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Pupal chaetotaxy of the common mosquitoes of Dacca

(With 15 textfig. on 5 plates)

Mosquitoes are of great importance in Medical Entomology mainly because they can act as vectors of various pathogens. Information on the biology and behaviour of the vector species is essential to effectively control the transmission of mosquito-borne diseases. In such studies it is sometimes desirable to be able to identify the vector species in its immature stages. The taxonomy of the larval mosquitoes has been worked out widely. The pupal stage did not receive such attention, mainly due to its short duration. The larval and adult anopheline mosquitoes of our region is rather well worked out, but there is a big gap in our knowledge of the immature stages of culicine and the pupae of anopheline mosquitoes. The present work was undertaken, mainly, to fill this gap. The pupal chaetotaxy of five common anopheline mosquitoes from Dacca have been described in this paper.

Historical

There have been several different systems of notation for the larval and pupal hairs of mosquitoes. Consequently, uniformity in the nomenclature, particularly of the abdominal setae, is absent. MACFIE (1920) described, named, and numbered the pupal hairs of *Aedes aegypti* for the first time. MACFIE & INGRAM (1920) applied the same nomenclature, as in *Aedes*, to the pupae of *Culex* species. MACFIE's notations and nomenclature of the pupal chaetotaxy have been followed by many workers. SENEVET (1930) studied the chaetotaxy of anopheline pupae, especially of the European and Mediterranean species. His description of the various pupal hairs is somewhat different from those of MACFIE. SENEVET, however, did not include the cephalothoracic hairs in his work. CHRISTOPHERS (1933) gave brief and provisional description of the Indian anopheline pupae, where he largely used SENEVET's nomenclature with slight modification. CRAWFORD (1938) pointed out the inconsistency of SENEVET's treatment of the ventral abdominal hairs of anophelines and proposed a new nomenclature for these setae, using word names. TAYLOR (1943) modified SENEVET's system by using arabic numerals instead of roman.

In reviewing the history of the nomenclature of chaetotaxy of mosquito pupae CHRISTOPHERS (1960) referred to the very complete study of the pupal abdomen by BAISAS between 1934 and 1938, who adopted with some modifications the scheme of notation introduced by MACFIE (1920) and developed by SENEVET (1930) and CHRISTOPHERS (1933). This scheme of notation was adopted by EDWARDS (1941) and was subsequently followed by many other workers. EDWARDS (1941), however, changed the designation of the large dorsal plumose hair of the 1st abdominal segment from 'dendritic tuft' to 'float hair'.

As a result of observations on a large number of genera KNIGHT & CHAMBERLAIN (1948) found the earlier nomenclature of the pupal chaetotaxy unsatisfactory for at least two reasons. (1) None of them included all the known elements of the chaetotaxy, and (2) all the systems employed mixed type of name designations (words, numerals, symbols, and letters), a condition which, according to them, introduced unnecessary difficulties into the mechanical handling of the nomenclature. They found that, in general, it was possible on the basis of (a) similarities in relative position, and (b) degree of development to establish homologies for the setae of abdominal segments I—VII, both between hairs of each segment of the abdomen and also between the hairs of equivalent segments of the different genera studied. However, they admitted "that homologies based on only these two points will be subject to error, but until additional or better criteria are described these must largely do". KNIGHT & CHAMBERLAIN (1948) used a nomenclature of arabic numerals (0—13) to the setae and 'hairless setal ring' of the segments I—VII, beginning at the dorsal mid-line and extending laterally and ventrally to the ventral mid-line. The hairs of segment VIII and IX were arbitrarily named with arabic numerals. BELKIN (1954 in CHRISTOPHERS 1960) pointed out that the hairless setal ring should not be included in the nomenclature of the pupal chaetotaxy since it appears to be a sensillum.

KNIGHT & CHAMBERLAIN (1948) did not attempt to homologize the elements of the larval and pupal chaetotaxy. The study of homologies between larval and pupal chaetotaxy by several workers, especially BAISAS and PAGAYON, showed the evident homologies between larval and pupal chaetotaxy. On the basis of such works BELKIN (1952) put forward a system of notations for the pupal setae and subsequently suggested a few corrections (BELKIN 1953). This system of notation is now in general acceptance (CHRISTOPHERS 1960). Later, BELKIN (1960) observed nerve connections between the external hairs of the fourth instar larva and the internal developing hairs of the pupa. He noted that these connections provided, for the first time, an absolute criteria of ontogenic homology of the elements of the mosquito chaetotaxy. However, BARR & MYERS (1962) showed, from a study of the nerves connecting larval and pupal setae, that some of the setae in the larva changed their position in the pupal stage. Accordingly, they suggested a few alterations in the pupal notations proposed by BELKIN. These modified notations were followed by SERVICE (1970).

CHRISTOPHERS (1960) rightly pointed out that alterations of the notations beyond a certain point lead to confusion. Moreover, there are important works dealing with the pupae of various regions of the world where notation has been that used

by EDWARDS or earlier workers. Therefore, he gave, for convenient cross reference, the original notations by MACFIE, the modification by BAISAS as used by EDWARDS, the consecutive numbers used by KNIGHT & CHAMBERLAIN, and the final notations of BELKIN in a tabular form (CHRISTOPHERS 1960, Table 21).

