

## MOUTH PARTS OF MOSQUITO LARVAE AS INDICATIVE OF HABITS.

BY EVELYN G. MITCHELL, WASHINGTON, D. C.

The larvae of the Culicidae follow the usual rule that a difference in the structure of the mouth parts is correlated with a corresponding difference in their food habits. This fact first forced itself upon the writer's attention when studying the habits of the Louisiana species, while making drawings and dissections for Dr. J. W. Dupree, and was later confirmed when making dissections and drawings of larvae of additional species for Dr. Howard's forthcoming monograph of this family.

These larvae fall into two categories, viz.: 1. Insectivorous, which, like *Megarhinus* and *Psorophora*, normally prey upon small aquatic larvae; and 2. Non-insectivorous, like *Culex*, which feed on *Euglena* and other protozoa, bacteria and vegetable matter; while between these groups are two others, somewhat intermediate, viz.: the *Uranotaenia* and *Anopheles* groups. That the differences in habits are correlated with marked differences in the structure of the mouth parts will be seen by the following critical comparison of the types of these four groups:

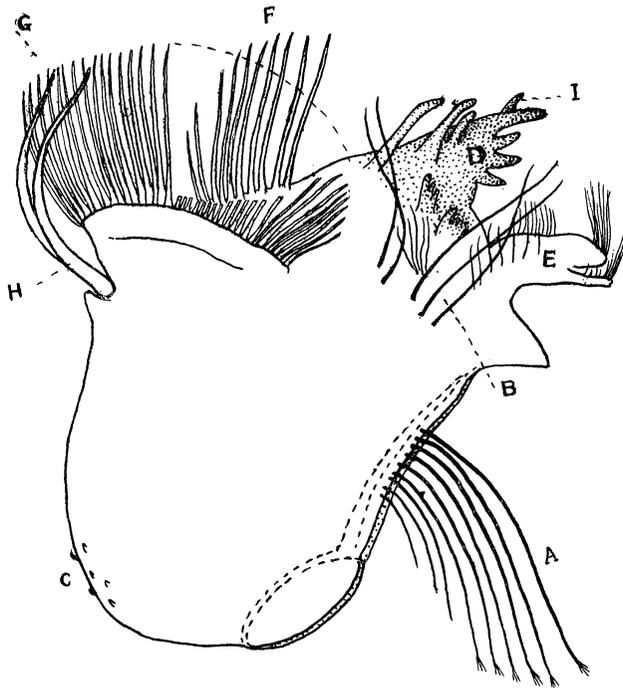


Fig 1. Mandible of *C. taeniorhynchus*.

I. NON-INSECTIVOROUS	II. URANOTAENIA.	III. ANOPHELES.	IV. INSECTIVOROUS.
<p>MOUTH BRUSHES.</p> <p>Hairs slender, very numerous, slightly pectinate or simple, projecting forward; adapted for making a current toward the mouth.</p>	<p>Same as I.</p>	<p>Same as I.</p>	<p>Stout, heavy, chitinised hairs, serrate on distal part; held at right angles to head or folded under. Adapted for seizing.</p>
<p>MANDIBLES.</p> <p>(See Fig. 1.)</p> <p><i>Biting Part.</i> (D.)</p> <p>Comprises 1-10 of whole mandible. Anterior tooth heavy, rather blunt, not sharply differentiated from the three following teeth (of which the third is largest and longest), which do not recede sharply; two teeth, usually sharp and slender, at base of primary tooth. Some short, blunt teeth on ectal side of mandible below main group and not projecting so far. Arrangement primarily for crushing.</p>	<p>Same as I, except that the anterior tooth is especially heavy and blunt, and the teeth at base of primary tooth are heavy and blunt.</p>	<p>Heavily chitinised; about 1-6 of whole bulk. Anterior tooth sharp, conspicuous, not sharply differentiated from the three smaller teeth which are placed so that their tips form a sharply receding line; two rather blunt teeth atop of the primary tooth at its base; a bunch of many short, sharp spines and small teeth below last well developed tooth. Arrangement for tearing or crushing.</p>	<p>Very heavily chitinised, forming about one-fourth of bulk. Anterior tooth (especially in <i>Psorophora</i>) very long, pointed, well separated from rest, heavy; other teeth sharp. Arrangement for tearing. Much more irregular than in the foregoing forms. Stout accessory spine on side of base of primary tooth, ectal aspect, in <i>Psorophora</i>.</p>
<p><i>Articulate serrate spine.</i> (E.)</p> <p>Sometimes deeply, sometimes bluntly serrate, narrow or broad, long or short, but never so wide as biting part, on ental side and projecting beyond biting part; four to twenty serrate-plumose, slender movable spines below it. Movement evidently like a chopper.</p>	<p>Of one very large tooth, serrate at base and differentiated from the four following sharp teeth; whole arrangement as large, though not so heavy, as the biting part. No small articulate spines.</p>	<p>A heavy, wide, flat, irregularly serrate spine; below it are two articulate, flat, narrow spines with hairs in the serrations.</p>	<p>Not present.</p>
<p><i>Lateral Comb.</i> (G.)</p> <p>Many, never very heavy, elongate, somewhat curved, triangular</p>	<p>The three uppermost spines heavy and strongly chitinised; base</p>	<p>The three uppermost spines not conspicuously heavier than the rest.</p>	<p>Long, curved, heavy, immovable spines, especially heavy and finely</p>

