

## Illustrated keys to the anopheline mosquitoes of Myanmar

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**ABSTRACT:** In the newly revised and illustrated keys to 4<sup>th</sup> instar larvae and adult female mosquitoes, the following 36 *Anopheles* species from Myanmar are included: *Anopheles aconitus*, *An. aitkenii*, *An. annularis*, *An. argyropus*, *An. barbirostris*, *An. bengalensis*, *An. culicifacies*, *An. dirus*, *An. fluviatilis*, *An. gigas*, *An. insulaeflorum*, *An. jamesii*, *An. jeyporensis*, *An. karwari*, *An. kochi*, *An. kyondawensis*, *An. lindesayi*, *An. maculatus*, *An. majidi*, *An. minimus*, *An. nigerrimus*, *An. nitidus*, *An. pallidus*, *An. peditaeniatus*, *An. philippinensis*, *An. pseudojamesii*, *An. sinensis*, *An. splendidus*, *An. stephensi*, *An. subpictus*, *An. sundaicus*, *An. tessellatus*, *An. theobaldi*, *An. vagus*, *An. varuna*, and *An. willmori*. The new keys presented in this paper will enable public health workers to rapidly identify mosquito vectors of malaria and to distinguish them from other species in the same genera. *Journal of Vector Ecology* 31(1): 9-16. 2006.

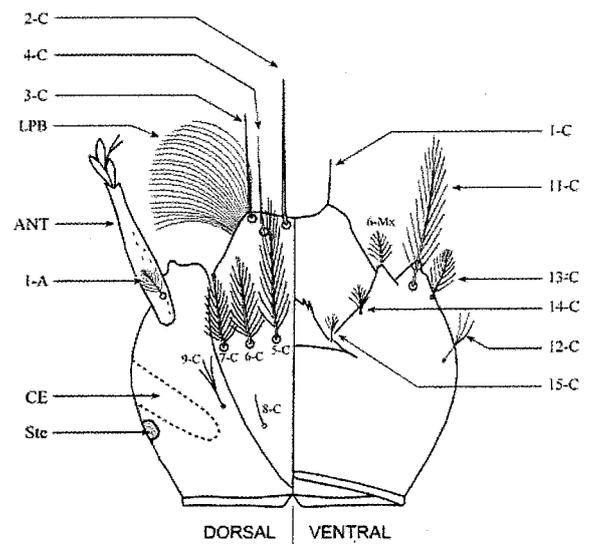
**Keyword Index:** Identification key, *Anopheles*, mosquitoes, Culicidae, Myanmar.

### INTRODUCTION

Correct identification of anopheline mosquitoes is essential to the effective control or prevention of malaria. The first taxonomic key for *Anopheles* mosquitoes of Myanmar (Burma) can be found in the *Fauna of British India including Ceylon and Burma* Vol. IV, by Christophers (1933). "A guide for the identification of the full-grown larvae and imagines of the anophelines of Burma" by Frederick Delphin and Venkat Rao (1957) can be used as a standard tool for the determination of anopheline mosquitoes, however, this book is no longer available. A new guide was prepared because some new species have been recorded since the 1950s and changes in taxonomy and systematics of Anopheline mosquitoes have taken place. In the present study, illustrations of anopheline larvae and female anopheline mosquitoes are modified after Becker et al. (2003), and the morphological terminology follows Harbach and Knight (1980) and Rattanarithikul and Panthusiri (1994).

The new edition of keys is important for two reasons. First, since the comprehensive description of the mosquito fauna of Myanmar by Frederick Delphin and Venkat Rao in 1957, much additional information has been gained for a number of species. Secondly, the keys should be a useful tool to enable public health workers to make a quick and accurate determination of the species.

### TERMINOLOGY OF 4<sup>TH</sup> INSTAR ANOPHELINE LARVAE



ANT = Antenna  
 LPB = Lateral Palatal Brush  
 CE = Compound eye  
 Ste = Stemmata  
 Numbers are numbers of setae

Figure 1. Fourth-instar anopheline larval head.