In the present work the notations proposed by KNIGHT & CHAMBERLAIN (1948) for the various pupal hairs on the cephalothorax and abdominal segments I—VIII have been followed, mainly because the homology of the pupal hairs with the larval hairs was not studied. The anal flap and the paddles are regarded as representing segment IX. The terminal hair at the posterior end of the paddle, known as paddle hair, was designated as hair P by MACFIE (1920), TAYLOR (1943), and HOLSTEIN (1954); SENEVET (1930) designated it by the arabic numeral 4; KNIGHT & CHAMBERLAIN (1948) by 8; and BELKIN (1953) by 9. The sub-terminal accessory paddle hair was designated as hair 5 by SENEVET (1930); hair 7 by KNIGHT & CHAMBERLAIN (1948); hair 8 by BELKIN (1953); and hair ap by TAYLOR (1943) and HOLSTEIN (1954). Since all these names were given arbitrarily and to avoid confusion with the numeral designations in other abdominal segments, the paddle hair and accessory paddle hair have been designated as hair P and ap, respectively in this paper.

In the descriptions of the chaetotaxy the figures in the parenthesis after setal numbers show the range of branching and the usual number of branches. The abdominal hairs have been described as very long, long, medium, or small according to the following criteria. Hairs smaller than half the length of the succeeding segment have been called small; about half the length of the succeeding segment — medium; more than half the length of the succeeding segment — long; and those longer than the succeeding segment — very long.

Materials and methods

Eggs, larvae, or pupae of mosquitoes were collected from various places in and around Dacca city, and these were reared in the laboratory. The pupal skins were mounted on glass slides for examination. The specific identifications were made from the reared adult mosquitoes. The pupal skins were preserved in 70% ethyl alcohol immediately after emergence of the adults to avoid rotting or breakage. The preserved pupal skin was passed through grades of alcohol and mounted in Canada balsam through xylene. The cephalothorax of the pupal skin was carefully separated from the abdomen under a stereoscopic binocular microscope; the metathorax, however, was kept with the abdomen. Thereafter, the cephalothorax was flattened by cutting through the mid-dorsal line, behind the ecdysial cleavage, with the help of a needle. Some whole pupae were also mounted in balsam.

The descriptions of the pupae are based on observations of ten specimens of each species.

Detailed pupal chaetotaxy of the various species studied

Anopheles (Myzomyia) vagus DÖNITZ

(Plate I, Figs. 1—3)

Cephalothorax: Trumpets of medium size, membranous, about 3 times longer than the width at the apex. Most of the cephalothoracic hairs small, a few moderately developed. Seta 1(1—3,2); 2(1—3,2); 3(2—3,2); 4(1—3,2); 5(2—4,3); 6(1—2,2); 7(2); 8(1); 9(1—2,1); 10(1); 11(1—2,1); 12(1—3,2).

Abdomen: Paddles not oval, mid-rib present; lower two-thirds of the paddle fringed, ending with the paddle hair. In segment II the dorsal hair 5 is displaced anteriorly from its usual position near the posterior margin of the segment. In segment VI hair 4 is internal to hair 2. Setae 1 and 13 always single and minute. Dorsal hairs 3, 4, 6, and 7 in segments II—VII usually small. Ventral hairs 9, 10, 11, and 12 in segments III—VII usually small, in some of the posterior segments seta 10 and 11 become moderately elongated.

Segment I: Seta 2 (long, dendroid; 7—9 main branches, each branch ramifies further to form more than 62 branches); 3(1—2,1); 4(1—3,1); 5(1—3,2); 6(2—3,2); 7(1); 8(1); 10(1—2,2). Setae 3 to 6 small; 7, 8, and 10 long.

Segment II: Seta 1(1); 2(5—8,6) medium; 3(1—3,3); 4(3—6,4); 5(1—3,1) small; 6(2—4,3); 7(1) medium; 8(1) stout, very small; 9(absent); 10(1—3,2) shifted dorsally; 11(1); 12 and 13 absent.

Segment III: Seta 1(1); 2(4—7,5) long; 3(1—4,1) strong; 4(3—6,5); 5(3—6,5) medium; 6(1—2,1); 7(1—3,1); 8(1) small, stout; 9(1—2,1); 10(1); 11(1—3,1); 12(1—2,1); 13(1).

Segment IV: Seta 1(1); 2(3—6,4) very long; 3(2—3,3); 4(3—5,3); 5(3—5,3) very long; 6(1); 7(1); 8(1) small, stout, sometimes spiny; 9(1—2,1); 10(1—2,1); 11(1); 12(1); 13(1).