I.	II.	III.	IV.
plates, set with flat sides parallel on a chitinised ridge; somewhat movable in a line parallel to base; base coming in a curve from a point half way between the lateral and mesal margins to the ectal end of the cephalic (or top) margin with which it forms an acute angle.	heavy, not forming so acute an angle as in I, but, like III, at not so great an angle with base of primary tooth, nor so far forward as in IV.	Base as in II.	set in <i>Psorophora</i> , few as compared with other forms (especially in <i>Psorophora</i> ), their base forming almost a right angle with top of mandible, and pushed forward almost to base of primary tooth.
<i>Marginal Comb.</i> (v.)	None	Two fringed plates near base of biting part and four or five long fringed hairs set at a distance from these and against the upper end of the base of the lateral comb.	None.
<i>Projection below last tooth.</i> (v.)	A huge, shapless projection about one-fourth size of whole mandible, bearing on the lateral margin a row of short, hooked hairs and two bunches of slightly longer hairs on the side, joined with projection below it.	A distinct, rounded projection, having on top a small papilla with a few minute hairs. No projection below.	Projection below last teeth aborted into a few irregular projections in <i>Psorophora</i> ; joined with the next lower projection and larger in <i>Megarthinus</i> , having a projection below it in <i>Psorophora</i> .
<i>Simple articulate spines.</i> (II.)	Four large, flat, sharp spines, the outer ones about one-third longer than the inner, which are a little fringed, taper	Four large, flat, sharp spines, dilated at base; outer two smooth, rather sharply bent near base; inner two sigmoid, more	A single, heavy, sharp curved spine in <i>Psorophora</i> ; two rather slender spines with three or four plumules in <i>Megar-</i>