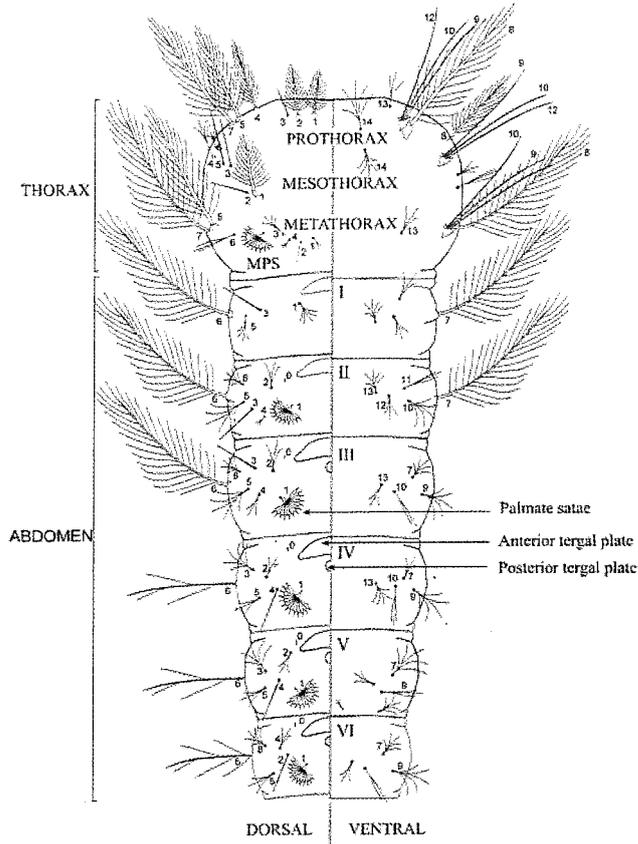


Figure 2. Fourth-instar anopheline larva thorax and abdomen.

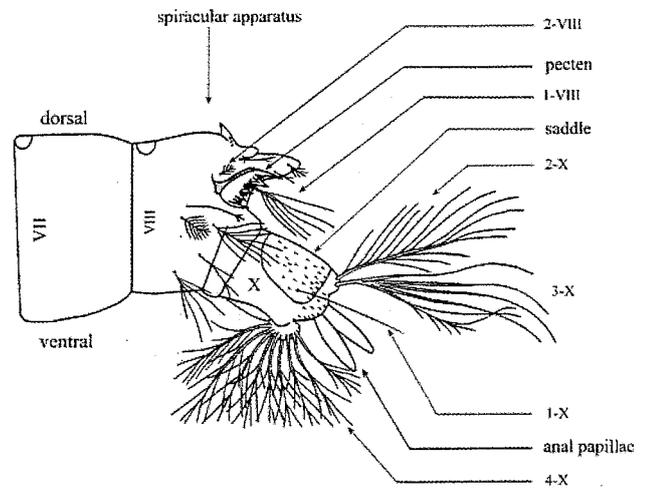


Figure 3. Fourth-instar anopheline larva: end of abdomen.

KEY TO 4<sup>TH</sup> INSTAR ANOPHELINE LARVAE

- 1     Seta of setae 2-C more or less approximated (Figure 4) ..... 2
- Seta of setae 2-C wide apart (Figure 5) ..... 8

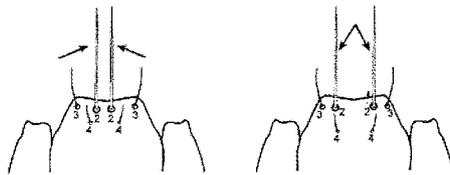


Figure 4

Figure 5

- 2 (1) Seta 2-C single ..... 3
- Seta 2-C branched ..... 6
- 3 (2) Seta 3-C single ..... 4
- Seta 3-C bushy, dendriform ..... 7
- Seta 3-C split distally into 2-3 branches; seta 4-C branched (Figure 6) ..... *An. gigas*

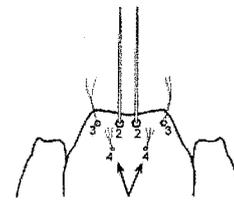


Figure 6

- 4 (3) Seta 4-C single (Figure 7) ..... *An. lindesayi*
- Seta 4-C branched (Figure 8) ..... 5

