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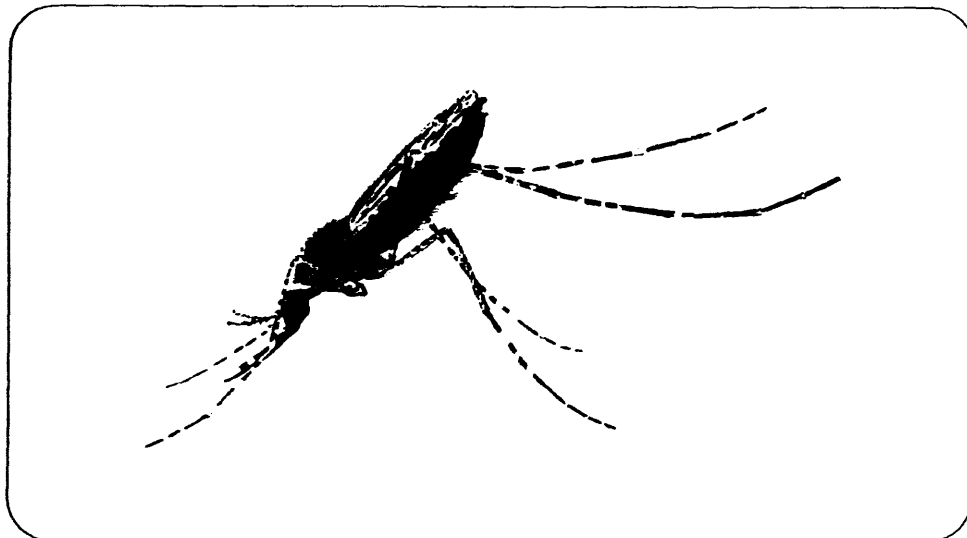
April 1990

Pages 131-162

**PICTORIAL KEY TO THE  
SPECIES OF INDIAN ANOPHELINE MOSQUITOES**

**Bina Pani Das   R. Rajagopal   J. Akiyama**

(With 177 Illustrations and 3 Tables)



**Female *Anopheles stephensi*, the vector of urban malaria**

**ASSOCIATION FOR THE ADVANCEMENT OF ZOOLOGY**

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This journal is intended for publication of scientific writings on all aspects of zoology in the widest sense. Its publication is not constrained by any fixed periodicity nor by the size of the articles, it is hence not a periodical. The prime objective of **Zoology (Journal of Pure and Applied Zoology)** is to make possible rapid publication of results of scientific investigations.

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## PREFACE

The resurgence of malaria in India since the late sixties, the numerous constraints in the eradication/control of the disease and the changed epidemiological situation, particularly the entomological aspects due to decades of insecticidal pressure and the numerous developmental activities leading to changes in the environment, have once again focused attention on the intensification of entomological studies in different parts of the country.

As a consequence of ecological changes, the results of socio-economic developments in many areas, the anopheline fauna vector bionomics and behaviour no longer resemble the situation that prevailed 30-40 years ago and the vectorial efficiency of the anophelines needs to be re-evaluated since the lack of this information adversely affects malaria control activities.

An important step in the assessment of the disease potential of an insect is the rapid separation and identification of mosquitoes. Entomologists and entomological technicians must ensure the correct identification of anopheline mosquitoes. Invariably the task is difficult even for experienced entomologists, unless adequate literature is at hand.

During the past two or three decades there have also been numerous studies on the various groups of anophelines such as *Anopheles annularis*, *culicifacies*, *hyrcanus*, *leucosphyrus*, *maculatus*, *subpictus*, etc., leading to many changes in the nomenclature of the anopheline species. Recently there have also been studies on cytotaxonomy, which have substantiated the existence of a number of sibling species as well. For any meaningful entomological study, correct identification of the different species is a prime requisite. In spite of the rapid advances in cytotaxonomy, the field entomologist and epidemiologist has to rely on morphological taxonomy for identification, as cytotaxonomy is restricted to only sophisticated laboratories and is also time-consuming.

The only available keys are by Christophers (1933) and Puri (1954). These keys have since long become antiquated and are of limited value because of changes in nomenclature, and the addition of further species in literature. It was, therefore, felt that an up to date key should be prepared for the 54 species of anophelines recognized at present, for the use of field entomologist. The present work is an attempt in that direction. To make identification easy, illustrations are provided for each distinguishing character used in the key. It is hoped that the field entomologists would find the key useful in their investigations. However, the detailed descriptions of the individual species in Christophers (1933) continue to be indispensable for all entomologists working on anophelines in the Oriental Region.

Although designed primarily for use in Indian malaria programmes, this pictorial key should also prove useful to persons engaged in similar activities in neighbouring countries, i.e. Bangladesh, Burma, Nepal and Sri Lanka. This key can be used effectively even by persons having preliminary taxonomic training.

Authors

## Pictorial Key to the Species of Indian Anopheline Mosquitoes

### INTRODUCTION

Keys for the identification of anopheline mosquitoes of India have been published by several authors, of which the most important are those by Christophers (1933) and Puri (1954, adults; 1960, larvae). Christophers' work is monumental, providing detailed description of each species, and even after half a century continues to be a valuable reference work for taxonomists on anophelines. He described 43 species and 10 varietal forms, of which 40 species and 9 variations are restricted to present-day India. The key by Puri is primarily meant for rapid identification of the adult anophelines and has been widely used by workers not only in India but also in some of the neighbouring countries. Puri also described 43 species and 9 varietal forms, of which 40 species are restricted to present India and 3 species, viz. *An. sergenti*, *An. habibi*, and *An. superpictus*, are not found in divided India. Of the 9 varietal forms, five were raised to species level, out of which four were included in Knight & Stone (1977). The current taxonomic status of these and some other names is shown in Table 1.

Since the publication of the above mentioned keys much work has been done on the taxonomy of anophelines, particularly *annularis*, *barbirostris*,

*hyrcanus*, *leucosphyrus*, and *maculatus* species groups and the *subpictus* and *culicifacies* sibling species complexes (Reid 1953, 1962, 1965, 1968; Harrison 1980; Rattanarithikul and Green 1986; Nural Huda and Harrison 1985; Harrison and Scanlon 1975; Peyton and Harrison 1979; Suguna 1982; Reuben and Suguna 1983; Yang 1983; Reid, Wattal, and Peters 1966). Rao (1984) published keys, but many species were treated as groups and there is no single key for all the species. Wattal & Kalra (1961) published pictorial keys for different regions of India but these keys included only 32 species of female anophelines.

The present work provides a key for 54 species of anophelines found in India (Table 2). Specimens from India reported as *An. vanus* Walker (Wattal, Kalra, and Rajagopal 1962) were found to belong to *An. barbirostris* (Reid 1968). The typical *An. balabacensis* *balabacensis* is believed to be restricted to Balabac and Palawan Islands of Philippines (Yang 1983) and the name *ramsayi* was sunk as junior synonym of *pseudojamesi* (Nural Huda and Harrison 1985). Since a few species (*subpictus*, *culiciformis*, and *aithenii* species groups, and *vanus* subgroup) can be differentiated using the egg,

larval, and adult male characters, the key is not based only on adult female characters. However, a majority of the species are distinguished on the basis of

the characters of adult females. The differentiating characters used in each couplet of the key have been illustrated so as to facilitate identification. The

**Table 1. Taxonomic status of some Indian *Anopheles*.**

| Christophers<br>(1933)                                        | Other Authors                                                                  | Knight & Stone<br>(1977)                                       | Present Status                     |
|---------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------|------------------------------------|
| <i>barbirostris</i> var.<br><i>ahomi</i>                      | As species by<br>Reid (1962)                                                   | <i>ahomi</i>                                                   | <i>ahomi</i>                       |
| <i>gigas</i> var. <i>baileyi</i>                              | —                                                                              | <i>gigas</i> var. <i>baileyi</i>                               | <i>gigas</i> var. <i>baileyi</i>   |
| <i>aithenii</i> var.<br><i>bengalensis</i>                    | As species by<br>Reid (1965)                                                   | <i>bengalensis</i>                                             | <i>bengalensis</i>                 |
| <i>jeyporiensis</i> var.<br><i>candidiensis</i>               | —                                                                              | Synonymized under<br><i>jeyporiensis</i> by<br>Harrison (1980) | <i>jeyporiensis</i>                |
| <i>annandalei</i> var.<br><i>interruptus</i>                  | As species by<br>Reid (1968)                                                   | <i>interruptus</i>                                             | <i>interruptus</i>                 |
| <i>lindesayi</i> var.<br><i>nilgircus</i>                     | —                                                                              | <i>lindesayi</i><br><i>nilgircus</i>                           | <i>lindesayi nilgircus</i>         |
| <i>pseudowillmori</i><br>(as synonym of<br><i>maculatus</i> ) | Taken back from syno-<br>nymy by Rattanari-<br>thikul & Green (1986)           | Synonym of<br><i>maculatus</i>                                 | <i>pseudowillmori</i>              |
| <i>ramsayi</i>                                                | Synonymized under<br><i>pseudojamesi</i> by<br>Nurul Huda &<br>Harrison (1985) | <i>ramsayi</i>                                                 | <i>pseudojamesi</i>                |
| <i>gigas</i> var.<br><i>simlensis</i>                         | —                                                                              | <i>gigas</i> var.<br><i>simlensis</i>                          | <i>gigas</i> var. <i>simlensis</i> |
| <i>hyrcanus</i> var.<br><i>sinensis</i>                       | Revalidated as species<br>by Reid (1953)                                       | <i>sinensis</i>                                                | <i>sinensis</i>                    |
| <i>maculatus</i> var.<br><i>willmori</i>                      | Raised to species by<br>Rattanarithikul &<br>Green (1986)                      | <i>maculatus</i> var.<br><i>willmorei</i>                      | <i>willmori</i>                    |

important morphological characters of adult and immature stages of anophelines used for identification of various species are given in Figs. 1 and 2. In the present keys we have followed the terminology used by Christophers (1933) and Puri (1954, 1960) for the sake of convenience, since a majority of field entomologists and biologists in India, engaged in malaria eradication programme, are familiar with this terminology. A comparison with the more appropriate terminology used by Harrison and Scanlon (1975) and Harbach and Knight (1980) is shown in Table 3.

No originality is claimed for the key, since it is based on descriptions by

Christophers, Puri, Reid, Harrison & Scanlon, Rattanarithikul & Green, and other authors.

