# Morphology of Adult Female Mosquitoes



The morphological descriptions below deal mostly with the structures used in the keys. For a more detailed account of mosquito anatomy, consult the references listed in the bibliography of mosquito morphology on page 341.

## Basic Structures

The body of the adult mosquito is composed of hardened plates, called **sclerites**, separated from each other by lines, known as **sutures**, or by membranes of various sizes. These structures comprise the integument, or outer covering of the body; those important in identification of the female will be discussed below.

Since **scales** are common on adult females and indeed constitute one of the principal structures of recognition, they must be distinguished from setae. **Setae** (hairs, hair tufts, bristles, and spiniforms) are usually round in cross section, tapering from base to apex, and arise from a relatively large movable socket, called an **alveolus** (pl. alveoli). Scales, on the other hand, are flat in cross section, widening from base to apex, with longitudinal ridges, attached to minute alveoli on the integument. They occur in three basic forms: broad and flat, narrow and curved, and erect and apically forked. The scales on the fringe of the mosquito wing are fusiform (see Harbach and Knight 1980).

The color of scales varies from black and brown to golden, shades of yellow, such as dingy yellow in *Cx. salinarius*, to white and silvery. The white color can be brownish white, as in *Cs. minnesotae*, to grayish white. The colors tend to fade as the pinned adult ages, so in the keys herein, pale has been used to mean shades of white, and dark to mean black or brown. It is important to adjust the lighting to observe the true color of scales.

The body of the adult female is divided into three principal regions: head, thorax, and abdomen (see plate 1).

## Head

The structure of the head is shown in plates 1 and 2C. It is ovoid and a large proportion is occupied by the **compound eyes** (CE). They are composed of circular morphological units called **corneal facets** (CoF). The **antennae** arise between the eyes. The sclerite ventrad to their bases is the convex **clypeus** (Clp). Dorsad is a sclerite between and above the antennae, the **frons** (Fr), above which is the dorsum of the head, made up of the **vertex** (V) anteriorly and the **occiput** (Occ) posteriorly. Since there is no dividing suture between them, it is customary to refer to the whole dorsum simply as the occiput. The anterior border along the dorsal edge of the compound eye is known as the **ocular line** (OL).

The head bears the following five appendages: two antennae, two palpi, and the proboscis (plates 2A and 2B). The two antennae are composed of a narrow, basal ring, the **scape** (Sc), the bulbous **pedicel** (= torus) (Pc), and the **flagellum** (Fl), which contains 13 or 14 flagellomeres (= flagellar segments) (Flm), each bearing a whorl of setae. A pair of **maxillary palpi** (Mplp), called simply palpi (sing. palpus), is located ventrolateral to the clypeus and each consists of five **palpomeres** (Plp); however, in some females the basal palpomere is small or rudimentary so that the palpi appear to be 4-segmented. The **proboscis** (P) extends forward from the anteroventral base of the head. Normally, only the outer scaled covering of the proboscis, known as the **labium** (Lb), and the two terminal lobes, the **labella** (La) (sing. labellum), can be seen. Inside the labium in most species are thin stylets for piercing the host's skin.

Nine characters of the head are used in the keys as follows: (1) Shape of proboscis. It is usually nearly straight, but in genus *Toxorhynchites*, it is decidedly curved downward (fig. 1). (2) Scales on proboscis. Sometimes the proboscis has a definite pale-scaled ring near the middle, as in *Oc. sollicitans* (fig. 49), or it is variously marked with pale scales; however, in most species it is dark-scaled throughout. (3) Length of palpi. This character is used to differentiate anopheline and culicine females. In the former, the palpi are as long as the proboscis while in the latter they are not more than 0.4 as long. Within the culicine species, *Ps. longipalpus* (fig. 523) has rather long palpi; i.e., somewhat more than 0.33 as long as the proboscis, and in some species of subgenus *Neoculex* the length is compared to the length of flagellomere 4 of the antenna (fig. 430). (4) Scales of palpi. Apices of some or all of segments 2–5 may have pale-scaled rings, as in *An. walkeri* (fig. 355), scattered pale among dark scales, or only dark scales. (5) Scales on antennal pedicel. The number and color are diagnostic (e.g., *Oc. fitchii*, fig. 125). (6) Length of antennae and flagellomere 1. Flagellomere 1 is unusually long in genus *Deinocerites* (fig. 39); in addition, antennae are longer than the proboscis. (7) Width of frons. The width of the frons between the eyes, called the interocular distance, can be measured by comparing it with the diameter of a corneal facet (e.g., *Oc. epactius*,fig. 167). (8) Interocular setae (IS). These are located on the dorsal part of the frons and medioanterior area of the vertex and are long and usually dark, but in some species they are pale (e.g., *An. freeborni*, fig. 353). (9) Scales on dorsum of head. Posteriorly the scales are erect, usually forked, while anteriorly and laterally they are decumbent and either narrow and curved (e.g, subgenus *Culex*, fig. 382), or broad and flat (e.g., subgenus *Melanoconion,* fig. 384).