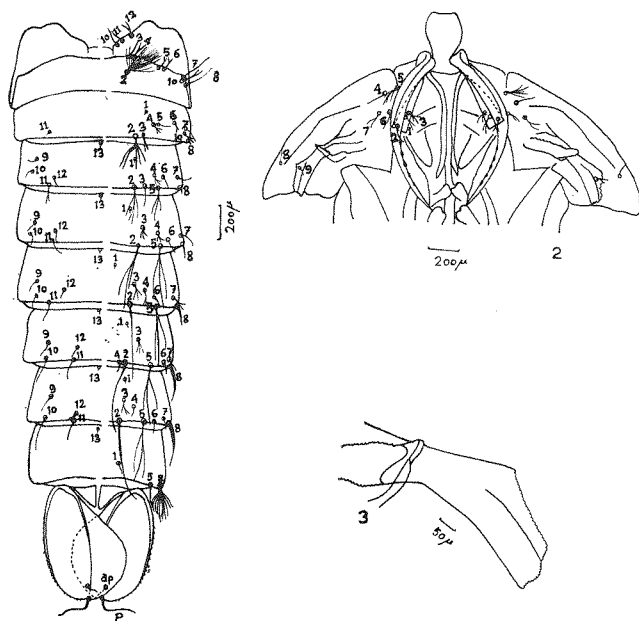
Segment V: Seta 1(1); 2(1) very long; 3(3—4,4); 4(1—2,2); 5(3—4,3) long, sometimes very long; 6(1—3,2); 7(1—2,1); 8(1) small, spiny; 9(1—2,1); 10(1—2,1); 11(1); 12(1); 13(1).

Segment VI: Seta 1(1); 2(1) strong, very long; 3(3—5,3); 4(1); 5(3—4,3) long; 6(1—2,1); 7(1—2,1); 8(1) medium, spiny, strong, inwardly curved; 9(1); 10(1); 11(1); 12(1); 13(1).

Segment VII: Seta 1(1); 2(1) very long, strong; 3(3—4,3); 4(1—2,1); 5(3—4,4) long; 6(1—2,1); 7(1); 8(1) medium, spiny, inwardly curved; 9(1—2,1); 10(1); 11(1); 12(1); 13(1).

Segment VIII: Seta 1(1) on the posterior half of the segment; 5(1) small; 8(11—15,14) medium, tufted; 13(1).

Segment IX: Seta P(1) long, strong; ap (1) small.



Explanation of all Figures

The cephalothoracic drawings are of skins opened along the dorsal midline with the outer surfaces up. All the metathoracic and abdominal drawings show the ventral surface on the left and the dorsal surface on the right. In each case the first segment shown is the metathorax.

Plate I. *Anopheles vagus*: Fig. 1. Metathorax and abdomen. — Fig. 2. Cephalothorax. — Fig. 3. Respiratory trumpet

Anopheles (Myzomyia) subpictus GRASSI

(Plate II, Figs. 4–6)

Cephalothorax: Trumpet membranous, about two times longer than the width at the apex. The cephalothoracic hairs are small to medium in size. Seta 1(1–3,2); 2(2–3,3); 3(2–3,3); 4(1–4,2); 5(2–6,2); 6(1); 7(2–3,2); 8(1–2,1); 9(1–2,1); 10(1–2,2); 11(1–3,2); 12(1–2,1).

Abdomen: Paddles more or less oval, semi-transparent, lower two-thirds fringed at the margin, mid-rib prominent. In segment II hair 5 is displaced anteriorly from its usual position near the posterior margin of the segment. In segment VI hair 4 is internal to hair 2. Seta 1 and 13 always single and minute. Dorsal hairs 3, 4, 6, and 7 in segments II–VII usually small. Ventral hairs 9, 10, 11, and 12 in segments III–VII small.

Segment I: Seta 2 (long, dendroid; the base of the dendritic tuft first divides into two main branches, each of these divides into 3 or more branches, which divide further to form more than 62 branches); 3(1–2,1); 4(2–7,3); 5(3–5,4); 6(2–3,3); 7(1); 8(1); 10(1–2,2). Setae 3 to 6 small; 7, 8, and 10 medium to long.

Segment II: Seta 1(1); 2(5–9,7) small; 3(1) strong; 4(3–6,5); 5(1–3,1) small; 6(2–3,2); 7(1); 8(1) very small, stout; 10(2) small, shifted dorsally. Setae 9, 11, 12, and 13 absent.

Segment III: Seta 1(1); 2(3–7,5) long; 3(1); 4(3–5,4); 5(3–6,5) medium; 6(1–2,1); 7(1); 8(1) very small, stout; 9(1–2,1); 10(1–2,1); 11(1–3,1); 12(1); 13(1).

Segment IV: Seta 1(1); 2(1–3,3) very long; 3(3–4,3); 4(1–3,3); 5(2–4,4) long; 6(1–2,2); 7(1); 8(1) small, stout; 9(1); 10(1–2,1); 11(1); 12(1); 13(1).

Segment V: Seta 1(1); 2(1) very long; 3(3–4,3); 4(1); 5(2–3,3) long; 6(1–3,3); 7(1–2,1); 8(1) small, spiny; 9(1); 10(1–2,1); 11(1); 12(1); 13(1).

Segment VI: Seta 1(1); 2(1–2,1) very long; 3(3); 4(1); 5(2–3,3) long; 6(1); 7(1); 8(1) medium, spiny, inwardly curved; 9(1–2,1); 10(1); 11(1); 12(1); 13(1).