In view of the revision in the nomenclature of some of the groups, much work remains to be done, so as to find out the precise distribution of the concerned species. Revisionary work is also needed in order to ascertain the extent of variation in these species. It does not need to be emphasized that revisionary studies on the taxonomy of the anopheline fauna of the country are urgently required. It is hoped that the publication of the present key, besides aiding in their identification, would also stimulate further work on the anophelines in India.

Table 2. Systematic List of Indian Species of *Anopheles*.

Subgenus *Anopheles* Meigen

- |                                                              |                                                                                   |
|--------------------------------------------------------------|-----------------------------------------------------------------------------------|
| 1. <i>Anopheles (Anopheles) ahomi</i> Chowdhury, 1929        | 12. <i>An. (An.) insulaeflorum</i> (Swellengrebel & Swellengrebel de Graaf), 1919 |
| 2. <i>An. (An.) aitkenii</i> James, 1903                     | 13. <i>An. (An.) interruptus</i> Puri, 1929                                       |
| 3. <i>An. (An.) annandalei</i> Prasad, 1918                  | 14. <i>An. (An.) lindesayi</i> Giles, 1900                                        |
| 4. <i>An. (An.) argyropus</i> (Swellengrebel), 1914          | 15. <i>An. (An.) nigerrimus</i> Giles, 1900                                       |
| 5. <i>An. (An.) barbirostris</i> Van der Wulp, 1884          | 16. <i>An. (An.) nitidus</i> Harrison, Scanlon & Reid, 1973                       |
| 6. <i>An. (An.) barumbrosus</i> Strickland & Chowdhury, 1927 | 17. <i>An. (An.) pedi'aeniatus</i> (Leicester), 1908                              |
| 7. <i>An. (An.) barianensis</i> James, 1911                  | 18. <i>An. (An.) pinjaurensis</i> Barraud, 1932                                   |
| 8. <i>An. (An.) bengalensis</i> Puri, 1930                   | 19. <i>An. (An.) roperi</i> Reid, 1950                                            |
| 9. <i>An. (An.) crawfordi</i> Reid, 1953                     | 20. <i>An. (An.) sinensis</i> Weidemann, 1828                                     |
| 10. <i>An. (An.) culiciformis</i> Cogill, 1903               | 21. <i>An. (An.) sintoni</i> Puri, 1929                                           |
| 11. <i>An. (An.) gigas</i> Giles, 1901                       | 22. <i>An. (An.) umbrosus</i> (Theobald), 1903                                    |

Subgenus *Cellia* Theobald

- |                                                  |                                                   |
|--------------------------------------------------|---------------------------------------------------|
| 23. <i>An. (C.) aconitus</i> Doenitz, 1902       | 25. <i>An. (C.) culicifacies</i> Giles, 1901      |
| 24. <i>An. (C.) annularis</i> Van der Wulp, 1884 | 26. <i>An. (C.) dirus</i> Peyton & Harrison, 1979 |

Table 2 (Continuation). Systematic List of Indian *Anopheles*.

- |                                                    |                                                               |
|----------------------------------------------------|---------------------------------------------------------------|
| 27. <i>An. (C.) dthali</i> Patton, 1905            | 41. <i>An. (C.) philippinensis</i> Ludlow, 1902               |
| 28. <i>An. (C.) elegans</i> (James), 1903          | 42. <i>An. (C.) pseudojamesi</i> Strickland & Chowdhury, 1927 |
| 29. <i>An. (C.) fluvialitis</i> James, 1902        | 43. <i>An. (C.) pseudowillmori</i> Theobald, 1910             |
| 30. <i>An. (C.) jamesii</i> Theobald, 1901         | 44. <i>An. (C.) pulcherrimus</i> Theobald, 1902               |
| 31. <i>An. (C.) jeyporiensis</i> James, 1902       | 45. <i>An. (C.) splendidus</i> Koidzumi, 1920                 |
| 32. <i>An. (C.) karwari</i> (James), 1902          | 46. <i>An. (C.) stephensi</i> Liston, 1901                    |
| 33. <i>An. (C.) kochi</i> Doenitz, 1901            | 47. <i>An. (C.) subpictus</i> Grassi, 1899                    |
| 34. <i>An. (C.) maculatus</i> Theobald, 1901       | 48. <i>An. (C.) sundaicus</i> (Rodenwaldt), 1925              |
| 35. <i>An. (C.) majidi</i> Young & Majid, 1928     | 49. <i>An. (C.) tessellatus</i> Theobald, 1901                |
| 36. <i>An. (C.) minimus</i> Theobald, 1901         | 50. <i>An. (C.) theobaldi</i> Giles, 1901                     |
| 37. <i>An. (C.) moghulensis</i> Christophers, 1924 | 51. <i>An. (C.) turkhudi</i> Liston, 1901                     |
| 38. <i>An. (C.) multicolor</i> Cambouliu, 1902     | 52. <i>An. (C.) vagus</i> Doenitz, 1902                       |
| 39. <i>An. (C.) nivipes</i> (Theobald), 1903       | 53. <i>An. (C.) varuna</i> Iyengar, 1924                      |
| 40. <i>An. (C.) pallidus</i> Theobald, 1901        | 54. <i>An. (C.) willmori</i> (James), 1903                    |

Species Groups of Indian *Anopheles*:

| Subgenus <i>Anopheles</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Subgenus <i>Cellia</i>                                                                                                                                                                                                                                                                                                                                                                               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>aithenii group.</b> <i>aithenii</i>, <i>bengalensis</i>, <i>insulaeflorum</i>, <i>pinjaurensis</i>.</p> <p><b>asiaticus group.</b> <i>annandalei</i>, <i>interruptus</i>.</p> <p><b>barbirostris group.</b> <i>ahomi</i>, <i>barbirostris</i>, <i>barbumbrosus</i>.</p> <p><b>barianensis group.</b> <i>barianensis</i>.</p> <p><b>culiciformis group.</b> <i>culiciformis</i>, <i>sintoni</i>.</p> <p><b>hyrcanus group.</b> <i>argyropus</i>, <i>crawfordi</i>, <i>nigerrimus</i>, <i>nitidus</i>, <i>peditaeniatus</i>, <i>sinensis</i>.</p> <p><b>lindesayi group.</b> <i>gigas</i>, <i>lindesayi</i>.<br/>These two species could not be segregated as a separate group in the key.</p> <p><b>umbrosus group.</b> <i>roperi</i>, <i>umbrosus</i>.</p> | <p>This subgenus is not divided into groups in the key, although some of the species can be arranged into groups.</p> <p><b>annularis group.</b> <i>annularis</i>, <i>nivipes</i>, <i>pallidus</i>, <i>philippinensis</i>.</p> <p><b>maculatus group.</b> <i>maculatus</i>, <i>pseudowillmori</i>, <i>willmori</i>.</p> <p><b>minimus group.</b> <i>aconitus</i>, <i>minimus</i>, <i>varuna</i>.</p> |

**Table 3. Terminology used in Mosquito Taxonomy.**

| Christophers (1933)<br>Puri (1954, 1960)            | Harrison & Scanlon (1975)<br>Harbach & Knight (1980) |
|-----------------------------------------------------|------------------------------------------------------|
| <b>Adult</b>                                        |                                                      |
| Coxite (Fig. 1 F)                                   | Basimere                                             |
| Harpago (Fig. 1 F)                                  | Claspette                                            |
| Mesonotum (Fig. 1 A)                                | Scutum                                               |
| <b>Larva</b>                                        |                                                      |
| <b>Head Capsule</b> (Fig. 2 B)                      |                                                      |
| Inner clypeal hair [I.C.H.]                         | 2-C [Clypeal hair 2]                                 |
| Outer clypeal hair [O.C.H.]                         | 3-C [Clypeal hair 3]                                 |
| Posterior clypeal hair<br>[Post.C.H.]               | 4-C [Clypeal hair 4]                                 |
| Frontal hairs [Fr.H.]<br>[Inner, mid, outer Fr.H.]  | 5-C, 6-C, 7-C [Clypeal hairs 5, 6, 7]                |
| Inner sutural hair [I.S.H.]                         | 8-C [Clypeal hair 8]                                 |
| Outer sutural hair [O.S.H.]                         | 9-C [Clypeal hair 9]                                 |
| Subantennal hair [S.Ant.H.]                         | 11-C [Clypeal hair 11]                               |
| <b>Thorax</b> (Fig. 2 C)                            |                                                      |
| Innermost hair of prothorax<br>[In.H.Pro.]          | 14-P [Prothoracic hair 14]                           |
| Prothoracic group of pleural<br>hairs [Pro.Pl.H.]   | 9-P to 12-P [Prothoracic hairs<br>9, 10, 11, and 12] |
| Mesothoracic group of pleural<br>hairs [Meso.Pl.H.] | 9-M to 12-M [Mesothoracic hairs<br>9, 10, 11 and 12] |
| Metathoracic group of pleural<br>hairs [Meta.Pl.H.] | 9-T to 12-T [Metathoracic hairs<br>9, 10, 11 and 12] |
| <b>Abdomen</b> (Fig. 2 A)                           |                                                      |
| Palmate hair of abdominal<br>segment III            | 1-III [hair no. 1 of abdominal<br>segment III]       |