I.	II.	III.	IV.
	to base and are not sigmoid.	or less fringed; all of about an equal length.	<i>binus</i> .
<i>Hairs</i> between articulate simple spines and upper end of base of lateral comb, usually not present but sometimes 5-6, rarely a pair so well developed that they might almost be considered spines.	A large number of hairs about as long as the serrate pair of articulate spines.	Eight or 9 short, slender hairs.	Nine hairs.
<i>Hairs. Group A.</i> (See Fig. 1.)  4-25 hairs, some of which are generally tufted at ends, occasionally a few are slightly plumose.	Two or 3 very large flat setae, serrate; the teeth may or may not end in small hairs.	About 22 hairs, those toward base of mandible split into 3 or 4 shreds at end.	About 25 long hairs in <i>Megarhinus</i> ; 8-10 short hairs in <i>Psorophora</i> .
<i>Group B.</i> (See Fig. 1.)  Two to 10 heavy hairs, occasionally split, in a scattered line between <i>A</i> group and lower end of base of lateral comb.	Eight to 16 graded hairs, somewhat split at tips, closely set in a group contiguous to <i>A</i> .	Four to five slender, short hairs well above <i>A</i> , near lower end of base of lateral comb.	Wanting.
<i>Group C.</i> (See Fig. 1.)  Two to 12 small spines (except in <i>Deinocerites</i> , which see in summary) on the lower part of the lateral aspect.	Two to 5 small spines.	Two slim, fringed hairs on papillae with 8-9 broad, plumose, long hairs in a transverse row below.	Very few, minute, broad spines.
<i>Maxilla.</i> (Fig. 2)  Cone-shaped, more or less flattened, always proportionately narrower than in <i>Uranotenia</i> (II).	A sort of flattened, irregular cone.	A parallelogram (approximately about 2 x 1).	Trapezoid, the cephalic aspect the longest in <i>Psorophora</i> ; nearly square with a deep emargination in middle

I.	II.	III.	IV.
<p><i>Palpus.</i></p> <p>Not large, distinct, cylindrical, somewhat constricted about middle, top rounded irregularly, 4-5 short, blunt spines, reaches <math>\frac{1}{4}</math>-<math>\frac{1}{2}</math> to top.</p>	<p>Not large, distinct, cylindrical, top flat, with 4 very large and 2 small, blunt spines (2 of the large spines sharp, 2 blunt; does not reach over <math>\frac{1}{3}</math> to top of cone.</p>	<p>Top about even with top of maxilla, very slightly rounded, with 4 large spines and 2 or 3 flat, sub-triangular plates articulated by the apex of the triangle; with a deep sinus between its upper part and the body of the maxilla; the lower part rounded and projecting below base of body of maxilla; upper part a truncate cone. A large, tree-like hair from a papilla on lateral aspect.</p>	<p>of cephalic edge in <i>Megarhinus</i>.</p> <p>Projects above body of maxilla; bluntly rounded at apex in <i>Megarhinus</i>; truncate in <i>Psorophora</i>; with four stubby spines; springing direct from top of maxilla in <i>Psorophora</i>, from the base in <i>Megarhinus</i>, being much larger therefore in the latter; cylindrical.</p>
<p><i>Strip of chitin.</i></p> <p>Narrow, very heavy, from top of cone to base, slightly curving from palpus as it approaches base and continuing into the heavy rim of chitin at base.</p>	<p>About the same as in I.</p>	<p>None.</p>	<p>None.</p>
<p><i>Spines.</i></p> <p>Two, stout, more or less blunt, from papillae next to above chitinous strip on same side as palpus and about on a level with its top; their points usually reaching across strip of chitin.</p>	<p>Present, very large, slightly removed from strip.</p>	<p>Very short, on the farther side from palpus of an imaginary line parallel to palpus and dividing body of maxilla in half, and on the upper half of the side.</p>	<p>In <i>Megarhinus</i> the spines are near top on the side of the emargination nearest the palpus; in <i>Psorophora</i> they are near the top on the third of the body of the maxilla farthest from the palpus.</p>