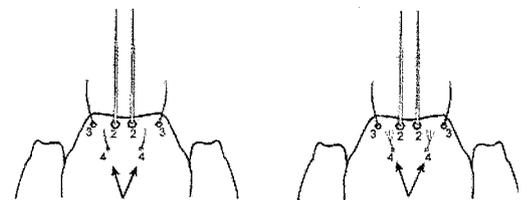


Figure 7

Figure 8

- 5 (4) Seta 1-I (palmate seta) well developed (Figure 9), setae 4-C, 5-C and 6-C long and branched ..... *An. insulaeflorum*  
 Seta 1-I (palmate seta) weakly developed, rudimentary (Figure 10), setae 4-C, 5-C and 6-C short ..... *An. kyondawensis*

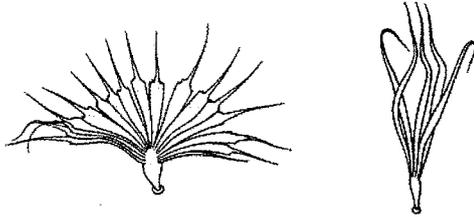


Figure 9                      Figure 10

- 6 (2) Seta 2-C split into 2 branches a little above base (Figure 11) ..... *An. aitkeni*  
 Seta 2-C split into 3-6 branches near middle (Figure 12) ..... *An. bengalensis*

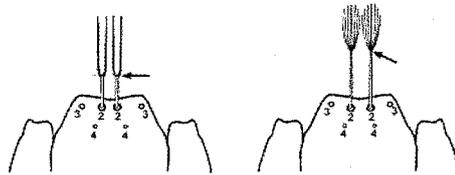


Figure 11                      Figure 12

- 7 (3) Seta 1-P simple or bifid (Figure 13) ..... **Hyrcanus Group** (*An. argyropus*, *An. nigerrimus*, *An. nitidus*, *An. peditaeniatus*, *An. sinensis*)  
 Seta 1-P with many branches (Figure 14) ..... *An. barbirostris*

**Note:** Keys for the identification of the Anopheles Hyrcanus Group are illustrated by Reid (1953) and Harrison and Scanlon (1975).

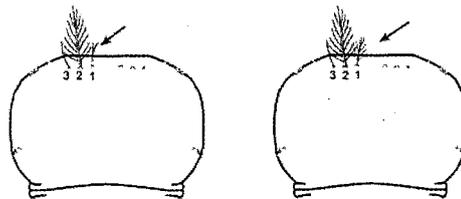


Figure 13                      Figure 14

- 8 (1) Anterior tergal plates on abdominal segments III-VII very large, enclosing posterior tergal plates (Figure 15) ..... **9**  
 Anterior tergal plates on abdominal segments III-VII smaller, not enclosing posterior tergal plates (Figure 16) ..... **11**

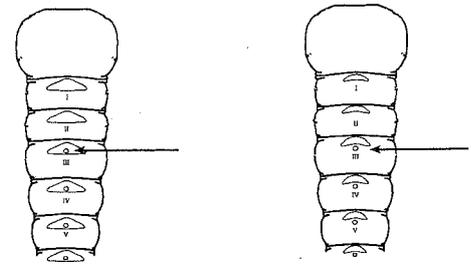


Figure 15                      Figure 16

- 9 (8) Setae 2-C and 3-C simple ..... **10**  
 Setae 2-C and 3-C aciculate (Figure 17) ..... *An. aconitus*

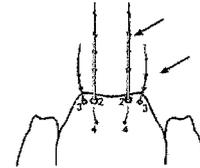


Figure 17

- 10 (9) Seta 0- II to 0-VIII arising on tergal plate (Figure 18) ..... *An. varuna*  
 Seta 0- II to 0-VIII arising external to tergal plate (Figure 19) ..... *An. minimus* and *An. fluviatilis*

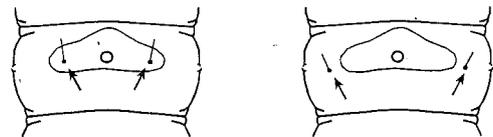


Figure 18                      Figure 19

- 11 (8) Seta 4-C inserted far forward, very close to and mesad of seta 2-C (Figure 20) ..... *An. vagus*  
 Seta 4-C inserted at some distance to and not mesad of seta 2-C ..... **12**