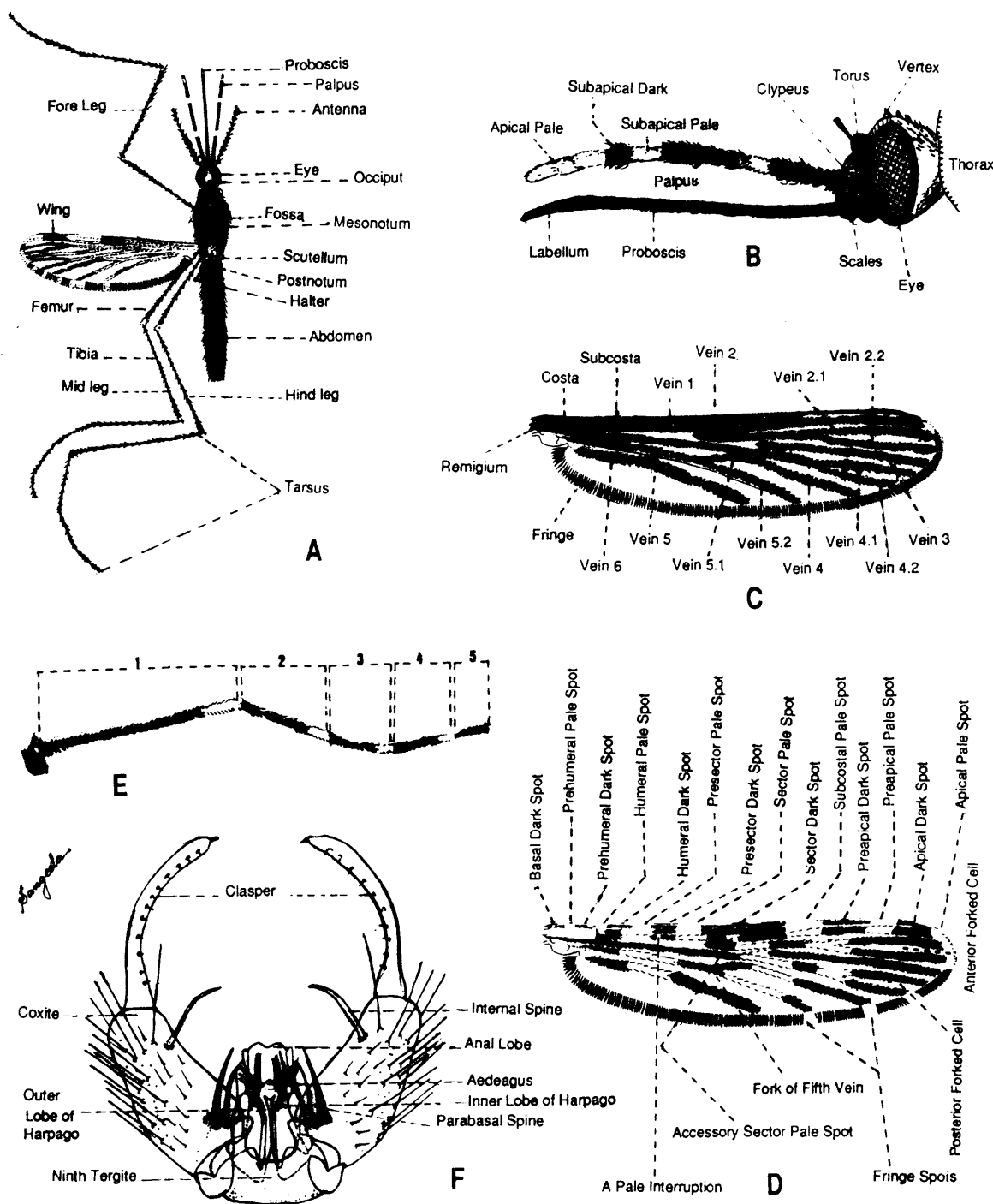


Fig.1 A, Adult female, dorsal view. B, Lateral view of head. C, Wing venation. D, Wing ornamentation. E, Tarsomeres. F, Male genitalia.

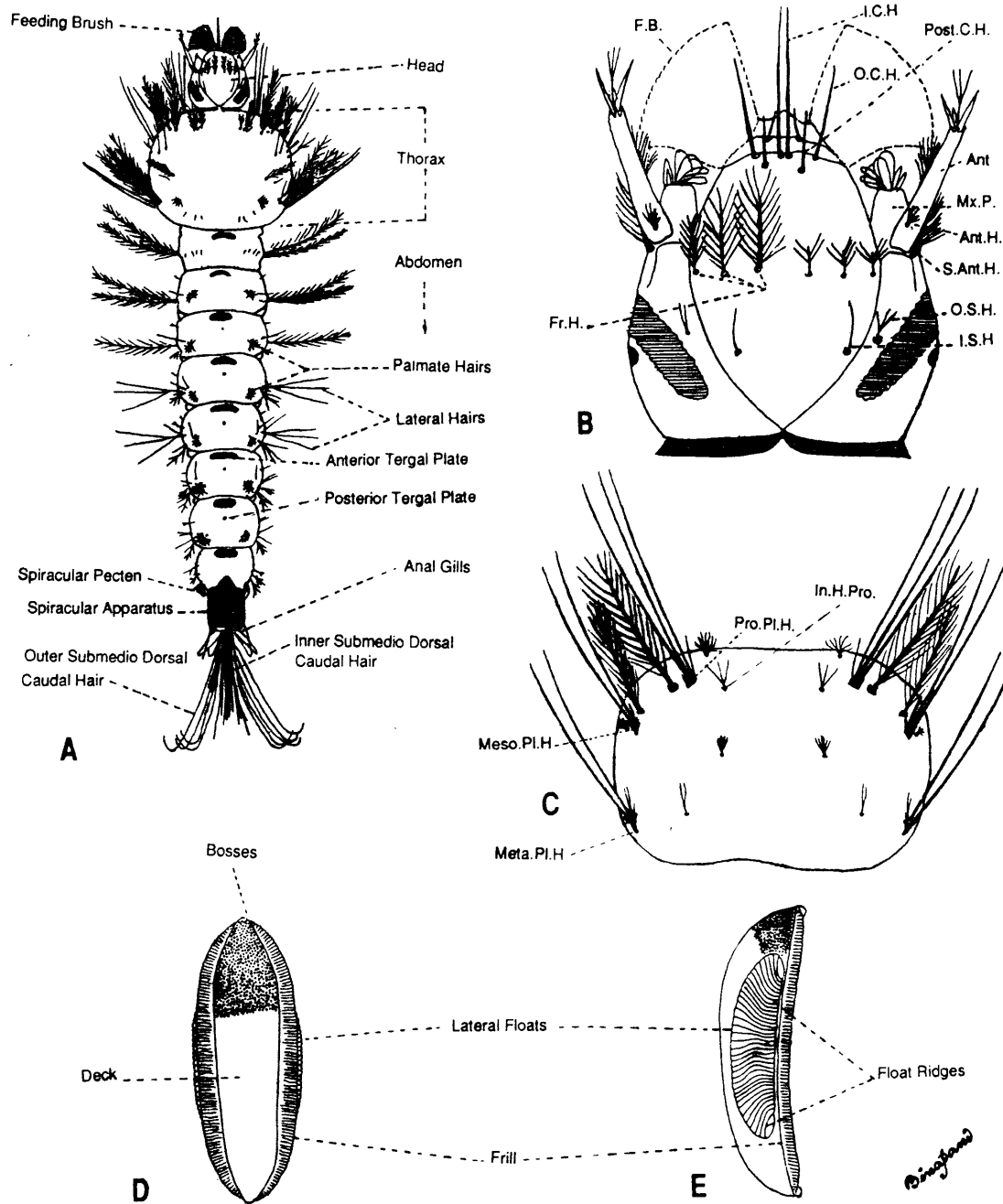


Fig. 2A. Full grown Larva, dorsal view. 2B. Dorsal view of Head; Ant., antenna; Ant.H., antennal hair; F.B., feeding brush; Fr.H., frontal hair; I.C.H., inner clypeal hair; I.S.H., inner sutural hair; Mx.P., maxillary palp; O.C.H., outer clypeal hair; O.S.H., outer sutural hair; Post.C.H., posterior clypeal hair; S.Ant.H., subantennal hair. 2C. Ventral view of Thorax; In.H.Pro., innermost hair of prothorax; Pro.Pl.H., Meso.Pl.H., and Meta.Pl.H., pro-, meso- and metathoracic group of pleural hairs. 2D. Egg dorsal view. 2E. Egg, lateral view.

### Key to the Indian Species of the genus *Anopheles*:

(Unless otherwise stated, the characters used in the key generally refer to adults of both sexes. However, in males: the wings are usually paler than in females, and the palpi are terminally clubbed).

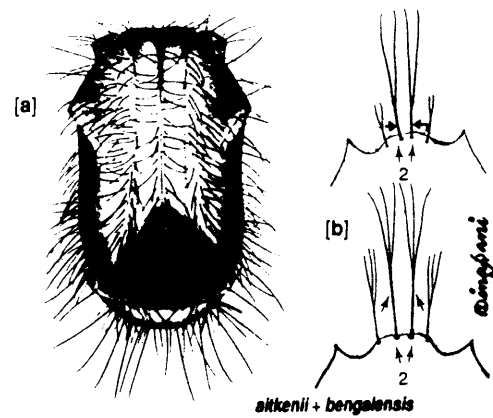
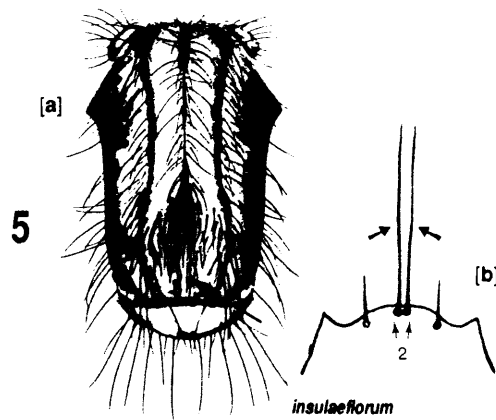
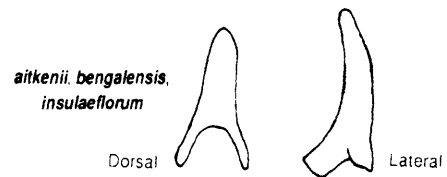
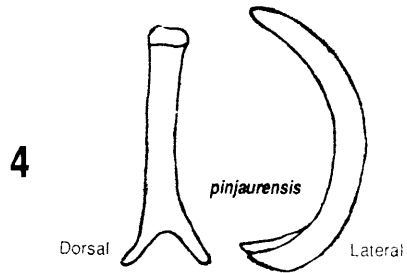
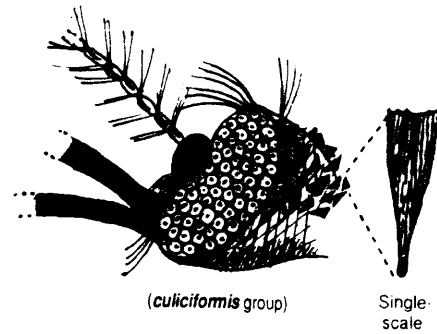
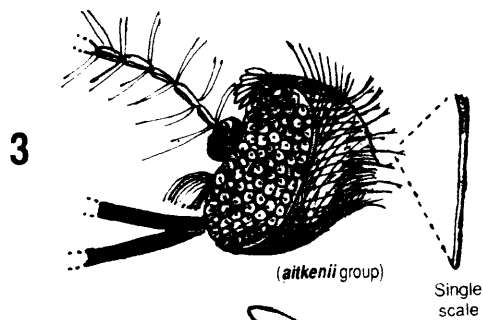
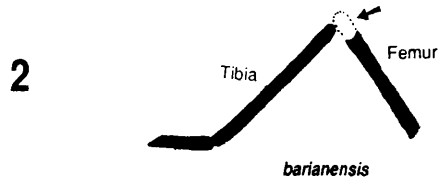
- |       |                                                                                                                                                                                                                               |                      |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| 1     | Wings entirely without pale markings<br>(subgenus <i>Anopheles</i> , in part)                                                                                                                                                 | 2                    |
|       | Wings with pale markings                                                                                                                                                                                                      | 8                    |
| 2 (1) | Hind femur with distinct white knee spot at distal end                                                                                                                                                                        | <i>barianensis</i>   |
|       | Hind femur without such a knee spot                                                                                                                                                                                           | 3                    |
| 3 (2) | Head scales very narrow, rod-like. ( <i>aitkenii</i> group)<br>( <i>An. pinjaurensis</i> belonging to this group is distinguished by male genitalia only)                                                                     | 4                    |
|       | Head scales of ordinary type. ( <i>culiciformis</i> group)<br>(The 2 species of this group are distinguished by larval characters only)                                                                                       | 7                    |
| 4 (3) | <u>Male</u> : aedeagus very long, tubular and expanded at the end                                                                                                                                                             | <i>pinjaurensis</i>  |
|       | <u>Male</u> : aedeagus shorter, not expanded at the end                                                                                                                                                                       | 5                    |
| 5 (4) | Pre-cutellar space with short fine setae [a] extending back to scutellum. <u>Larva</u> : with inner clypeal hair unbranched, bases nearly touching [b]; palmate hair present on abdominal segments I-VII                      | <i>insulaeflorum</i> |
|       | Pre-cutellar space with a distinct median bare area immediately above the scutellum [a]. <u>Larva</u> : inner clypeal hair with 1-9 branches, bases not close together [b]; palmate hair present on abdominal segments II-VII | 6                    |