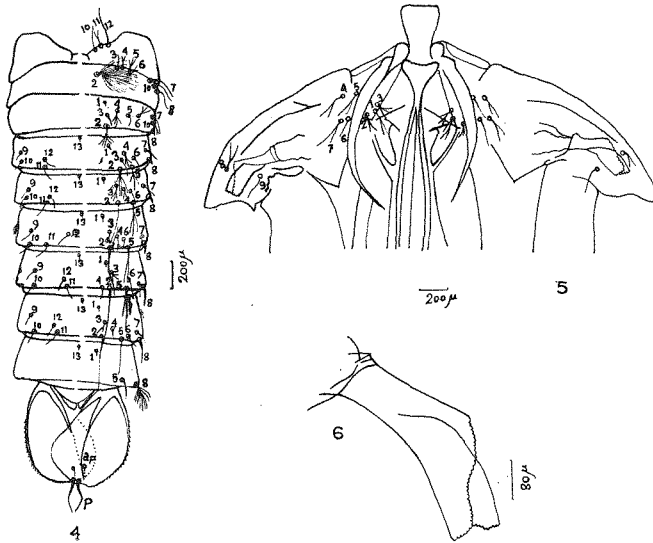


Plate II. *Anopheles subpictus*: Fig. 4. Metathorax and abdomen. — Fig. 5. Cephalothorax. — Fig. 6. Respiratory trumpet

Segment VII: Seta 1(1); 2(1-2,1) very long; 3(2-4,3); 4(1); 5(2-3,3) long; 6(1); 7(1); 8(1) medium to long, spiny, inwardly curved; 9(1-3,1); 10(1); 11(1-2,1); 12(1-2,1); 13(1).

Segment VIII: Seta 1(1) on the anterior half of the segment; 5(1) small; 8(4-10,7) medium; 13(1).

Segment IX: Seta P(1) long, strong; ap(1) small, a little anterior to P and external to the mid-rib of the paddle.

Anopheles (Myzomyia) annularis VAN DER WULF

(Plate III, Figs. 7-9)

Cephalothorax: Trumpet membranous, about three times longer than the width at the apex. Most of the cephalothoracic hairs small, a few moderately developed. Seta 1(1-5,3); 2(1-4,1); 3(3-5,3); 4(1-3,2); 5(2-5,3); 6(1-3,1); 7(1-2,2); 8(1); 9(1-2,2); 10(1); 11(1-3,2); 12(1-2,1).

Abdomen: Paddles not oval, more or less sclerotized; lower two-thirds of the paddle fringed at the margin. In segment II hair 5 shifted anteriorly from its usual position near the posterior margin of the segment. In segment VI hair 4 is internal to hair 2. Setae 1 and 13 always single and minute. Ventral hairs are absent in segment I and II. Dorsal hairs 3, 4, 6, and 7 in segments II-VII small. Ventral hairs 9 to 12 in segments III-VII small; seta 11, among these setae, tends to be larger.

Segment I: Seta 2 (long, dendroid, moderately strengthened; the base generally divides into 8 primary branches which divide and redivide to form more than 68 branches, usually 65 branches); 3(1); 4(1-3,2); 5(1-3,1); 6(1-2,1); 7(1-2,1); 8(1-3,1); 10(1-2,1). Setae 3 to 6 small; 7, 8, and 10 small to medium.

Segment II: Seta 1(1); 2(5-10,6) small; 3(1) strong; 4(3-7,5); 5(2-5,3); 6(3-5,3); 7(1); 8(1) very small, stout; 10(2-5,3) small, shifted dorsally.

Segment III: Seta 1(1); 2(4-6,5) small; 3(1) strong; 4(3-5,4); 5(5-8,6) small; 6(1-3,3); 7(2-4,2); 8(1) small, stout; 9(1-4,3); 10(1-3,1); 11(1-3,1); 12(1); 13(1).

Segment IV: Seta 1(1); 2(3-7,4) long; 3(3-4,3); 4(2-4,4); 5(4-5,4) long; 6(1-2,1); 7(1-3,2); 8(1) small, stout, spiny; 9(1-3,2); 10(1-3,2); 11(1); 12(1); 13(1).

Segment V: Seta 1(1); 2(1) very long, strong; 3(3); 4(1-2,1); 5(2-3,3) long; 6(1-3,1); 7(1-2,2); 8(1) spiny, strong; 9(1-3,1); 10(1-3,2); 11(1); 12(1); 13(1).

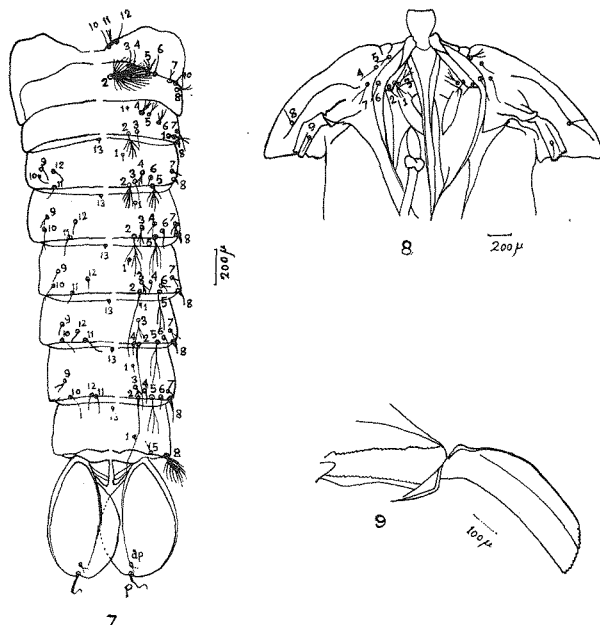


Plate III. *Anopheles annularis*: Fig. 7. Metathorax and abdomen. — Fig. 8. Cephalothorax. — Fig. 9. Respiratory trumpet

Segment VI: Seta 1(1); 2(1-2,1) very long; 3(3); 4(1); 5(2-3,3) long; 6(1); 7(1-2,1); 8(1) spiny, strong, stout; 9(1-2,1); 10(1); 11(1-2,1); 12(1); 13(1).