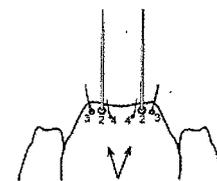


Figure 20

- 12 (11) Setae 2-C and 3-C either simple or with fine inconspicuous fraying ..... **13**  
 Setae 2-C and 3-C with conspicuous lateral branches ..... **21**
- 13 (12) Seta 1-I palmate ..... **14**  
 Seta 1-I not palmate ..... **18**

- 14 (13) Setae 9-T and 10-T both simple (Figure 21). Seta 2-C very finely frayed and about 4 times the length of seta 3-C ..... *An. kochi*  
At least one of setae 9-T and 10-T pectinate ..... **15**

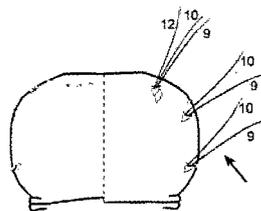


Figure 21

- 15 (14) Seta 9-T pectinate and seta 10-T simple (Figure 22) ..... **16**  
Setae 9-T and 10-T both pectinate (Figure 23) .. **17**

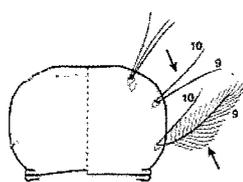


Figure 22

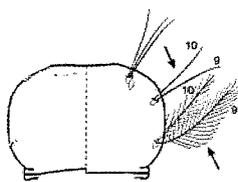


Figure 23

- 16 (15) Filaments of abdominal palmate setae about 0,5 length of blades (Figure 24a) ..... *An. culicifacies*  
Filaments of abdominal palmate setae about 0,25 length of blades (Figure 24b) ..... *An. majidi*

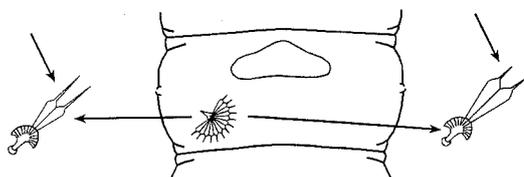


Figure 24a

Figure 24b

- 17 (15) Spicules on abdominal segment X coarse, pigmented and cone-shaped (Figure 25); seta 1-VIII with 8-9 branches ..... *An. sudaicus*  
Spicules on abdominal segment X slender, not pigmented and almost flattened at base (Figure 26); seta 1-VIII with 4-5 branches ..... *An. subpitius*

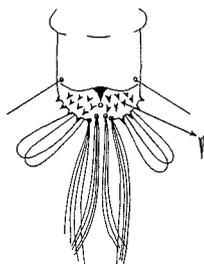


Figure 25

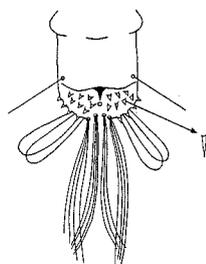


Figure 26

- 18 (13) Seta 9-M pectinate and seta 10-M simple ..... **19**  
Setae 9-M and 10-M both simple ..... **20**

- 19 (18) Setae 2-C and 3-C simple, seta 2-I with 3-5 branches (Figure 27) ..... *An. stephensi*  
Setae 2-C and 3-C aciculate, seta 2-I with 6-8 branches. (Figure 28) ..... *An. maculatus*, *An. willmori* and *An. theobaldi*

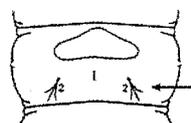


Figure 27

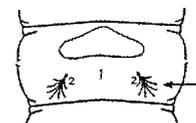


Figure 28

- 20 (18) Seta 1-P with 2-4 branches arising from an inconspicuous stem ..... *An. tessellatus*  
Seta 1-P with more than 4 branches arising from a distinct stem ..... *An. dirus*

- 21 (12) Seta 3-C with long lateral branches ..... **22**  
Seta 3-C with short lateral branches ..... **25**