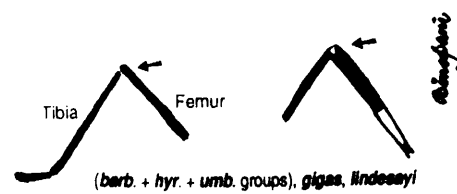
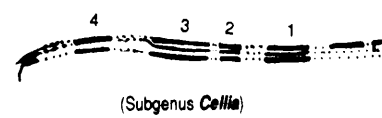
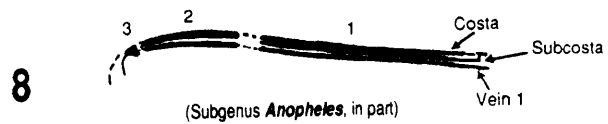
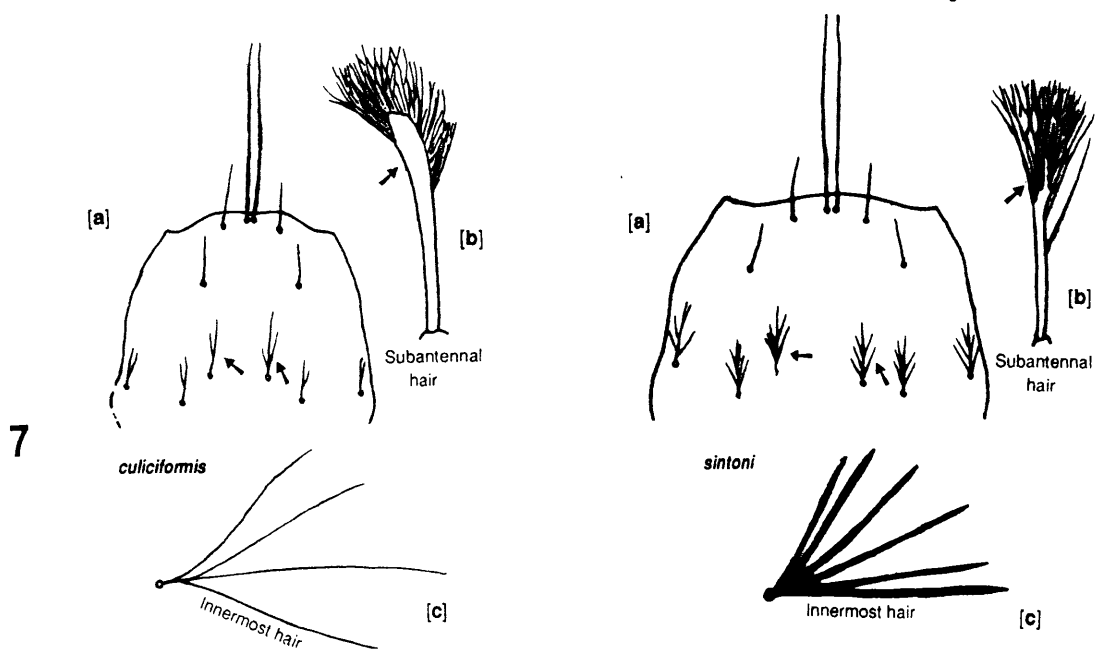
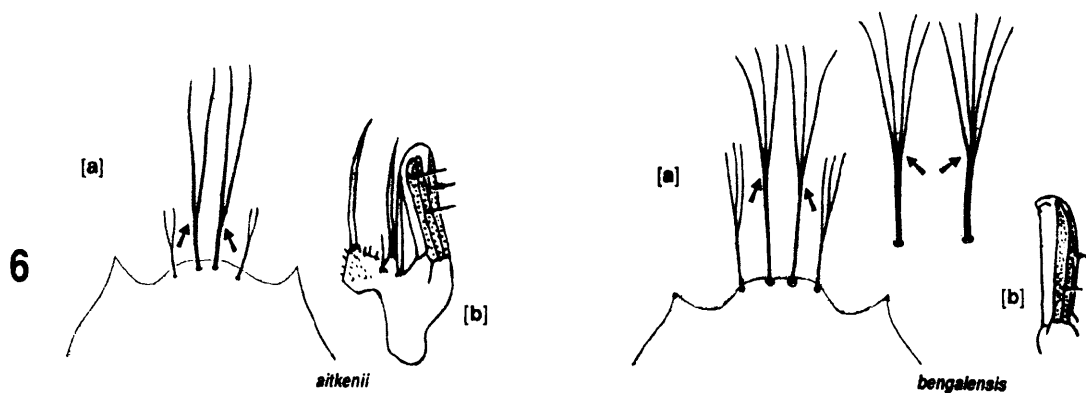
(Subgenus *Anopheles*, in part)



[8]



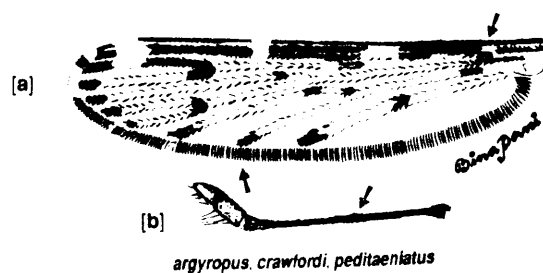
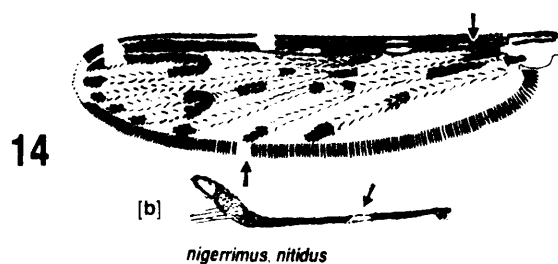
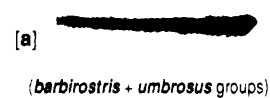
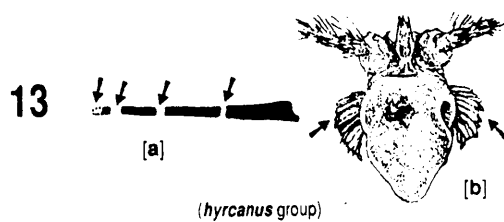
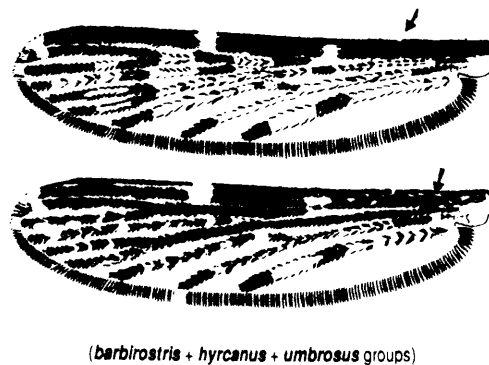
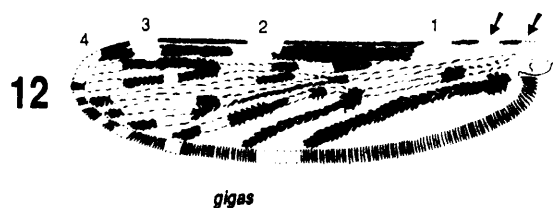
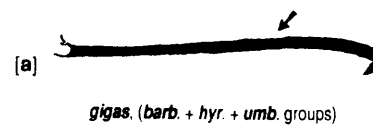
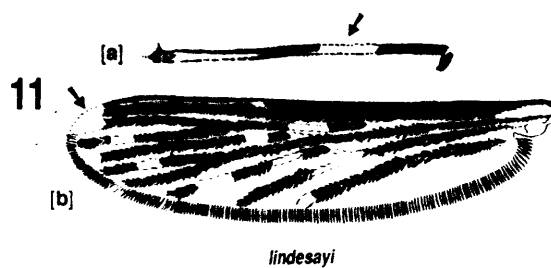
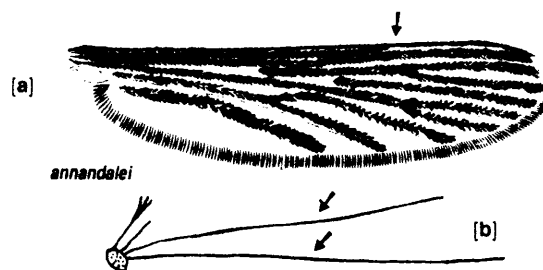
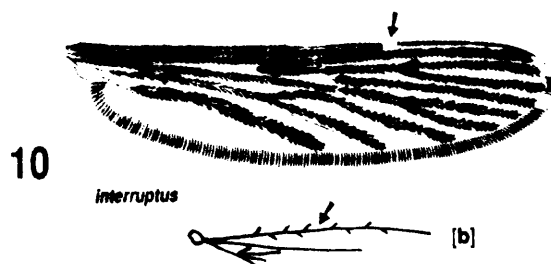
- 6(5) Larva: inner clypeal hair [a] with 1-2 branches at about 1/4 from base. Male: outer part of dorsal lobe of harpago usually with 2-3 spines [b] *aithenii*
- Larva: Inner clypeal hair usually with 4-7 branches at about 1/2 from base [a]. Male: outer part of dorsal lobe of harpago usually with 1-2 spines [b] *bengalensis*
- 7(3) Larva: frontal hair with one or two branches [a]; lateral hair on abdominal segments III-VI long, with a few very fine, short, barb-like branches; subantennal hair [b] club-shaped; innermost hair on ventral surface of prothorax not spine-like [c] *culiciformis*
- Larva: frontal hair short but feathered [a], each having 5-7 branches; lateral hair on abdominal segments III-VI with long branches; subantennal hair splitting distally into a number of branches [b]; innermost hair on ventral surface of prothorax spine-like, having 4-7 individual parts [c] *sintoni*
- 8(1) Wings with 3 or less than three dark spots on costa [1, 2, 3], which also involve vein 1. (subgenus *Anopheles*, in part) 9
- Wings with 4 or more dark spots on costa [1, 2, 3, 4], which also involve vein 1. (subgenus *Cellia*) 23
- 9(8) Apex of hind femur with a prominent tuft of white scales preceded by a tuft of black scales visible to the naked eye. 10  
(*asiaticus* group)
- Hind femur not so. 11