Segment VII: Seta 1(1); 2(1) very long; 3(2-3,3); 4(1-2,1); 5(2-3,2) long; 6(1); 7(1-2,1); 8(1) small, spiny, tip slightly curved; 9(1-2,1); 10(1); 11(1); 12(1); 13(1).

Segment VIII: Seta 1(1) on the posterior half of the segment; 5(1-2,1) small; 8(7-12,10) medium, tufted; 13(1).

Segment IX: Seta P(1) long, strong; ap (1-2,2) small.

***Anopheles (Anopheles) hyrcanus* var. *nigerrimus* GILES**

(Plate IV, Figs. 10-12)

Cephalothorax: Trumpets a little wider at the apex than its length. Cephalothoracic hairs medium. Seta 1(2-3,3); 2(2-3,2); 3(1-3,2); 4(2-3,2); 5(2-3,2); 6(1-2,2); 7(2); 8(1); 9(1-2,2); 10(1-2,1); 11(2-4,2), 12(1-2,2).

Abdomen: Paddles oval, provided with delicate mid-rib; middle area of the margin slightly fringed. In segment II hair 5 shifted anteriorly from its usual position near the posterior margin of the segment. In segment VI hair 4 is internal to hair 2. Seta 1 minute and branched. Seta 13 always single and minute. Dorsal hairs 3, 4, 6, and 7 in segments II-VII small. All the ventral hairs small.

Segment I: Seta 2 (long, dendroid, moderately developed, more than 75 branches); 3(5-7,6); 4(2-3,3); 5(3-4,3); 6(1-2,2); 7(1); 8(1); 10(1-3,3). Hair 10 long, all the others small. Ventral hairs absent.

Segment II: Seta 1(2-3,2); 2(8-14,13) small, brushy; 3(2-3,2); 4(5-7,6); 5(1-2,2) small; 6(1-2,2); 7(1-2,2); 8(1) very small; 10(1-3,2) small, shifted dorsally; 11(1-3,1). Ventral hairs 9, 12, and 13 absent.

Segment III: Seta 1(2-3,3); 2(15-20 or more) small, brushy; 3(5-7,6); 4(6-7,7); 5(15-20 or more) small, brushy; 6(1-2,2); 7(1-2,2); 8(1) stout, spiny; 9(1); 10(1-2,2); 11(1-2,2); 12(1-2,1); 13(1).

Segment IV: Seta 1(2-4,4); 2(10-17 or more) small, brushy; 3(4-5,4); 4(7-8,7); 5(20-25 or more) small, brushy; 6(1); 7(1); 8(1) spiny; 9(1-2,1); 10(1-2,2); 11(1); 12(1-2,1); 13(1).

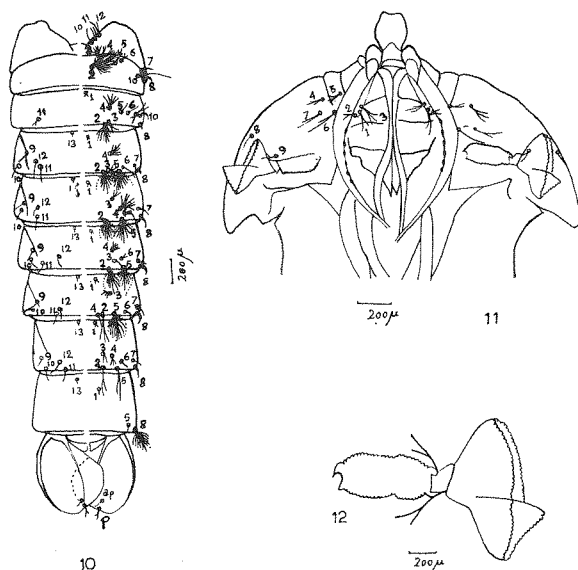


Plate IV. *Anopheles hyrcanus* var. *nigerrimus*: Fig. 10. Metathorax and abdomen. — Fig. 11. Cephalothorax. — Fig. 12. Respiratory trumpet

Segment V: Seta 1(2–3,3); 2(11–14 or more) medium, brushy; 3(1–2,2); 4(5–6,6); 5(20–25 or more) medium, brushy; 6(1–3,1); 7(1); 8(1) small, stout, spiny; 9(1–2,1); 10(1–3,2); 11(1); 12(1–2,1); 13(1).

