WHARTON, R.H., EYLES, D.E., MOOREHOUSE, D.E., and SANDOSHAM, A.A. (1963).—Investigations leading to the identification of members of the *Anopheles umbrosus* group as probable vectors of mouse deer malaria. *Bull. Wld Hlth Org.* **27** : 357-374.
- WHARTON, R.H., EYLES, D.E., WARREN, McW., and CHEONG, W.H. (1964).—Studies to determine the vectors of monkey malaria in Malaya. *Ann. trop. Med. Parasit.* **58** (1) : 56-77.

\*Reference not seen.

## APPENDIX

## A LIST OF PROVINCES OF THAILAND

- |                                              |                           |
|----------------------------------------------|---------------------------|
| 1. Ang Thong                                 | 36. Phetchabun            |
| 2. Ayutthaya<br>(= Phra Nakhon Si Ayutthaya) | 37. Phangnga              |
| 3. Buri Ram                                  | 38. Phatthalung           |
| 4. Chachoengsao                              | 39. Phetchaburi           |
| 5. Chai Nat                                  | 40. Phitsanulok           |
| 6. Chaiyaphum                                | 41. Phuket                |
| 7. Chanthaburi                               | 42. Phichit               |
| 8. Chiang Mai                                | 43. Prachin Buri          |
| 9. Chiang Rai                                | 44. Prachuap Khiri Khan   |
| 10. Chon Buri                                | 45. Phrae                 |
| 11. Chumphon                                 | 46. Ranong                |
| 12. Kalasin                                  | 47. Ratchaburi            |
| 13. Kamphaeng Phet                           | 48. Rayong                |
| 14. Kanchanaburi                             | 49. Roi Et                |
| 15. Khon Kaen                                | 50. Sakon Nakhon          |
| 16. Krabi                                    | 51. Samut Prakan          |
| 17. Phra Nakhon (= Bangkok)                  | 52. Samut Sakhon          |
| 18. Lampang                                  | 53. Samut Songkhram       |
| 19. Lamphun                                  | 54. Saraburi              |
| 20. Loei                                     | 55. Satun                 |
| 21. Lop Buri                                 | 56. Sing Buri             |
| 22. Mae Hong Son                             | 57. Songkhla              |
| 23. Maha Sarakham                            | 58. Si Sa Ket (=Khu Khan) |
| 24. Nakhon Nayok                             | 59. Sukhothai             |
| 25. Nakhon Pathom                            | 60. Suphan Buri           |
| 26. Nakhon Phanom                            | 61. Surat Thani           |
| 27. Nakhon Ratchasima                        | 62. Surin                 |
| 28. Nakhon Sawan                             | 63. Tak                   |
| 29. Nakhon Si Thammarat                      | 64. Thon Buri             |
| 30. Nan                                      | 65. Trat                  |
| 31. Narathiwat                               | 66. Trang                 |
| 32. Nong Khai                                | 67. Ubon Ratchathani      |
| 33. Nonthaburi                               | 68. Udon Thani            |
| 34. Pathum Thani                             | 69. Uthai Thani           |
| 35. Pattani                                  | 70. Uttaradit             |
|                                              | 71. Yala                  |