- 10 (9) Wing [a] usually with a subcostal pale spot on the costa. Larva: one of the long thoracic pleural hairs with barb-like side branches [b]  
*interruptus*
- Wing [a] without a subcostal pale spot on costa. Larva: pleural hairs [b] of all thoracic segments simple  
*annandalei*
- 11 (9) Hind femur [a] with a broad white band; costa with only apical pale spot [b]  
*lindesayi*
- Hind femur without such a band [a] 12
- 12 (11) Wing: inner quarter of costa with large pale spots, costa with three or more pale spots [1, 2, 3, 4] including a presector pale spot (but *in male*: preapical pale spot [3] usually extending on vein 2.1). Very large species (wing length 5-6 mm)  
*gigas*
- Inner quarter of costa mainly dark, sometimes with a few scattered pale scales 13
- 13 (12) Palpi with definite pale markings [a]; clypeus of female with tuft of dark scales at sides [b]. (*hyrcanus* group\*) 14
- Palpi without any pale markings [a]; clypeus without dark scales at sides 19
- 14 (13) Wing [a]: basal third of costa with scattered pale scales, fringe spot usually present at vein 5.2. Male: palpi [b] with a basal pale band on segment III 15
- Wing [a]: basal third of costa entirely dark, fringe spot absent at vein 5.2 (except *sinensis*). Male: palpi [b] without a basal pale band on segment III 16

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\*Variations in Indian species belonging to this group need further study.



- 15 (14)** Wing [a] with basal dark mark [1] on vein 5 short, about 0.2x as long as stem of vein 5; frequently with small humeral pale spot [2]; hind tarsomeres [b] with broad apical pale bands, at least one tarsomere 4 with basal pale band or patch [3] *nitidus*

Wing [a] with basal dark mark [1] on vein 5 long, about 0.4x as long as stem of vein 5; humeral pale spot absent [2]; hind tarsomeres [b] with apical pale bands only [3] *nigerrimus*

- 16 (14)** Hind tarsomeres with narrow apical pale bands 17  
Hind tarsomeres with broad apical pale bands across the joints 18

- 17 (16)** Wing with usually a fringe spot [1] at vein 5.2, apical pale spot or apical fringe spot [2] long, commencing at or above vein 1; with some pale scales [3] on vein 1 between subcostal pale and preapical pale spot, tip of vein 1 dark scaled [4] *sinensis*

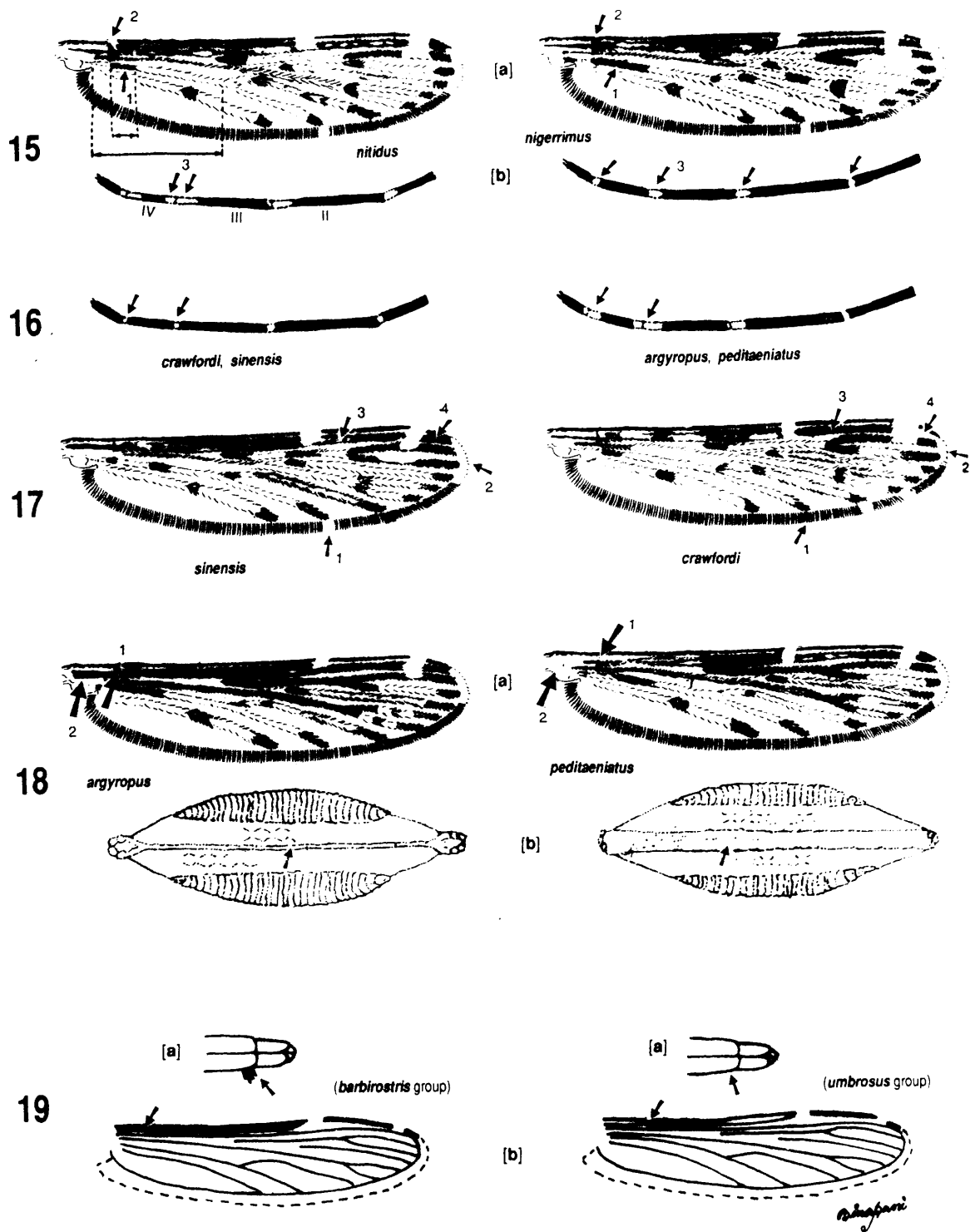
Wing without a fringe spot [1] at vein 5.2, apical fringe spot [2] a little shorter, commencing at 2.1; no pale scales [3] on vein 1 between subcostal pale and preapical pale spot, tip of vein 1 pale scaled [4] *crawfordi*

- 18 (16)** Wing [a]: humeral cross vein with patch of dark scales [1], remigium mostly dark scaled [2]. Egg [b]: with very narrow deck *argyropus*