Segment VI: Seta 1(2–3,3); 2(3–7,5) medium; 3(4–6,4); 4(1–2,2); 5(15–20 or more) medium, brushy; 6(1–2,2); 7(1); 8(1) small, stout, spiny; 9(1–2,1); 10(1); 11(1); 12(1); 13(1).

Segment VII: Seta 1(2–3,2); 2(2) medium; 3(2); 4(3–4,3); 5(2–7,2) medium; 6(1); 7(1–2,1); 8(1) small, stout, spiny; 9(1–3,3); 10(1); 11(1–2,2); 12(1–2,2); 13(1).

Segment VIII: Seta 1(1–2,2) on the anterior half of the segment; 5(1) small; 8(5–17,10) small, the hairs arising from a median stout and spiny structure; 13(1).

Segment IX: Seta P (2–3,2) small, strong; ap (1) small, anterior to hair P.

***Anopheles (Anopheles) barbirostris* VAN DER WULP**

(Plate V, Figs. 13–15)

Cephalothorax: Trumpets membranous, wider at the apex than its length. Seta 1(2); 2(2); 3(2–3,2); 4(1–3,2); 5(2–3,2); 6(1–2,1); 7(2–3,2); 8(1–2,1); 9(1–2,1); 10(1–3,2); 11(2–3,2); 12(1–3,2).

Abdomen: Paddles oval, strengthened by mid-rib, part of the margin fringed. In segment II hair 5 shifted anteriorly from its usual position near the posterior margin of the segment. In segment VI hair 4 is internal to hair 2. Seta 1 minute and branched. Seta 13 always single and minute. Dorsal hairs 3, 4, 6, and 7 in segments II–VII usually small. Ventral hairs small in all segments.

Segment I: Seta 2 (long, dendroid, the base divides into several branches which divide further to form more than 70 branches); 3(1–4,2); 4(2–3,3); 5(1–6,3); 6(2); 7(1); 8(1); 10(1–3,2). Seta 7 long, others small to medium in size.

Segment II: Seta 1(1–2,2); 2(5–6,5) small; 3(1); 4(5–8,6); 5(2–4, 2) small; 6(2–3,2); 7(1–2,1); 8(1) spiny, very small; 10(1–2,1) shifted dorsally; other ventral hairs absent.

Segment III: Seta 1(1–2,2); 2(12–20 or more) small, brushy; 3(4–6,6) brushy; 4(7–9,9) brushy; 5(12–25 or more) medium to long, brushy; 6(1–2,1); 7(1–2,1); 8(1) small, strong, spiny; 9(1); 10(1); 11(1–2,1); 12(1–2,1); 13(1).

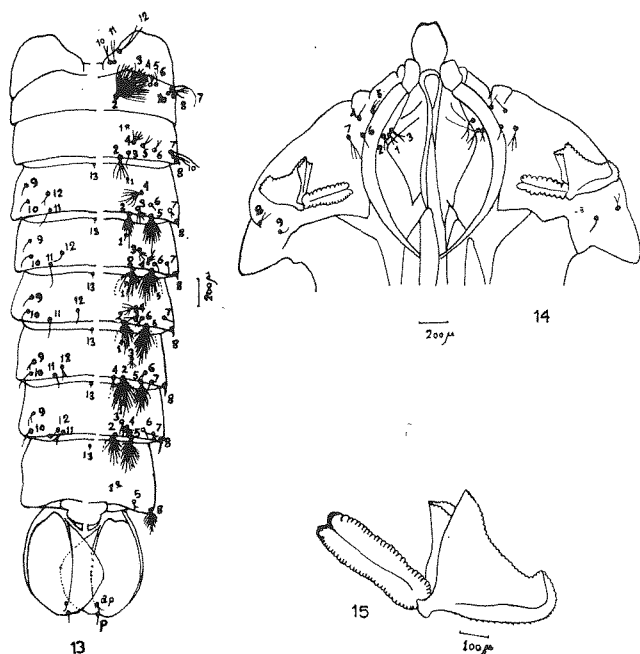


Plate V. *Anopheles barbirostris*: Fig. 13. Metathorax and abdomen. — Fig. 14. Cephalothorax. — Fig. 15. Respiratory trumpet

Segment IV: Seta 1(1–2,1); 2(15–20 or more) medium to long, brushy; 3(3–5,3); 4(5–7,5); 5(20–30 or more) medium to long, brushy; 6(1–3,1); 7(1); 8(1) small and spiny; ventral hairs 9 to 13 unbranched.

Segment V: Seta 1(1–2,1); 2(20–30 or more) long, brushy; 3(2–3,2); 4(5–7,6); 5(20–25 or more) long, brushy; 6(1–3,3); 7(1); 8(1) small, strong, and spiny; ventral hairs 9 to 13 unbranched.

Segment VI: Seta 1(1–2,2); 2(20–30 or more) long, brushy; 3(5–7,5); 4(1–2,1); 5(20–25 or more) long, brushy; 6(1–2,1); 7(1); 8(1) small, strong, and spiny; 9(1–2,1); 10(1); 11(1); 12(1–2,1); 13(1).

Segment VII: Seta 1(1–2,2); 2(10–20 or more) long, brushy; 3(2–4,3); 4(5–10,6); 5(15–20 or more) long, brushy; 6(1–2,2); 7(1–3,1); 8(1) small, strong, spiny; 9(1–2,2); 10(1); 11(1–2,1); 12(1–2,1); 13(1).