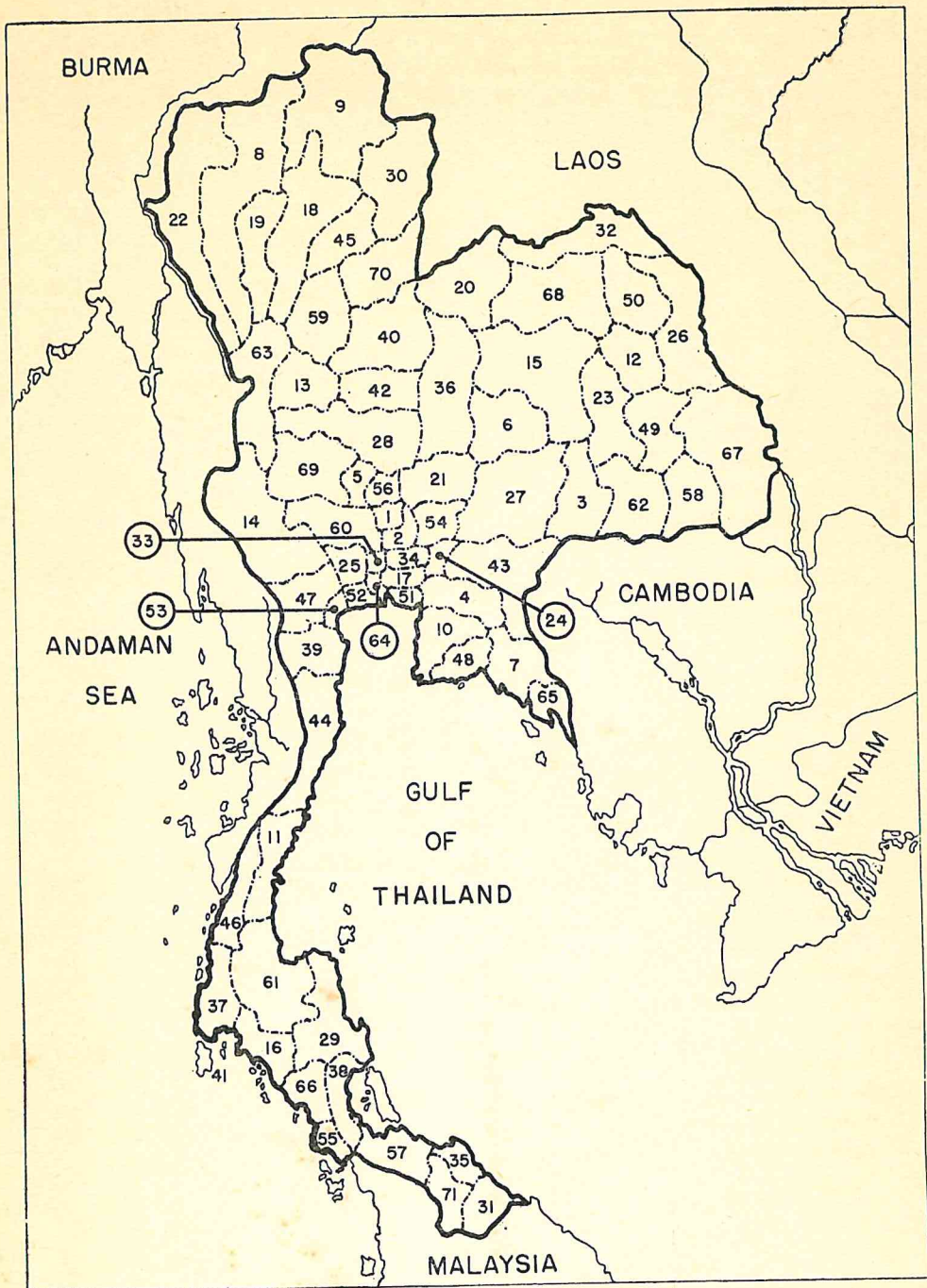


Figure 1. Map of Thailand.  
(For explanation see opposite page.)

## NOTICE TO AUTHORS

Authors should aim at a concise style and should avoid presenting large bodies of primary data.

**Manuscripts** must be typewritten, using double spacing throughout and leaving ample margins. The top (ribbon) copy must be submitted together with one carbon copy.

The **title** of the paper should be kept as short as possible. A running title not exceeding 50 letters should be added.

Each paper must start with a brief but informative **summary** of its contents, and should conform to the normal usage of the Thai National Scientific Papers in the matters of layout and typography.

The metric system is adopted as the standard for **units of measurement**.

**References** are listed alphabetically at the end of the paper; personal communications and papers that have not been accepted for publication are not to be included in the list of references. The full title of each paper must be given. Titles of papers, but not of books, are decapitalized. Titles of journals are abbreviated as in the *World List of Scientific Periodicals*, 4th ed., 1963 on. References to books should include the publisher and the town of publication. Citation in the text is to be given by the author's name followed by the year of publication in brackets.

*Examples:*

BARNES, M.E. (1923).—Notes on the anopheline mosquitoes of Siam. *Am. J.Hyg.* 3 (2): 121–126.

BONNE-WEPSTER, J., and SWELLENGREBEL, N.H. (1953).—"The Anopheline Mosquitoes of the Indo-Australian Region." (de Bussey: Amsterdam.)

**Tables** should be set out on separate sheets numbered in arabic numerals, and given concise headings. They should be arranged having regard to the printed page, and the number of columns should be kept to a minimum. Duplication of information in tables and graphs is to be avoided.

**Text-figures** must be drawn with black ink on board, drawing or tracing paper, coordinate paper with *faint blue* rulings. In general it is unnecessary to supply diagrams more than twice the linear dimensions desired in the final reproduction. The maximum space available on a page is 127 × 180 mm.

Axes and graduation marks on graphs must be inked in. Where reduction to one half in linear dimension is intended, a suitable thickness for the axes is 0.3 mm and for other lines 0.4 or 0.5 mm depending on the complexity of the graph. The preferred symbols are solid and open circles, solid and open squares, solid and open triangles.

All lettering on original figures should be in soft lead pencil or indicated on a transparent overlay.

The originals and two copies of each are required. The title of the paper and the name of the author must appear on each sheet. Figures must be numbered consecutively in the order in which they are mentioned in the text, and their approximate position should be indicated in the margin. A typed list of captions must be supplied.

**Photographic prints** must be of the highest quality, printed on glazed paper, and should be supplied at a size requiring reduction to not less than one-half dimension. The maximum size of a plate is 127 × 170 mm. Three copies are required together with a typed list of captions.

**Reprints** are supplied free to authors as follows: one author, 40; two authors, 30 each; three or more authors, 20 each. Additional reprints may be obtained at cost if ordered no later than when the galley proofs are returned.

ศูนย์ความรู้ (ศคร.)



BE37167