I.	II.	III.	IV.
<p><i>Tuft A.</i> (See Fig. 2.)</p> <p>A large tuft of long or short movable hairs at apex, often a line extending down the chitinous strip toward the double spines.</p>	<p>Of immense, flat setae serrate on one side.</p>	<p>A row of papillae, bearing several short hairs each, extending along top of body of maxilla from end nearest palpus about half way; a row of erect, hooked hairs for about the same distance, continued into a thick mass of hairs curling down across the top; a bunch of short spines at end farthest from palpus.</p>	<p>In <i>Psorophora</i> a row of short, flat, triangular spines along the apex from base of pulpus, curling over and continued in a patch half down the side on the half away from the pulpus, at the third farthest from the pulpus these spines are very large, hooked and in 3 rows. In <i>Megarhinus</i> a large patch of straight, short spines and one long, slender spine on side of emargination nearest pulpus; a double row of large, hooked spines on farthest elevation, continued into a graded row of straight spines <math>\frac{1}{3}</math> down mesal margin, and 1 hair-like spine.</p>
<p><i>Long patch of short hairs.</i></p> <p>Some slender, some spine-like or thickened and split, on side of chitin strip farthest from pulpus. Usually a few hairs on side next pulpus.</p>	<p>Same, but the hairs not thickened but closely set.</p>	<p>Many short, curved hairs in groups on upper <math>\frac{1}{3}</math> next pulpus, set thickly on upper middle <math>\frac{1}{3}</math> and upper and lower <math>\frac{1}{3}</math> farthest from pulpus.</p>	<p>Wanting.</p>
<p><i>Labial Plate.</i></p> <p>Nine to 33 teeth; in general tending to 15-23 rather fine, evenly graded teeth except in the long breathing tubed species where the teeth show a tendency to irregularity difficult to describe but easy to see.</p>	<p>Coarse, bluntly rounded teeth, 11 in number. General shape of plate ellipsoidal, a regular outline.</p>	<p>Coarse, much separated, rather sharp, irregular teeth, 9. Not a regular curve.</p>	<p>Teeth tend to coarseness and to have center and end teeth largest in <i>Psorophora</i>.</p>

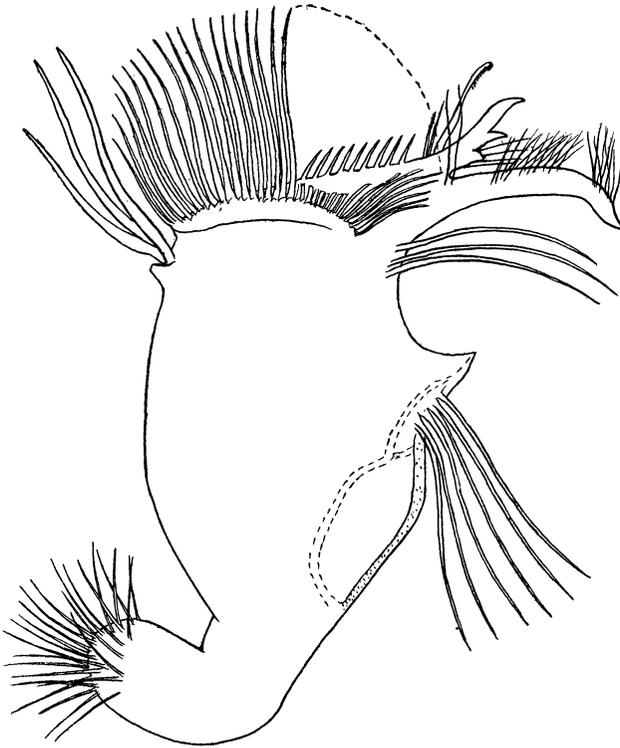


Fig. 2. Maxilla of *C. salinarius*.

As the above comparative scheme shows, in insectivorous forms the principal appendages of the mandibles and maxillae are sharp, heavy and fitted for tearing; or stiff, spiny, immovable, and adapted for holding the struggling prey. The corresponding appendages in the non-insectivorous forms, whose food is microscopic, are more blunt and better adapted for crushing; or are slender, more or less movable, and fitted (as the *A* tuft of the maxilla) for aiding the mouth brushes to draw food into the mouth; or (as the smaller hairs of the maxilla) for a sieve. The plates of the lateral comb on the mandible are movable in the plane of the base, and, so the writer thinks, help to direct food toward the crushing portion, the other comb acting as a sieve and the remaining appendages being sieves or tactile organs.

*Anopheles* and *Uranotaenia* seem to exactly correspond with neither of the foregoing groups. *Psorophora* we know will prey on larvae of other species and even turn cannibal if hard pressed. *Megarhinus* will do the same. *Psorophora*,

however, can exist, temporarily if necessary, on a diet of *Euglena*, though it does not thrive on this, as Dr. Dupree proved when the writer was with him. *Anopheles* will bite each other viciously, tearing off the hairs so frequently that perfect specimens of the larvae are to be obtained only by isolation; will devour skins, occasionally kill other larvae and always eat any which die. *Uranotaenia* is supposed to have the same habits as *Anopheles*, save that, whereas *Anopheles* skims the surface, *Uranotaenia* feeds just below. From the shape of the mouth parts, however, the writer would judge the latter to be distinctive in its method, a vegetarian and also feeding on minute crustacea and the like.