## Thorax

The thorax (plates 3 and 4), the body region between the head and abdomen, is divided into three segments: **prothorax**, **mesothorax**, and **metathorax**. Each bears a pair of legs; in addition, the mesothorax has a pair of functional wings, and the metathorax, a pair of knobbed **halteres** (Hl). The dipterous mesothorax is typically greatly enlarged to accommodate the flight muscles associated with the functional wings. The pro- and metathorax are correspondingly reduced in size.

In dorsal view (plates 3A and 3B) proceeding from anterior to posterior, the **antepronota** (= anterior pronotal lobes) (Ap), part of the prothorax, are found laterally just posterior to the head. The size and scales are used in the keys. Two genera, *Haemagogus* and *Wyeomyia*, have enlarged antepronota that approach each other middorsally (fig. 31).

The next three structures are mesothoracic, starting with the **scutum** (Scu), the largest sclerite of the mosquito body and rather spheroid. Anterolateral depressions in the sphere are known as the **scutal fossae** (SF) and the slightly depressed, usually unscaled area posteromedially is the **prescutellar space** (PrA). The scutum has setae arranged in three somewhat irregular longitudinal rows in the middle third. The central one is composed of **acrostichal setae** (AcS), and the rows on either side are the **dorsocentral setae** (DS). In addition, there is a group in front of and superior to the wing root, the **supraalar setae** (SaS). Those anterolateral setae occurring around and in the scutal fossa are the **scutal fossal setae** (SFS) (plates 3A and 4A). In some species the scutal setae are quite numerous and long (e.g., *An. barberi*, fig. 348), while in others they are shorter and fewer. In the subgenus *Melanoconion* (fig. 383) the acrostichal setae are absent, and in some species the acrostichal and dorsocentral setae

are absent anteriorly, a condition termed the "acrostichal gap" and the "dorsocentral gap" by Lunt and Nielsen (1972). The color of some of these setae, particularly the supraalars, is diagnostic for several species (e.g., *Oc. hexodontus*, fig. 319).

The scutal integument may have spots or be a distinctive color (e.g., *Cx. erythrothorax*,fig. 401). The patterns made by the scutal scales are extensively employed in culicine mosquito identification (see *Oc. atlanticus*, fig. 189), and usually have the same names as the setae just described when they occur in the same location. One difficulty commonly encountered is rubbed specimens in which the scutum is devoid of scales and setae. This is particularly true of those collected in mechanical light traps. When such specimens are examined under high power of a stereoscopic microscope the color of some few scales still attached may give a clue about the pattern of that species. Likewise the presence of alveoli will indicate the prior location of setae in the specimen.

Posterior to the scutum is a narrow transverse sclerite, the **scutellum** (Stm). In the subfamily Anophelinae (fig. 5) it is arcuate and bears an even row of setae, the **scutellar setae** (MSS, LSS). In the subfamily Culicinae the scutellum is trilobate, with a group of setae on each lobe (fig. 7). In addition, the kind and color of scales and setae on this sclerite may be important.

The shiny, dome-shaped structure posterior to the scutellum is the **mesopostnotum** (Mpn). In most species it is bare, but in the sabethine mosquitoes (e.g., *Wyeomyia*) a group of setae occurs near its attachment to the **metanotum** (Mtn) and **abdominal tergum I** (Ab-1) (fig. 9) and is known as the **mesopostnotal setae** (MpnS).