- 22 (21) Seta 8-C simple or bifid (Figure 29) ..... **23**  
Seta 8-C branched from base (Figure 30) ..... **24**

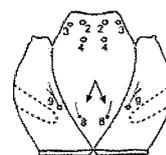


Figure 29

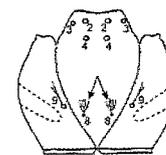


Figure 30

- 23 (22) Seta 1-I well developed (Figure 9) .. *An. annularis*  
Seta 1-I weakly developed, rudimentary (Figure 10) ..... *An. jamesii*

- 24 (22) Seta 4-C with 2-5 branches ..... *An. pallidus*  
Seta 4-C with 7-10 branches .... *An. philippinensis*

- 25 (21) Seta 9-T branched and seta 10-T simple, seta 4-C with a large number of branches from the base, anterior tergal plates on abdominal segments rather large and concave ..... *An. jeyporiensis*  
Both setae 9-T and 10-T branched ..... **26**

- 26 (25) Seta 2-C exceptionally long, more than double the length of 3-C (Figure 31), seta 1-II without well-developed leaflets ..... *An. pseudojamesii*  
Seta 2-C about double the length of 3-C (Figure 32), seta 1-II with well-developed leaflets ..... **27**

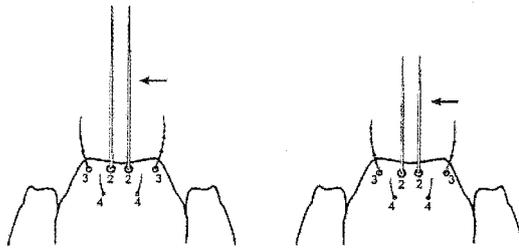
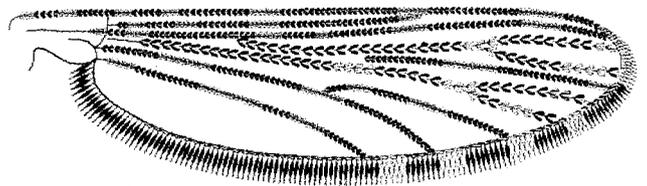
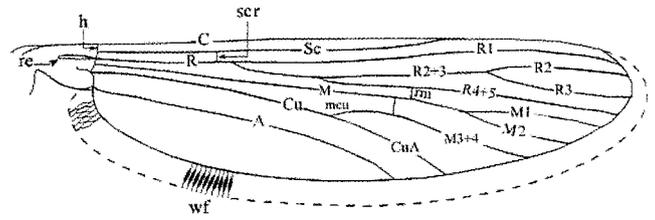


Figure 31

Figure 32

- 27 (26) Seta 8-C single ..... *An. karwari*
- Seta 8-C with 2-4 branches ..... *An. splendidus*



3. TERMINOLOGY OF ADULT FEMALE ANOPHELINE MOSQUITOES

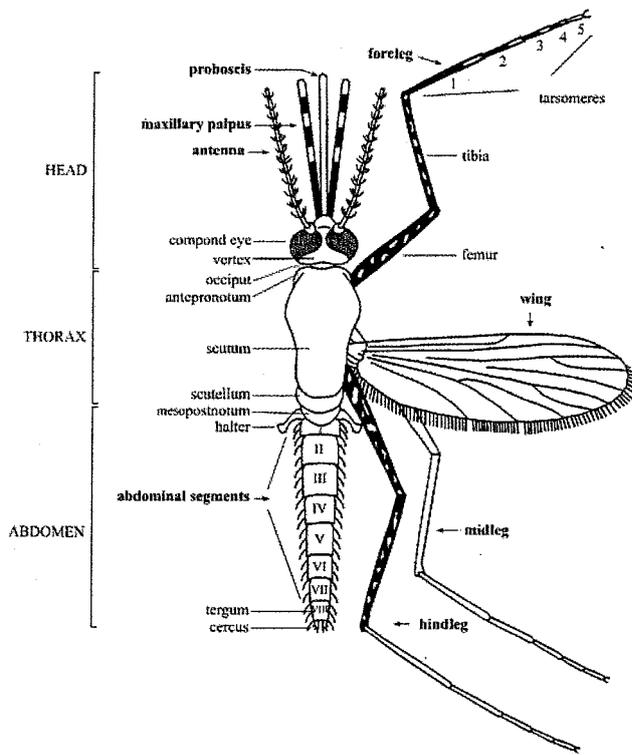


Figure 33. Morphological features of adult female anopheline mosquitoes.