In the non-insectivorous groups are two distinct types of mandible and maxilla. The facts on hand suggest that these are associated with two types of breathing tubes and antennae, as well as with different habits of feeding. The author hopes to make further observations when opportunity offers, not having hitherto paid special attention to this point.

The group with long breathing tubes (*M. atratus*, *C. pipiens*, *C. territans*, *C. restuans*, *C. salinarius*), feed with the tubes almost continually at the surface, sailing about by the movement of their mouth-brushes, and leaving the surface only when disturbed. Their food evidently floats freely, and is drawn in by the currents set up by the brushes. In these forms the antennae have very large and plumose tufts; the marginal comb on the mandible is reduced to papillae bearing a few hairs and moved over the top somewhat onto the opposite side from the lateral comb. The maxillae are of a pointed, sub-conical form, with the terminal hairs freely movable and very long, many of them as long as, or longer than, the body of the maxilla, with several long-plumose hairs in the tuft, which is mostly composed of single hairs. The plumose hairs are probably sensory, while the function of the simple hairs is probably only to brush in food.

*C. discolor* forms an apparent exception, having this type of maxilla and mandible, but when one considers that, although he feeds at the bottom, he lies on his back most of the time, and feeds on floating matter, his not feeding near the surface makes no great difference.

*C. jamaicensis*, *F. musica*, and *F. varpes* also belong to this type, though the latter two can stay at the bottom a long time if disturbed.

The bottom feeders, as far as known, have straight, stubby antennae, generally bare of spines, with one hair or a very few simple hairs in the tuft. The mandible has the marginal comb well developed, the maxilla is a flattened cone, the terminal tuft of stiff, straight hairs, which are rather short, is evidently for use in brushing over the debris at the bottom, where the very long, slender hairs would be a disadvantage. *C. dupreei*, with its very short antennae, and its bottom feeding habits, is a very good example. *C. triseiatus* lives in hollow trees, and

feeds at the bottom of the hollow; the antennae, mandible and maxilla are all typical of this habit. To have such a type of mouth parts the larvae need not necessarily be bottom feeders; they may brush over the sides of a tank or floating or half-submerged objects, grasses, spirogyra, etc. There are maxillae which seem transitional, though there are only the two types of mandibles; and there are in some maxillae peculiar developments of the lateral hairs, which are probably related to some peculiar habit of feeding, or character of food.

Among the non-insectivorous larvae is one, *Deinocerites cancer*, that so distinctly and strikingly, in several respects, departs from the ordinary type of larvae as, so the writer believes, to justify its being placed in a new sub-family, DEINOCERITINAE. The head is sub-circular and is characterized by an angular projection of the chitin caudad of the base of each antenna. This lateral angle forms a groove, running on the ventral side of the head, in which groove the basal portion of the lateral aspect of the mandible moves in and out, so as to be visible from above, a thing which, so far as the writer knows, exists in no other culicid larva. The anal gills are entirely absent.

The maxilla affords no striking departure from the type, it being in general that of a larva feeding on floating objects.

The labial plate is different from others in that the teeth, instead of being broad at the base and coming gradually to a distinctly narrow point (with but few exceptions), are but little narrowed until they abruptly point off, are very long for their width and, especially, are all separated from each other by a space of more than their width, while the two basal are very much longer than any but the central (which is about twice the length of the rest), and are set caudad from the base of the next by about their own length.