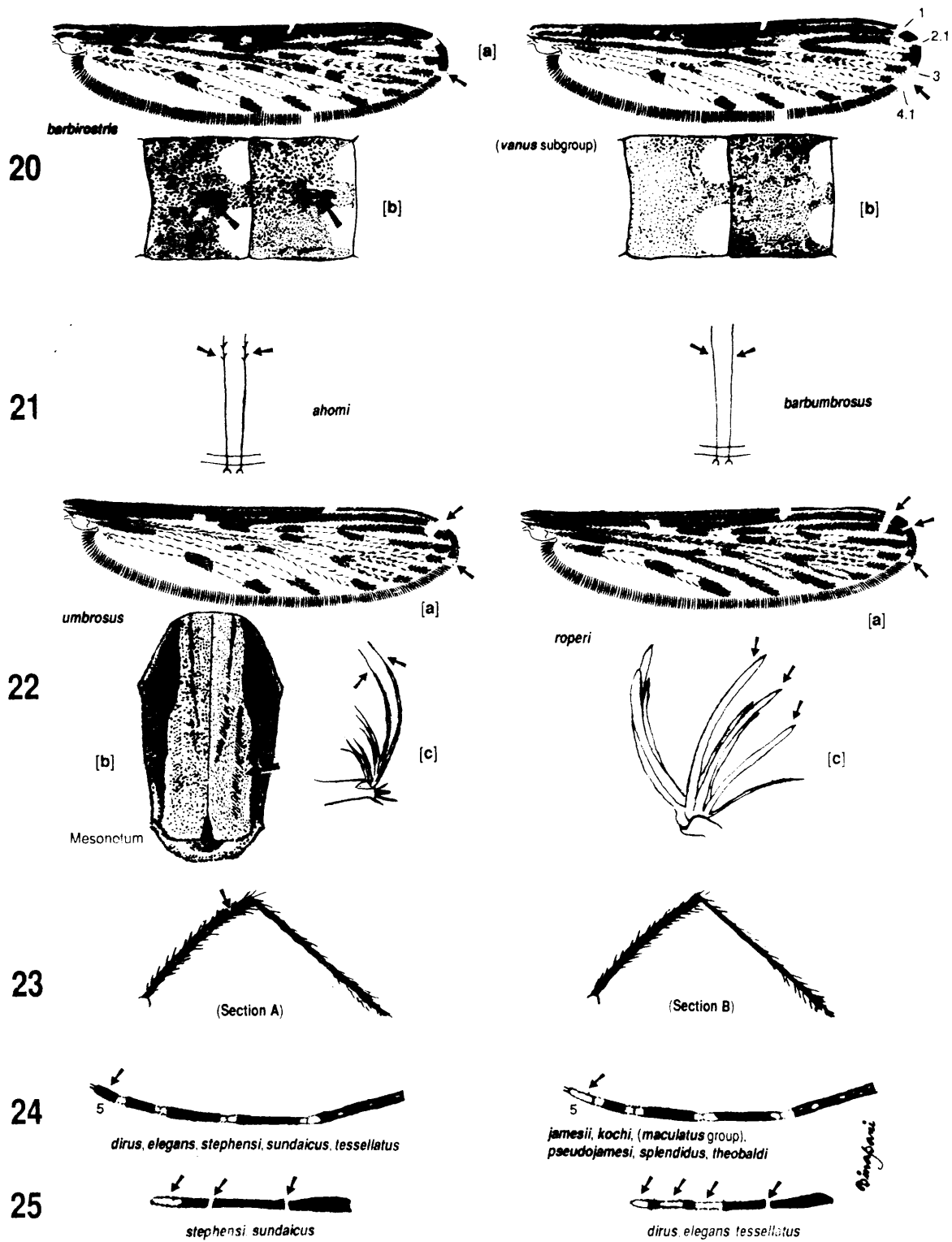
Wing [a]: humeral cross vein without dark scales [1], remigium mostly pale scaled [2]. Egg [b]: deck wider, about 0.17x the width of the egg *peditaeniatus*

- 19 (13)** Female with prominent tuft of dark scales on ventral side of abdominal segment VII [a]. Wing [b]: inner quarter of costa with scattered pale scales, usually with a fringe spot at vein 5.2 (*barbirostris* group) 20

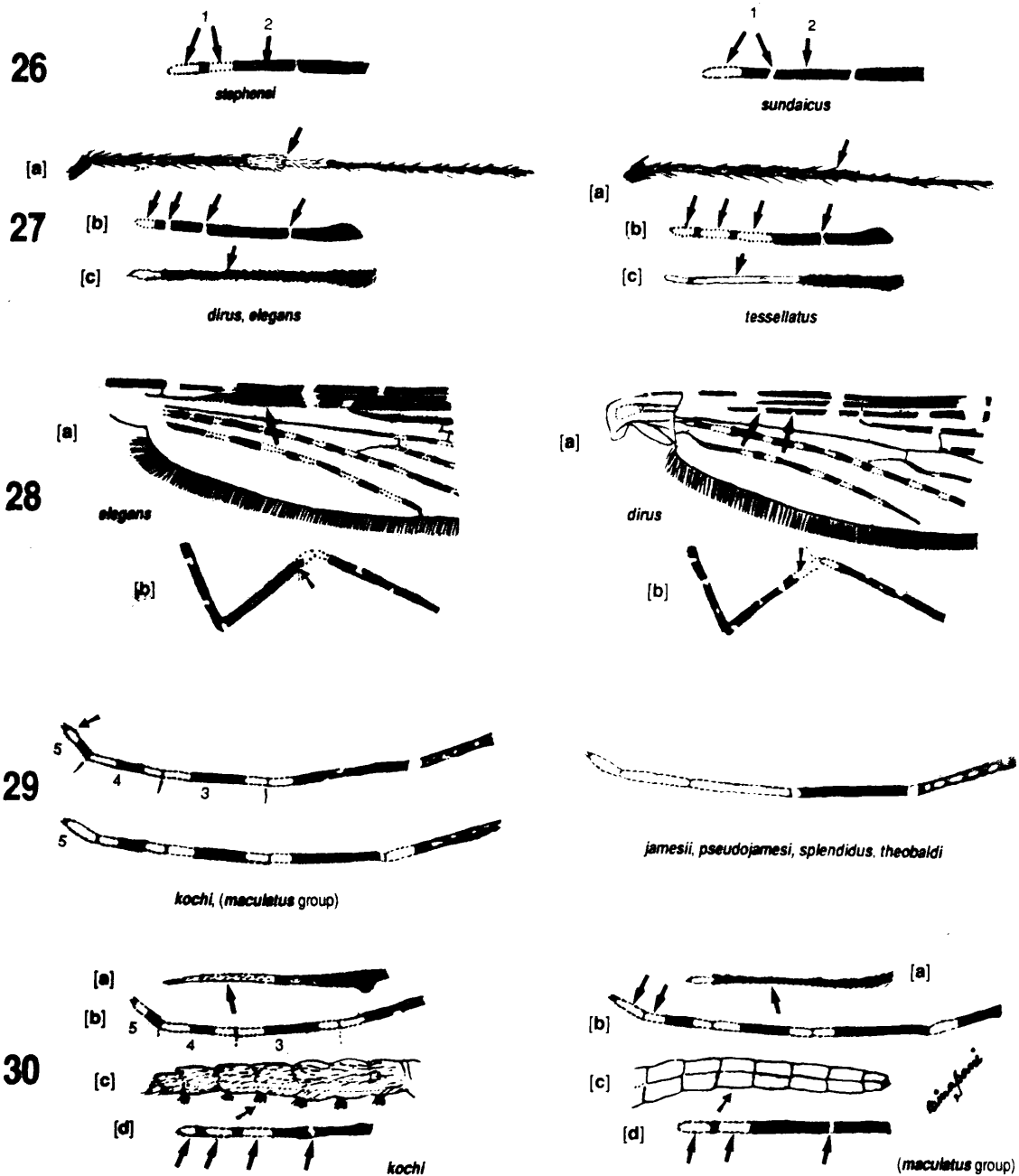
Female without such tuft [a]. Wing [b]: inner quarter of costa without pale scales, no fringe spot at vein 5.2 (*umbrosus* group) 22



- 20 (19) Wing [a] with narrow lower apical fringe spot opposite to vein 3 only;  
abdominal sternites II-VI usually with some pale scales [b].  
(*barbirostris* subgroup) *barbirostris*
- Wing [a] with broad lower apical fringe spot, at least from vein 3 to  
4.1; no pale scales [b] on abdominal sternites II-VI.  
(*vanus* subgroup) 21  
(The 2 species belonging to this group are  
distinguishable by larval characters only)
- 21 (20) Larva: inner clypeal hair with fine lateral branches in the apical  
portion *ahomi*
- Larva: inner clypeal hair without side branches *barbumbrosus*
- 22 (19) Wing [a] with two apical fringe spots; propleural setae present;  
centre of mesonotum uniformly pale [b]. Male: aedeagus with  
8-11 pairs of slender thread-like leaflets [c] *umbrosus*
- Wing [a] with three apical fringe spots; propleural setae absent;  
centre of mesonotum not uniformly pale. Male: aedeagus with  
3-5 pairs of narrow, curved, and strap-like leaflets, the larger  
ones with tiny points at the tips [c] *roperi*
- 23 (8) Femur and tibia speckled. (Section A) 24  
Femur and tibia not speckled. (Section B) 36
- 24 (23) Hind tarsomere 5 not white 25  
Hind tarsomere 5 white 29
- 25 (24) Palpi with three pale bands 26  
Palpi with four pale bands 27



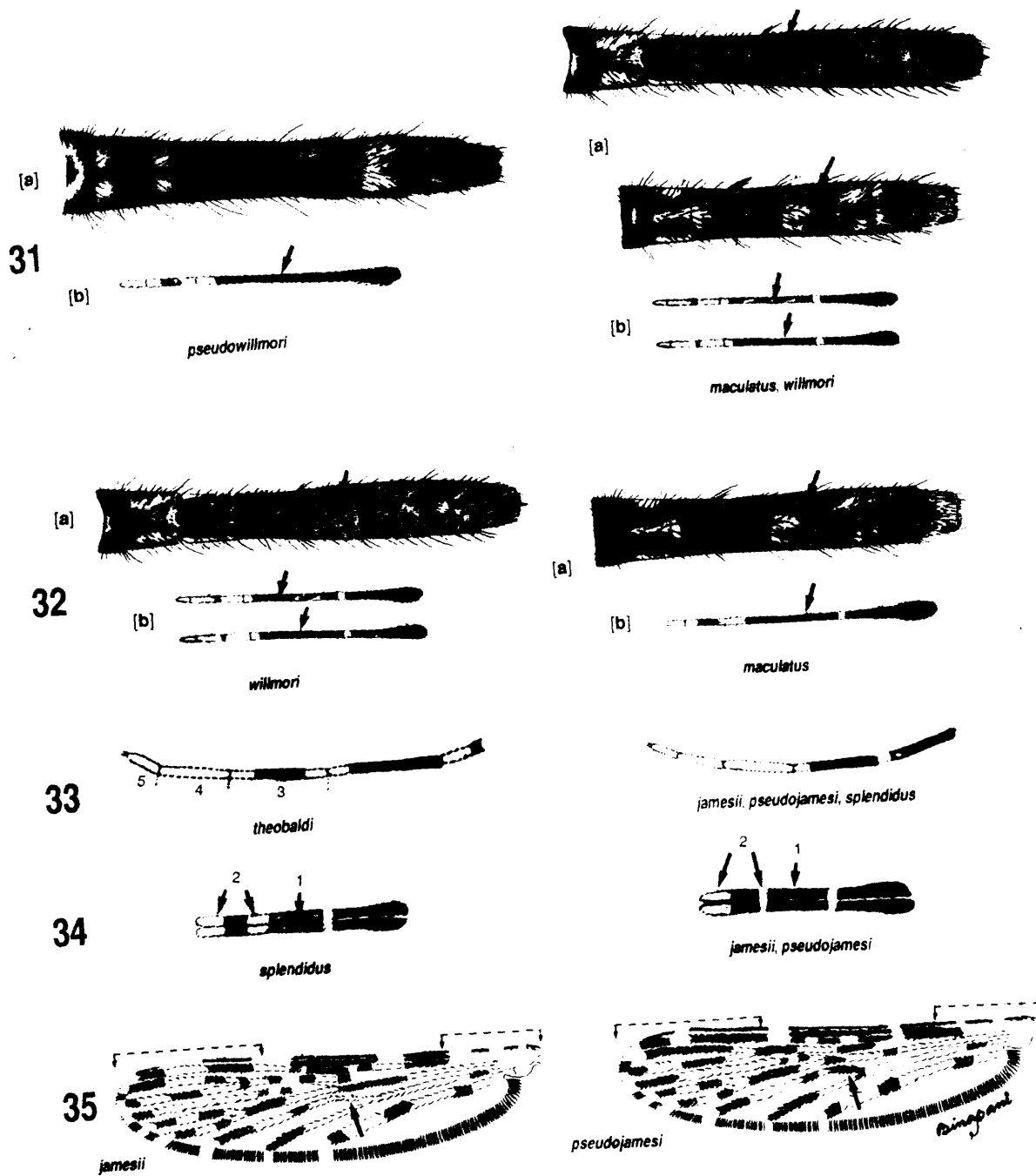
- 26 (25) Apical and subapical pale bands of palpi equal [1]; palpi speckled [2]  
*stephensi*  
Apical and subapical pale bands of palpi unequal [1]; palpi not speckled [2]  
*sundaicus*
- 27 (25) Hind leg [a] with a broad white band at the tibio-tarsal joint; palpi [b] with one broad and three narrow pale bands; apical half of proboscis [c] dark 28  
Hind leg [a] without such band at the tibio-tarsal joint; palpi [b] with one narrow and three broad pale bands; apical half of proboscis [c] pale (but *in male*: proboscis all dark) *tessellatus*
- 28 (27) Wing [a]: presector dark mark on vein 1 without any pale interruption; proboscis distinctly longer, about 1.25x the length of fore femur; apical pale band on hind tibia [b] with a longitudinal basal dark stripe on ventral aspect *elegans*  
Wing [a]: presector dark mark on vein 1 with one or more pale interruptions; proboscis as long as or slightly shorter than fore femur; apical pale band on hind tibia [b] without a ventral dark stripe *dirus*
- 29 (24) Hind tarsi with less than two apical tarsomeres completely white 30  
Hind tarsi with at least two apical tarsomeres completely white 33
- 30 (29) Apical half of proboscis pale [a]; apical or terminal half of hind tarsomere 5 white [b]; underside of abdomen with tuft of dark scales on segments II-VII [c]; female palpi with one narrow and three broad pale bands [d] *kochi*  
Apical half of proboscis dark [a]; hind tarsomere 5 and part of 4 white [b]; abdomen without such tuft of scales beneath [c]; female palpi with one narrow and two broad pale bands [d].  
(*maculatus* group) 31