- C = Costa
- Sc = Subcosta
- R = Radius
- M = Media
- Cu = Cubitus
- A = Anal vein
- wf = Wing fringe
- h = Humeral crossvein
- re = Remigium
- rm = Radiomedial crossvein
- mcu = Mediocubital crossvein
- scr = Subcostal-radial vein

Figure 34. Adult anopheline mosquito wing veins and spots.

KEY TO ADULT FEMALE ANOPHELINE MOSQUITOES

- 1 Wings entirely dark sccaled, without pale spots ... *An. aitkeni*, *An. bengalensis* and *An. insulaeflorum*
- Wings with pale spots ..... 2
- 2 (1) Fewer than 4 dark areas involving both costa and vein R<sub>1</sub> (Figure 35) ..... 3
- At least 4 dark areas involving both costa and vein R<sub>1</sub> (Figure 36) ..... 6

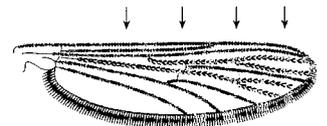
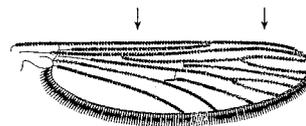


Figure 35

Figure 36

- 3 (2) Inner quarter of costa mainly pale ..... *An. gigas*  
Inner quarter of costa mainly dark ..... 4
- 4 (3) Hindfemur with a broad white band near middle (Figure 37) ..... *An. lindesayi*  
Hindfemur without a broad white band; a prominent tuft of scales on ventral surface of abdominal segment VII (Figure 38) ..... 5

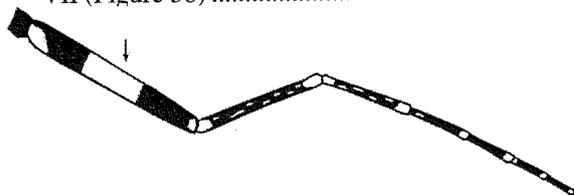


Figure 37

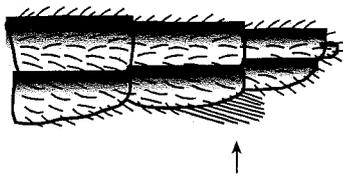


Figure 38

- 5 (4) Maxillary palpus entirely dark scaled; basal half of anal vein with scattered dark scales, wing fringe with a broad pale area at apex ..... *An. barbirostris*  
Maxillary palpus with distinct narrow pale apical bands; basal half of anal vein almost entirely pale scaled, wing fringe without a broad pale area at apex ..... **Hyrceanus Group**  
(*An. argyropus*, *An. nigerrimus*, *An. nitidus*, *An. peditaeniatus*, *An. sinensis*)

Note: Keys for the identification of the Anopheles Hyrceanus Group are illustrated by Reid (1953) and Harrison and Scanlon (1975)

- 6 (2) Hindtarsomere 5 dark scaled ..... 7  
Hindtarsomere 5 pale scaled ..... 18
- 7 (6) Femora and tibiae speckled (Figure 39) ..... 15  
Femora and tibiae not speckled ..... 8

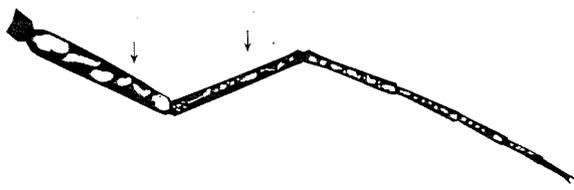


Figure 39

- 8 (7) Joints between foretarsomeres with broad basal and apical pale bands ..... 9  
Joints between foretarsomeres without pale bands or only with narrow basal and apical pale bands .... 10
- 9 (8) Maxillary palpus with pre-apical dark band equal or nearly equal length to apical pale band (Figure 40) ..... *An. subpictus*  
Maxillary palpus with a pre-apical dark band not more than half the length of apical pale band (Figure 41) ..... *An. vagus*