Segment VIII: Seta 1(1–2,1) on the posterior half of the segment; 5(1–2,1); 8(8–13,10) small, brushy; 13(1).

Segment IX: Seta P (1) small, strong; ap (1–2,2) small.

Discussion

A few general remarks should be made after describing the chaetotaxy of the individual species. Abdominal hairs 1 and 13 are situated in the anterior half and the other hairs in the posterior half of the segment. However, in many species the hair 1 in segment VIII occurs in the posterior half of the segment. Thus, it is situated on the anterior half of the segment in *A. subpictus* and *A. hyrcanus* var. *nigerrimus*; whereas in *A. vagus*, *A. annularis*, and *A. barbirostris* it is situated on the posterior half of the segment.

Abdominal hairs 2, 5, and 8 are normally situated at the posterior margin of the segments dorsally. They constitute the submedian, sublateral, and lateral dorsal abdominal hairs respectively of the earlier authors. The hairs 3, 4, 6, and 7 lie a little anterior to the posterior margin of the segment on the dorsal side. However, in segment II the hair 5 does not

occur in its usual position on the posterior margin of the segment. It is shifted a little cephalad and mesad from its original position as described by KNIGHT & CHAMBERLAIN (1948).

In segment VI the hair 4 is internal to hair 2 and lies near the posterior border of the segment. The hair was designated as C' by SENEVET (1930), CHRISTOPHERS (1933), and TAYLOR (1943). KNIGHT & CHAMBERLAIN (1948) discussed the positional problem of the hair and designated it as hair 4.

Abdominal hair 8 is important in distinguishing the anopheline and culicine pupae. In the anopheline pupae they are usually stout and spine-like and lie exactly at the posterior lateral corners of the dorsal surface in segments II—VII. In segment VIII the hair 8 is many branched and brushy in the genus *Anopheles*. In the culicine pupae this hair is usually fine and branched and does not arise exactly at the postero-lateral angles of the dorsal surface, but a little anterior and dorsal to this point.

The ventral hairs are absent altogether in segment I and in most cases in segment II. SENEVET (1930), CHRISTOPHERS (1933), and TAYLOR (1943) did not describe any ventral hair on segment II in the genus *Anopheles*. However, they described an extra dorsal hair on this segment which is actually the hair 10 shifted dorsally. KNIGHT & CHAMBERLAIN (1948) pointed out that hair 10 is the only ventral hair consistently present on segment II, and it is as often dorsal as ventral. But they did not show any other ventral hair on segment II in the genus *Anopheles*. However, in the anopheline pupae described above ventral hair 11 on segment II was present in both *A. vagus* and *A. hyrcanus* var. *nigerrimus*, and was absent in the other species.

In *Anopheles* spp. the accessory paddle hair (ap) is located on the ventral surface of the paddle, a little in front of the hair P. In the culicines the hair ap is placed on the dorsal surface, very close to the hair P. BARRAUD (1939) and TAYLOR (1943) observed that the position of the accessory paddle hair provided an excellent character for distinguishing anopheline pupae from those of the culicines.

No serious attempt was made earlier to recognise the species of the mosquito in the pupal stage mainly because of its very short duration. Pupal chaetotaxy of 13 mosquito species from Dacca, belonging to 6 genera, have been studied so far. Five of them are described in this paper, the others will be described later on. It became apparent from these studies that the species can be identified in the pupal stage following a provisional key. However, it is not certain as to what would be the situation when the chaetotaxy of the other species will be known.

The 5 *Anopheles* species described in this paper belong to 2 subgenera: *Anopheles* MEIGEN and *Myzomyia* BLANCHARD. It was observed that in the *Myzomyia* species the dorsal hairs 2 and 5 are few-branched, not exceeding 8 in any segment, and these hairs are very long in segments V—VII (Figs. 1, 4, 7). Whereas in the subgenus *Anopheles* these hairs are small to medium in size, and are many branched and brushy in appearance (Figs. 10, 13). Another characteristic difference in the chaetotaxy of the two subgenera is that in *Myzomyia* species the hair 1 is always unbranched but in *Anopheles* species it is bifid or trifid in some of the segments.

A provisional key for the identification of the pupae described in this paper is given below. The pupae of the genus *Anopheles* MEIGEN may be distinguished from the other genera by the following characters.

Hair 8 on abdominal segment VIII may branched, simple in segments II—VII; Hair 5 branched in all abdominal segments; Hair 2 of cephalothorax not long; Paddle incompletely fringed with small hairs; Accessory paddle hair (ap) on the ventral surface of the paddle, a little in front of the hair P.