- 31 (30)** Abdominal terga II-VIII shiny, absolutely with no pale scales [a]; segment 3 of palpi [b] not speckled *pseudowillmori*  
Abdominal terga with pale scales [a]; palpi [b] with or without median pale spots on segment 3 32
- 32 (31)** Abdominal terga II-VIII [a] heavily covered with short, broad, blunt, and round-ended pale scales; palpi [b] with or without pale spots\* on segment 3 *willmori*  
Abdominal terga IV-VIII [a] with a few long and not very broad pale scales; palpi usually not speckled [b], only 20 per cent of females with speckled palpi *maculatus*
- 33 (29)** Hind tarsomeres 5, 4 and part of 3 white *theobaldi*  
Hind tarsomeres 5, 4 and 3 completely white 34
- 34 (33)** Female palpi speckled [1], with apical and subapical pale bands equal [2] *splendidus*  
Female palpi not speckled [1], apical and subapical pale bands unequal [2] 35
- 35 (34)** Dorsum of VII and VIII abdominal segments covered with golden scales. Wing: inner quarter and outer third of costa chiefly pale; vein 5.1 pale at base *jamesii*  
Dorsum of VII-VIII abdominal segments with dark scales only. Wing: inner quarter and outer third of costa chiefly dark; vein 5.1 dark at base *pseudojamesi*

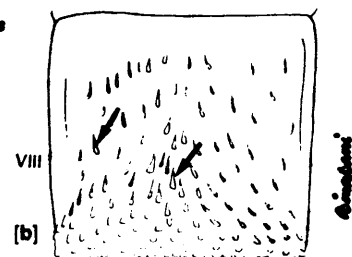
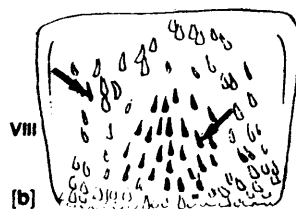
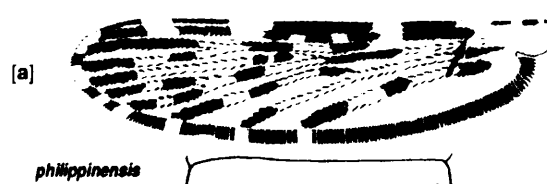
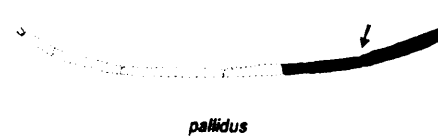
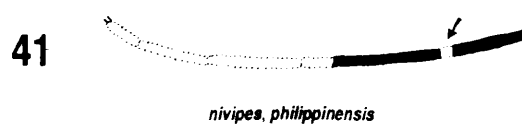
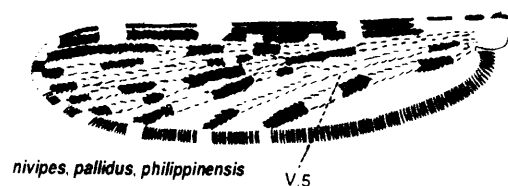
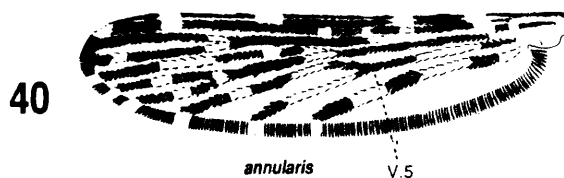
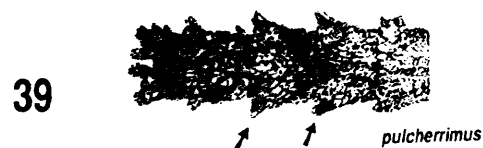
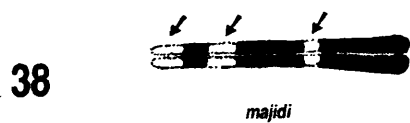
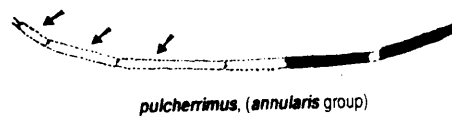
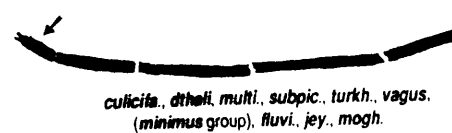
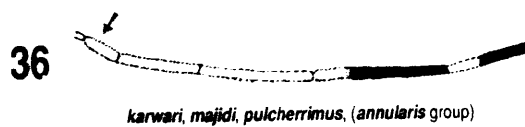
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\* The presence or absence of pale spots on segment 3 of palpi needs thorough study in Indian specimens. In the NICD museum, in specimens from Kasauli (Himachal Pradesh) the palpi are not speckled, but in specimens from Kashmir they are speckled.