Posteriorly is the metanotum, a thin sclerite that enlarges laterally and there bears the **halteres**, the organs of balance. Next the intersegmental cleft separates the thorax from abdominal segment I, then there is a second, very thin, metathoracic element, the **metapostnotum** (Mtpn). It actually adheres to the first abdominal tergum, but extends lateroventrally as a thin strip to touch the metameron (see plate 4A). The halteres are usually dark scaled, but have pale scales in *An. walkeri* (fig. 375).

The three thoracic segments are also represented by the structures of the thoracic pleuron (plate 4A). Two of the visible sclerites, the **antepronotum** (Ap) and the **postpronotum** (Ppn), are components of the tergum of the prothorax, not of its pleuron. Starting anteriorly, the prothoracic elements consist of the antepronotum, which is connected ventrally by a straplike piece to the **proepisternum** (Ps); both of these bear setae, i.e., **antepronotal setae** (ApS) and **upper proepisternal setae** (PeSU), and sometimes scales. The proepisternum bends around medially to cover the ventroanterior face of the thorax below the head and cervix (see plate 3A) and lobes from each side extend ventrally between the forecoxae. This anterior face of the proepisternum is sometimes covered with scales, the **lower proepisternal scales** (Pscl) (e.g., *Oc. hexodontus*, fig. 310). The last prothoracic sclerite, the postpronotum, is found posterior to the antepronotum and lateral to the scutum at the level of the scutal fossa. It bears scales that sometimes have a distinctive pattern; and a number of setae (PpS), usually confined to the posterior margin, but sometimes scattered over the posterior 0.5 (e.g., *Oc. impiger*, fig. 298).

The mesothoracic pleuron has five large and important sclerites. Just posterior to the postpronotum is an opening in the thorax, the **mesothoracic spiracle** (MS). It is surrounded by a large sclerite, the **anterior mesanepisternum** (Amas), and divided into four areas: (1) The **prespiracular area** (PsA), a small triangle dorsoanterior to the spiracle. It adjoins the posterior border of the postpronotum, and sometimes bears setae, the **prespiracular setae** (PsS) (e.g., genus *Culiseta*, fig. 18). (2) The **postspiracular area** (PA), a rather large space posterior to the spiracle with or without setae and scales; when present these are the **postspiracular setae** (PS) (e.g., genus *Psorophora*, fig. 17), and **postspiracular scales** (PoSc) (e.g., *Oc. brelandi*, fig. 200). (3) The **hypostigmal area** (HyA), immediately ventral to the spiracle and at times with **hypostigmal scales** (HySc) (e.g., *Oc. pullatus*, fig. 241), or a dark integumental spot, as in *Oc. fulvus pallens* (fig. 183). (4) The **subspiracular area** (SA), a depression ventral to the hypostigmal area, adjoining the mesokatepisternum ventrally, with or without **subspiracular setae** (SaS) and **scales** (Ssc) (e.g., *Oc. varipalpus*, fig. 175).

The largest of the mesopleural sclerites, the **mesokatepisternum** (Mks) is rather pear shaped, bulging ventroanteriorly. It is united with a dorsal narrow linear area, the **posterior mesanepisternum** (Pmas), containing the prealar area (Pa) with its prealar knob (PK) that bears a group of setae, the

**prealar setae** (PaS). The mesokatepisternum has two groups of setae, the **upper** (MkSU) and **lower** (MkSL) **mesokatepisternal setae**. These are often combined into a single line of setae, the **mesokatepisternal setae** (MkS). The **mesokatepisternal scales** (MkSc) are sometimes arranged in distinct patterns, e.g., narrow lines of scales as in *Oc. papago* (fig. 64), or more frequently an extensive patch that may or may not reach the anterior angle, as in *Oc. provocans* (fig. 253). Between the forecoxa and the ventroanterior border of the mesokatepisternum there is a membrane, the **postprocoxal membrane** (PM). In some species of *Ochlerotatus*, it bears a small patch of scales, the **postprocoxal scales** (Psc) (e.g., *Oc. punctor*, fig. 268).