The mandible is like no other (see fig. 3). The biting part is three, weak teeth, not heavily chitinised (the whole larva is almost transparent), set in a decidedly receding row. Normally, the non-insectivorous larvae have four teeth, not receding very much. The projection just below the teeth, instead of being about twice as long as wide, and having an "under jaw," is fully six times as long as wide, the tip pointed and bent down for about one-fourth the length. The marginal comb is nine short, sharp, stright spines. The chopper-like part is a sort of narrow hook, finely serrate at the distal end. There is a third articulate spine, shorter than the others, between the usual two, an odd number in this place being very unusual. But the distinguishing feature is the caudal portion of the lateral aspect. In other mandibles, so far as the writer can ascertain, this part forms an even, continuous curve with the rest of the mandible body and bears a very few minute spines, or (as in *Anopheles*), a row of fringed hairs. In *D. cancer* this portion of the mandible is produced, and in shape is like the thumb held on a plane with the hand and flexed at the second joint. The part flexed in the man-

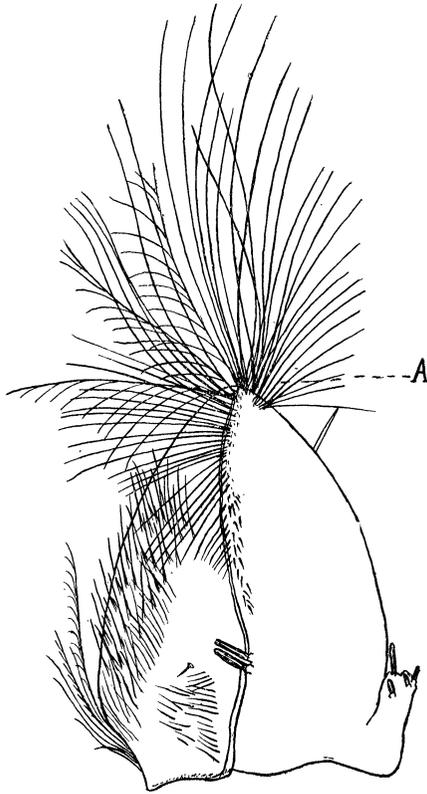


Fig. 3. Mandible of *Deinocerites cancer*.

dible seems to be rather soft as, although no suture can be seen, the projection is capable of a slight flexion and extension. The projection works in the trough formed by the angle of the head. Instead of the usual minute spines at this point there are about twenty-five long, slender spines placed in a group with their bases well separated. They are apparently somewhat movable. The function is difficult to imagine.

The adult is distinguished from all others by the unusually long antennae in both sexes; according to Mr. Coquillett, the second antennal joint is over fourteen times as long as wide, whereas in other forms of culicidae it is less than eight times as long as wide.

It will be noted in the forgoing comparative study that *Psorophora* falls into the same category with *Megarhinus*, to which it is much more nearly related both in anatomy and habits than to *Culex*, in the same sub-family with which it is at

present classed. The larva, however, differs from *Megarhinus* in several important respects, not only in mouth parts but also in regard to external characters. In *Megarhinus* the antennae are situated far forward, and the eyes are near the middle of the side of the head; in *Psorophora* the antennae are near the middle of the side of the head, and the eyes are near the caudal angle. On the thorax of *Megarhinus* are a number of stiff, coarse spines with spinules; no such spines occur in *Psorophora*. In *Megarhinus* the hairs of the abdomen are on large, heavily chitinised papillae, which is not the case in *Psorophora*. *Megarhinus* has the comb of the eighth segment represented by a chitinised plate from which spring two bristles and three minute tufts; the comb is present in *Psorophora*. The hairs of the ninth segment brush in *Megarhinus* are branched, not in tufts; in *Psorophora* they are simple and in tufts. The breathing tube in *Megarhinus* is without a pecten; *Psorophora* has a large pecten.

The adult *Megarhinus* has a strongly decurved proboscis, while in *Psorophora* it is straight. The depressed scales of the head and body in *Megarhinus* are much wider than in *Psorophora*; moreover, in *Megarhinus* the scales of the legs are never erect as in *Psorophora*. Therefore *Psorophora* can neither be placed in the same sub-family with *Megarhinus* nor with *Culex*, but should constitute a distinct sub-family, *Psorophorinae*.



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