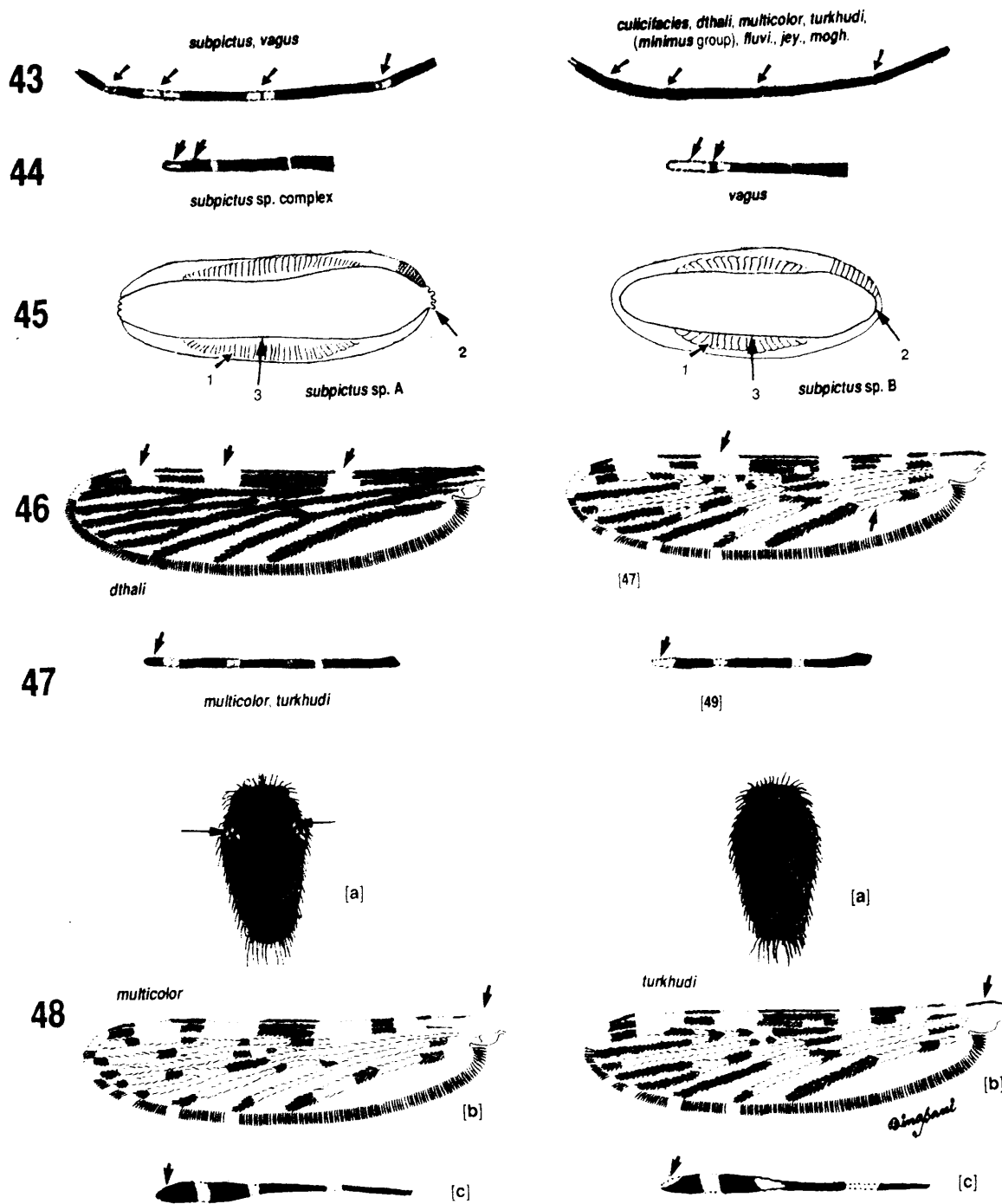
|         |                                                                                                                                                                                                                                                                               |                       |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| 36 (23) | Hind tarsomere 5 white                                                                                                                                                                                                                                                        | 37                    |
|         | Hind tarsomere 5 not white                                                                                                                                                                                                                                                    | 43                    |
| 37 (36) | Hind tarsomere 5 and part of 4 white                                                                                                                                                                                                                                          | 38                    |
|         | Hind tarsomeres 5, 4 and 3 completely white                                                                                                                                                                                                                                   | 39                    |
| 38 (37) | Female palpi with three pale bands                                                                                                                                                                                                                                            | <i>majidi</i>         |
|         | Female palpi with four pale bands                                                                                                                                                                                                                                             | <i>karwari</i>        |
| 39 (37) | Dorsum of abdomen heavily clothed with broad pale scales, forming laterally projecting tufts on all segments                                                                                                                                                                  | <i>pulcherrimus</i>   |
|         | Dorsum of abdomen not so, with at most rather narrow scales not forming tufts, except on last few segments. ( <i>annularis</i> group)                                                                                                                                         | 40                    |
| 40 (39) | Wing vein 5 mainly dark, with dark spot at the point of bifurcation (but <i>in male</i> : subcostal pale spot also extending to vein 1)                                                                                                                                       | <i>annularis</i>      |
|         | Wing vein 5 mainly white, with no dark spot at the point of bifurcation                                                                                                                                                                                                       | 41                    |
| 41 (40) | Apex of hind tarsomere 1 usually with white band                                                                                                                                                                                                                              | 42                    |
|         | Apex of hind tarsomere 1 without white band                                                                                                                                                                                                                                   | <i>pallidus</i>       |
| 42 (41) | Wing [a]: presector* dark mark on vein 1 long, usually reaching or overlapping the distal end of the humeral dark mark on costa. <u>Male</u> : a median patch of dark scales surrounded by pale scales on sternum VIII [b]                                                    | <i>nivipes</i>        |
|         | Wing [a]: presector* dark mark on vein 1 shorter, either of same length as on costa or extending basally beyond the end of corresponding dark mark on costa, but not reaching the distal end of humeral dark mark on costa. <u>Male</u> : scales on sternum VIII all pale [b] | <i>philippinensis</i> |

\* This wing character is the only difference known at present between females of *An. nivipes* and *An. philippinensis*, and is uncertain in some specimens. Cytotaxonomically identified specimens of *An. nivipes* and *An. philippinensis* from Assam showed both the wing characters (personal communication, Dr. Sarala K. Subbarao).



- 43 (36) Fore tarsi with broad pale bands 44  
 Fore tarsi with narrow pale bands or unbanded 46
- 44 (43) Female palpi with subapical dark band equal or nearly equal to the apical pale band. (*subpictus* species complex\*) 45  
 Female palpi with subapical dark band 0.25-0.3x the length of apical pale band *vagus*
- 45 (44) Egg: lateral float with average 33 ridges [1]; bosses [2] placed at the extremities of the deck; frill opaque, extended all around the deck except at the ends; deck [3] distinctly narrower in the middle *subpictus* sp. A  
Egg: lateral float with average 18 ridges [1]; bosses [2] placed subterminally on the deck; frill transparent, extended around the ends of the egg; deck [3] not much narrowed in the middle *subpictus* sp. B
- 46 (43) Pale spotting of wing confined to costa and vein 1 only; small sized mosquito resembling *An. culicifacies* in appearance *dthali*  
 Pale spots present on other wing veins besides costa and vein 1 47
- 47 (46) Female palpi with dark tip 48  
 Female palpi with pale tip 49
- 48 (47) Fossae at the sides of mesonotum covered with scattered broad creamy scales [a]. Wing [b] with extreme base of costa pale. *multicolor*  
Male: tip of palpi [c] usually dark  
 Fossae at the sides of mesonotum devoid of scales [a]. Wing [b] with extreme base of costa dark. Male: tip of palpi [c] usually with distinct pale scales *turkhudi*

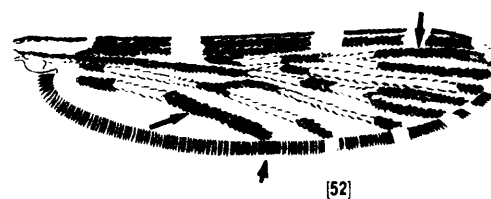
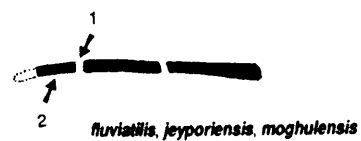
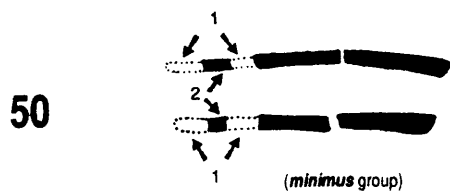
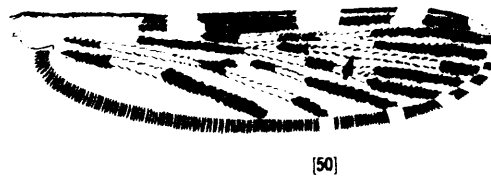
\* *An. subpictus* is a complex of two species A and B, recognizable on the basis of inversion on X-chromosome (detected in polytene chromosome), egg morphology, and tolerance to salinity (Suguna 1982, Reuben and Suguna 1983). The egg of species A agrees with the description of the egg of *An. subpictus* described from India by Christophers and Barraud (1931). However, neither of these two species resembles *An. indefinitus* in the larval, pupal, or adult stage (Reuben and Suguna 1983).



- 49 (47) Wing vein 3 mainly dark *culicifacies* species complex\*  
Wing vein 3 mainly white 50
- 50 (49) Female palpi with both apical and subapical pale bands [1] as broad  
as or broader than subapical dark band [2]. (*minimus* group) 51  
Female palpi with subapical pale band [1] narrow and subapical  
dark band [2] much broader 53
- 51 (50) Wing: vein 6 with 2 dark spots on distal or apical half; hind margin  
with pale fringe spot at vein 6; vein 2.1 with a median pale spot  
*aconitus*  
Wing: vein 6 with one large dark spot on apical half; fringe spot  
absent at vein 6; vein 2.1 dark except at base and apex 52
- 52 (51) Wing [a]: basal third of costa with white interruptions; fore tarso-  
meres 1-4 [b] with very small dorso-apical pale patches *minimus*  
Wing [a]: basal third of costa without white interruptions; fore  
tarsomeres entirely dark scaled [b] *varuna*
- 53 (50) Basal third of costa with one or more white interruptions  
*jeyporiensis*  
Basal third of costa without white interruptions 54
- 54 (53) Wing [a]: vein 6 with three dark spots, distal half with pale interrup-  
tion, the base of anterior forked cell (a.f.c.) at a greater distance  
from the wing base than that of the posterior forked cell (p.f.c.);  
hind tarsomeres 1-4 with narrow apical pale bands [b]  
*moghulensis*  
Wing [a]: vein 6 with two dark spots, distal half mainly dark, base of  
anterior forked cell not so and as usual in anophelines; hind  
tarsomeres uniformly dark [b], sometimes with a faint indication  
of narrow banding at the joints *fluviatilis*

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\* *An. culicifacies* is a species complex comprising four sibling species, i.e. A, B, C, and D. These four species are distinguished by species-specific fixed paracentric inversions detectable in polytene chromosomes or by structural variations in metaphase chromosomes in males (personal communication, Dr. Sarala K. Subbarao).



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Some of the figures in this paper have been redrawn from the following sources: Figs. 1 A-F (Pratt and Stojanovich 1966), Figs. 2 A-C (Puri 1960), Figs. 2 D-E (Christophers and Barraud 1931).

All figures accompanying the key are original, drawn by Bina Pani Das, who alone is responsible for errors, if any, in the figures.

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### ZUSAMMENFASSUNG

#### **Bildliche Darstellung einer Bestimmungstabelle für die aus Indien bekannten Arten der Mückengattung *Anopheles* (Diptera: Culicidae).**

Dieser mit 177 Abbildungen voll illustrierte Bestimmungsschlüssel für die aus Indien soweit bekannten 54 Arten der Mückengattung *Anopheles* Meigen richtet sich auf eine rasche und zuverlässige Bestimmung der Arten. Die Tabelle soll in der Praxis bei dem Malaria-Bekämpfungs-Programm in Indien sehr nützlich sein.

Die Tabelle ist so gestaltet, daß sie sehr leicht vom Sachverständigen sowie auch vom angelernten Techniker benutzt werden kann.

Die für die Bestimmung gebrauchten diagnostischen Merkmale für die *Anopheles*-Arten sind zuerst abgebildet. Genaue Abbildungen sind für die jeweils unmittelbar gegenübergestellten zusammengehörigen Alternativen jedes Couplets geliefert. Ein systematisches Verzeichnis der indischen Arten ist auch angegeben.

Da mehrere Arten im Gebiet weit verbreitet sind, soll der Bestimmungsschlüssel auch für benachbarte Länder nützlich sein.

### SUMMARY

This pictorial key is meant for enabling rapid identification of 54 species of the genus *Anopheles* Meigen so far known from India, and will be of practical use in malaria eradication programmes in the country.

The key will be easy to use both for the specialist and for the semiskilled technician.

The diagnostic characters used in the identification of the *Anopheles* species are illustrated and figures are also provided along with each couplet of the key. A systematic list of Indian species is given.

It should also be useful in neighbouring countries, since many of the species are widely distributed in the region.

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