The rectangular sclerite just posterior to the mesokatepisternum and ventral to the wing root is the **mesepimeron** (Mam). It bears a group of setae in the dorsoposterior corner, the **upper mesepimeral setae** (MeSU). Sometimes another group, the **lower mesepimeral setae** (MeSL), usually with not more than 1–6 setae in a single row, occurs along the anteroventral border. These are often used to separate groups of species in the genus *Ochlerotatus* (e.g., *Oc. riparius*, fig. 105, vs. *Oc. stimulans*, fig. 106).

The mesepimeron may also have varying amounts of scaling. In some species of the subgenus *Melanoconion* the mesepimeron has a definite pale spot or light and dark colored integumental areas that provide species differentiation (fig. 440).

Just ventral to the mesepimeron is the fifth and smallest, mesopleural sclerite, the **mesomeron** (Msm). It is triangular and situated between the mid- and hindcoxae. The relation of the base of the mesomeron to the base of the hindcoxa is a generic character. Usually the base of the hindcoxa is distinctly ventral to the base of the mesomeron, but in the sabethine females the base of the hindcoxa is about even with the base of the mesomeron (see figs. 10, 12).

The metathoracic pleuron is much reduced (plate 4A). The largest element is the **metepisternum** (Mts), located posterior to the mesepimeron. It is strap shaped with a dorsoventral axis and surrounds the **metathoracic spiracle** (MtS), the other opening in the thorax, in its dorsal half. Ventral to the metepisternum is a small sclerite, the **metameron** (Mem), articulating with the hindcoxa posteriorly and with the ventroposterior border of the mesepimeron. Rarely it bears scales (see fig. 248). Dorsoposterior to the metepimeron is the metanotum, already discussed under the mesopostnotum.

The sternal elements of the thorax are not included in this discussion since they have not been used as identifying characters—except for one, the intersegmental membrane connecting the metepisternum with abdominal sternum I. It sometimes bears **postmetasternal scales** (MscP) (e.g., *Oc. pionips*, fig. 318).

### *Appendages of the Thorax*

**Wings**. The two functional wings (W) of adult mosquitoes are attached to the mesothorax (see plate 3C). Each is composed of a network of longitudinal thickenings called **veins**. Between the veins are stretched membranes known as **cells**. The veins are clothed with scales dorsally and ventrally. The apical and posterior margin of the wing is bordered by long, fusiform scales, the **wing fringe** (FS), which may have pale and dark sections, best exemplified in *Ps. signipennis* (fig. 497), or a coppery or silvery, apical spot (e.g., *An. earlei*, fig. 328).

The veins and cells have names as shown in plate 3C, which follows the Comstock-Needham system of nomenclature. There are six major longitudinal veins: costa (C), subcosta (Sc), radius (R), media (M), cubitus (Cu), and anal (A). If the veins are traced from base to apex, several have one or more subdivisions. For example, the radius has a basal vein R, with primary branches $R_1$ and $R_s$. The latter further divides into $R_{2+3}$ and $R_{4+5}$. The $R_{2+3}$ separates into $R_2$ and $R_3$ apically. There are several crossveins, short connectors between major veins. The humeral crossvein (h) joins the costa and subcosta, the radiomedial crossvein (r-m), the radius with the media, and the mediocubital (m-cu), the media with the cubital veins.

The cells likewise have names, per plate 3C (letters in italics). Each cell derives its name from the vein just anterior to it. An important one to know is cell $R_2$ because it is shortened in the genus *Uranotaenia* (fig. 13). In the key character its length is compared to the length of the vein $R_{2+3}$, a portion of vein $R_s$ between the branching of $R_{4+5}$ and the junction of veins $R_2$ and $R_3$. This section of the vein is called the "petiole" by some authors.

The wing scales provide many useful characters. They can be broad and numerous (e.g., *Cq.*

*perturbans*, fig. 37), triangular shaped (e.g., *Oc. grossbecki*,fig. 91), or narrow and filiform (e.g., *Cx. pipiens*, fig. 15 ). Colors are important, too. Many species have the wing scales entirely dark, or they may vary in number of pale scales, from a small patch at the base of the costa (e.g., *Oc. atropalpus*, fig. 155), to scattered pale scales on the anterior veins (e.g., *Oc. cataphylla*, fig. 236), to generally intermixed pale and dark scales (e.g., *Oc. sollicitans*, fig. 54), to alternating mostly dark- with mostly pale-scaled veins (e.g., *Oc. s. idahoensis*, fig. 221), to mostly pale scales (e.g., *Oc. dorsalis* fig. 145).