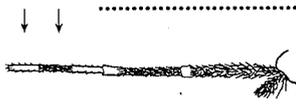


Figure 40



Figure 41

- 10 (8) Vein R<sub>4+5</sub> mainly or entirely dark scaled; inner quarter of costa with a pale interruption and with an opposing dark area on the first longitudinal vein (Figure 42) ..... *An. culicifacies*  
Vein R<sub>4+5</sub> mainly or entirely pale (Figure 43) ..... 11

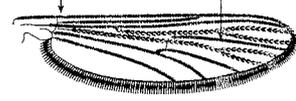


Figure 42

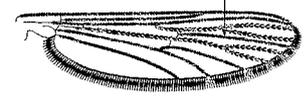


Figure 43

- 11 (10) Maxillary palpus with 2 distal pale bands separated by an intervening dark band much longer than the apical pale band (Figure 44) ..... 14  
Maxillary palpus with 2 pale distal bands separated by an intervening dark band about equal to or narrower than apical pale band (Figure 45) ..... 12



Figure 44

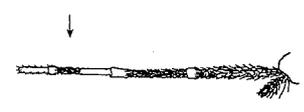


Figure 45

- 12 (11) Wing fringe with a pale spot at the termination of anal vein (Figure 46) ..... *An. aconitus*  
Wing fringe without a pale spot at the termination of anal vein ..... 13

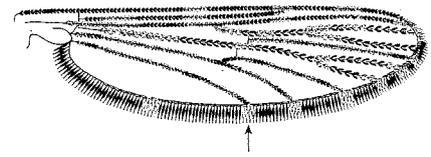


Figure 46

- 13 (12) Basal portion of costa with a pale interruption or an indication of such at least on one wing (Figure 47); proboscis without pale scaling ..... *An. minimus*  
 Basal portion of costa without any pale interruption, proboscis with pale scaling all round distal half ...  
 ..... *An. Varuna*

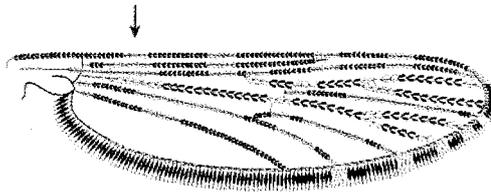


Figure 47

- 14(11) Joints of hind- and foretarsi with narrow but distinct white bands; inner quarter of costa with at least one pale interruption; wing fringe with pale spot at termination of anal vein ..... *An. jeyporiensis*  
 Joints of hind- and foretarsi without distinct white bands; inner quarter of costa without any pale interruption; wing fringe without pale spot at termination of anal vein ..... *An. fluviatilis*

- 15 (7) Joints of foretarsi with broad pale bands ..... 16  
 Joints of foretarsi with narrow pale bands on joints 1-2 and 2-3 ..... *An. stephensi*

- 16 (15) Maxillary palpus with 3 pale bands, dark preapical band equal or nearly equal length to apical pale band (Figure 40); anal vein with less than 4 dark areas ..  
 ..... *An. sudaicus*  
 Maxillary palpus with 4 pale bands (Figure 48); anal vein with 5-6 dark areas ..... 17

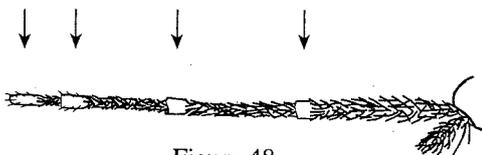


Figure 48

- 17 (16) Tibiotarsal joint of hindleg with a broad and conspicuous white band (Figure 49) ..... *An. dirus*  
 Tibiotarsal joint of hindleg without such band (Figure 50) ..... *An. tessellatus*

- 18 (6) Femora and tibiae not speckled ..... 19  
 Femora and tibiae speckled ..... 23