Key to the species

- | | |
|---|---|
| 1 Abdominal hairs 2 and 5 are short to medium in size, many branched and brushy in appearance; abdominal hair 1 bifid or trifid in some of the abdominal segments | 2 |
| Abdominal hairs 2 and 5 are long or very long in segments V—VII, a few branched (not exceeding 8); abdominal hair 1 always single and unbranched | 3 |

- 2 Paddle hair P branched; accessory paddle hair ap single; ventral hair 11 on abdominal segment II present; hair 1 on the anterior half of abdominal segment VIII *A. hyrcanus* var. *nigerrimus*
 Paddle hair P unbranched, small, spiny; accessory paddle hair ap sometimes bifid; ventral hair 11 on abdominal segment II absent. Hair 1 on the posterior half of abdominal segment VIII *A. barbirostris*
- 3 Hair 7 and 10 on abdominal segment I long and unbranched; accessory paddle hair ap unbranched 4
 Hair 7 and 10 on abdominal segment I small and branched; accessory paddle hair ap sometimes bifid *A. annularis*
- 4 Ventral hair 11 on abdominal segment II present; hair 1 on the posterior half of abdominal segment VIII; Paddle longer than broad *A. vagus*
 Ventral hair 11 on abdominal segment II absent; hair 1 on the anterior half of abdominal segment VIII; Paddle length and widest width almost equal *A. subpictus*

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Summary

The history of nomenclature of the pupal chaetotaxy of mosquitoes has been reviewed. The chaetotaxy of 5 species of the genus *Anopheles*, viz., *A. vagus*, *A. subpictus*, *A. annularis*, *A. hyrcanus* var. *nigerrimus*, and *A. barbirostris*, has been described and illustrated.

Zusammenfassung

Die Geschichte der Nomenklatur der Chaetotaxie von Stechmückenpuppen wird dargestellt und die Chaetotaxie der Stechmückenpuppen der *Anopheles*-Arten *A. vagus*, *A. subpictus*, *A. annularis*, *A. hyrcanus* var. *nigerrimus* und *A. barbirostris* beschrieben und abgebildet.

Резюме

Излагается история номенклатуры хэтотаксии куколок кровососущих комаров и описывается и изображается хэтотаксия куколок *Anopheles vagus*, *A. subpictus*, *A. annularis*, *A. hyrcanus* var. *nigerrimus* и *A. barbirostris*.

References

- BARR, A. R. & MYERS, C. M. Pupae of the Genus *Culiseta* FELT. I. The homology of larval and pupal setae (Diptera: Culicidae). Ann. Ent. Soc. Amer. 55(1), 94—98; 1962.
- BARRAUD, P. J. Entomological Course for the Students of Malariology. Hlth. Bull. No. 9, Govt. of India Publication, Delhi; 1939.
- BELKIN, J. N. The homology of the chaetotaxy of immature mosquitoes and a revised nomenclature for the chaetotaxy of the pupa (Diptera, Culicidae). Proc. Ent. Soc. Washington 54(3), 115—130; 1952.
- Corrected interpretations of some elements of the abdominal chaetotaxy of the mosquito larva and pupa (Diptera, Culicidae). Proc. Ent. Soc. Washington 55(6), 318—324; 1953.
- Innervation as a criterion of homology of the elements of the larval and pupal chaetotaxy of mosquitoes (Diptera, Culicidae). Proc. Ent. Soc. Washington 62(3), 197; 1960.
- CHRISTOPHERS, S. R. Fauna of British India. Diptera, Vol. IV. The Anophelini. TAYLOR & FRANCIS, London; 1933.
- *Aedes aegypti* (L.). The Yellow Fever Mosquito. Its Life History, Bionomics and Structure. Camb. Univ. Press; 1960.
- CRAWFORD, R. Some Anopheline Pupae of Malaya with a note on pupal structure. Gov. Straits Settlm. Mal. Adv. Bd. F. M. S. Singapore; 1938.
- EDWARDS, F. W. Mosquitoes of the Ethiopian Region. Vol. III. Culicine Adults and Pupae. Brit. Mus. Nat. Hist., London; 1941.
- HOLSTEIN, M. H. Biology of *Anopheles gambiae*. W. H. O. Palais de Nations, Geneva; 1954.
- KNIGHT, K. L. & CHAMBERLAIN, R. W. A new nomenclature for the chaetotaxy of the mosquito pupa, based on a comparative study of the genera (Diptera, Culicidae). Proc. Helminth. Soc. Washington 15(1), 1—10; 1948.
- MACFIE, J. W. S. The chaetotaxy of the pupa of *Stegomyia fasciata*. Bull. Ent. Res. 10, 161—169; 1920.
- MACFIE, J. W. S. & INGRAM, A. The early stages of West African mosquitoes. V. *Culex decens* THEO. and *Culex invidiosus* THEO. Bull. Ent. Res. 11, 105—112; 1920.
- SENEVET, G. Contribution à l'étude des nymphes de Culicidae. Description de celles de certains anophélins et plus spécialement des espèces européennes et méditerranéennes. Trans. 2^e Congr. International du Paludisme. Inst. Pasteur Algér; 1930.
- SERVICE, M. W. Studies on the biology and taxonomy of *Aedes (Stegomyia) vittatus* (BIGOT) (Diptera: Culicidae) in Northern Nigeria. Trans. Roy. Ent. Soc. London 122 (4), 101—143; 1970.
- TAYLOR, F. H. Mosquito intermediary hosts of disease in Australia and New Guinea. Service Publication (School of Pub. Hlth. and trop. Med.), No. 4, Commonwealth of Australia. Dept. of Health; 1943.