Furthermore, there are wings with unicolorous spots produced by dense clusters of scales along some veins (e.g., *An. quadrimaculatus*, fig. 328). The costa, subcosta, and radial veins in some anophelines possess spots of pale scales that are named (Wilkerson and Peyton 1990). The area of pale scales at or near the apex of the wing is called the apical spot and the subcostal spot is found where the subcostal vein joins the costal vein. Although they are called "spots" they are really patches of pale scales sometimes extending over several veins (e.g., *An. punctipennis*, fig. 332). Most mosquito wings do not bear prominent setae, but in the genus *Culiseta* (fig. 28), a row occurs ventrally near the base of the subcosta.

**Legs**. There are three pairs of legs, one attached to each thoracic segment. The leg consists of five main parts: **coxa** (CI, CII, CIII), **trochanter** (Tr), **femur** (Fe), **tibia** (Ti), and **tarsus** (Ta) (plate 2D). The tarsus is composed of five segments known as **tarsomeres**. The fifth tarsomere ($Ta_5$) bears two **unguis** (U) (claws, Cl) that, in most species, have a secondary element, the tooth. The tarsal claws are used frequently in the *Ochlerotatus* key (e.g., *Oc. excrucians*, fig. 103). They can be studied under the stereoscopic microscope best by shining the light on the stage below the specimen and viewing the claws in silhouette. Tarsomere 4 ($Ta_4$) is unusually small in the fore- and midlegs of the genus *Orthopodomyia* (fig. 34).

Scale patterns on the various segments of the legs are extensively employed as key characters. The scales on coxa I can be brown or pale (e.g., *Ae. cinereus*, fig. 275). The femora may have the basal half pale (e.g., *Oc. zoosophus*, fig. 75), or with subapical pale rings (e.g., *Ps. columbiae*, fig. 488), or with apical pale rings (= knee spots) (e.g., *Oc. implicatus*, fig. 252). The foretibia sometimes has a complete line of pale scales separate from the pale-scaled ventral half of the segment (e.g., *Cx. tarsalis*, fig. 393). The femora and tibiae of some *Psorophora* species have long, erect scales apically, giving them a shaggy appearance (fig. 499). The tarsomeres, especially on the hindleg, may have basal pale rings, which are narrow, as in *Ae. vexans* (fig. 77), or broad as in *Oc. excrucians* (fig. 45), both apical and basal pale rings, creating the effect of appearing to be very wide bands, as in *Oc. c. canadensis* (fig. 48), or with tarsomeres 4, 5 and part of 3 all pale, as in *Ps. ferox* (fig. 501). In some cases it is necessary to distinguish shades of the pale scales. For example, the pale band on the hindtarsomere 1 in *Oc. sollicitans* is yellow scaled, while in *Oc. nigromaculis*, it is white scaled (see figs. 59, 61).

## Abdomen

The abdomen is composed of ten segments, of which the first seven are quite similar in external structure. The three terminal segments are specialized for reproduction and excretion. It has become customary to refer to the abdominal segments by Roman numerals (e.g., abdominal segment III) and they are referred to in the keys by just the Roman numeral.

Each of the seven segments has a dorsal sclerite, the **tergum** (Te), and a ventral sclerite, the **sternum** (S) (see plate 4B). Laterally, they are connected by expandable, elastic tissue, the **pleural membrane** (Pme). A similar intersegmental membrane separates the terga dorsally and the sterna ventrally. These membranes permit the abdomen to expand during blood feeding and when the female becomes gravid.

Segments VIII–X are shortened and modified. In some genera, e.g., *Culex*, *Culiseta*, and *Mansonia* (fig. 19), these segments are mostly telescoped inside the terminal segments, making the apex of the abdomen appear bluntly rounded. In other genera, e.g., *Ochlerotatus* and *Psorophora*, part of these segments protrude posteriorly, giving the abdominal terminus a pointed appearance. Also in those with blunt abdomens, segment VII is almost the same width as VI, for in the pointed abdomens, VII is decidedly smaller than VI. Abdominal segment VIII usually has a larger sternum than tergum.