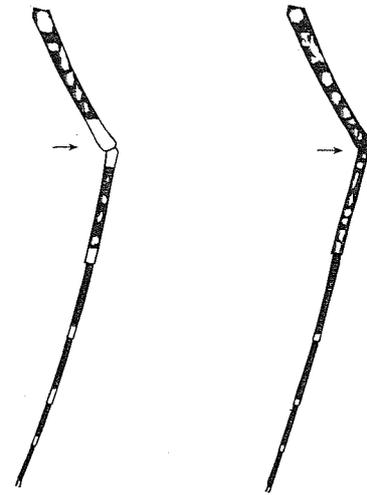


Figure 49

Figure 50

- 19 (18) At least hindtarsomeres 4 and 5 completely white scaled ..... 20  
 Only hindtarsomere 5 completely white scaled, 2 broad white bands at joints of hindtarsomeres 2-3 and 3-4 ..... 22

- 20 (19) Cubitus largely dark scaled, if not so, at least a dark area near mcu (Figure 51) ..... *An. annularis*  
 Cubitus largely pale scaled, without any dark area near mcu (Figure 52) ..... 21

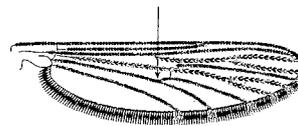


Figure 51

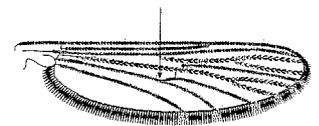


Figure 52

- 21 (20) Hindtarsomere 1 without white apical band (Figure 53) ..... *An. pallidus*  
 Hindtarsomere 1 usually with white scaling at apex (Figure 54) ..... *An. philippinensis*



Figure 53

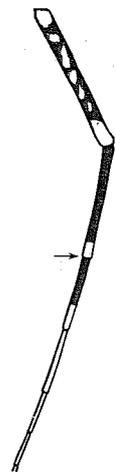


Figure 54

- 22 (19) Maxillary palpus with 4 white bands, 2 broad apical and 2 narrow basal bands (Figure 55) *An. karwari*  
 Maxillary palpus with 3 white bands, 2 broad apical bands and 1 narrow basal band (Figure 56) ..... *An. majidi*

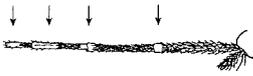


Figure 55

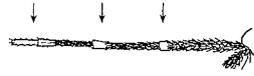


Figure 56

- 23 (18) Abdomen with a row of conspicuous tufts of black scales on ventral surface (Figure 57) ..... *An. kochi*  
 Abdomen without such tufts ..... 27

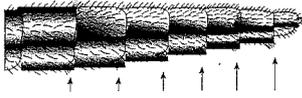


Figure 57

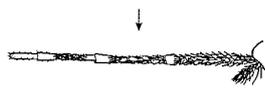


Figure 58

- 24 (23) Maxillary palpus with palpomere 3 speckled (Figure 58) ..... *An. splendidus*  
 Maxillary palpus with palpomere 3 entirely dark scaled, not speckled ..... 25

- 25 (24) Hindtarsomeres 3-5 completely white scaled .... 27  
 Hindtarsomeres 3-5 not completely white scaled ..  
 ..... 26

- 26 (25) Hindtarsomere 5 entirely white scaled, hindtarsomere 4 with white scales at base and apex, dark scaled in its middle portion (Figure 59) ..... *An. maculatus* and *An. willmori*  
 Hindtarsomeres 4-5 entirely white scaled (Figure 60) ..... *An. theobaldi*

Note: *An. willmori* differs from *An. maculatus* in having profuse scaling on abdominal terga III-VII. A large proportion of individuals of *An. willmori* also show speckling on the maxillary palpus. The larvae of the two species are, however, indistinguishable.



Figure 59



Figure 60

- 27 (25) Proximal quarter and distal third of costa mainly pale (Figure 61) ..... *An. jamesii*  
 Proximal quarter and distal third of costa mainly dark (Figure 62) ..... *An. pseudojamesii*

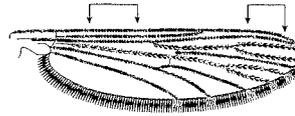


Figure 61

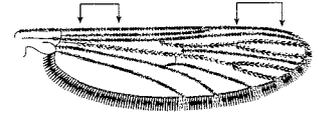


Figure 62

Acknowledgments

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