PSYCHE.

ANATOMY OF THE MOUTH-PARTS AND OF THE SUCTORIAL APPARATUS OF *CULEX*.*

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(*With Plate I.*)

FROM early times the mosquitoes, *Culex* of different species, have attracted the attention of mankind, and many attempts have been made to settle various points of their anatomy and life-history. Of their anatomy nothing is, perhaps, of more interest than a study of their proboscis. While the importance of the mouth-parts in the classification of insects remained undiscovered until Fabricius, in the last century, made them a basis for dividing the insects into classes and genera, considering that they furnished "sufficient and constant characters, and far more natural genera;"[1] and their homological significance remained a mystery until Savigny,[2] in 1816, showed that the mouth-parts of all insects were reducible to the same general plan as those of chewing insects, and that these mouth-parts were the serial homologs of locomotory appendages; yet, previous to the before-mentioned dates, a number of anatomists, attracted, probably, as much by the minuteness of the objects and the difficulty of the work as by the popular interest which the mosquito excites, sought to complete our knowledge of the number, position and use of the mouth-parts of this insect. The earliest of these anatomists whose work is worthy of note is Swammerdamm, who studied *Culex* in 1668.[3] The difficulty of the work which Swammerdamm undertook, with the crude apparatus at that time at his command, can be easily comprehended when we consider that the proboscis of the female of most species of *Culex* has about the diameter of a hair from the human head, that is, a diameter of about one tenth of a millimetre; that it is composed (*see* pl. 1, fig. 8) for the most part of the sheath, within which are six so-called setae, later to be more fully described; and that these setae are of transparent chitin, one of them being so transparent and delicate that it has of-

* Extract, with additions and changes, from "The anatomy of the mouth-parts and of the sucking apparatus of some diptera. Dissertation for the purpose of obtaining the philosophical doctorate at the Leipzig University, by George Dimmock, of Cambridge, Mass., U. S. A. Boston, A. Williams & Co., 1881." t.-p. cover, t.-p., 50 [+10] p., 4 pl., 24.5×19, t 12.5×17.

1 Fabricius, J. C. Systema entomologiae, ... 1775. Preface.

2 Savigny, J. C. Mémoires sur les animaux sans vertèbres. I. partie, I. fascicule. Mém. I.-II. ... 1816.

3 Swammerdamm, J. Bybel der natuure ... 1737-1738. [I have used the German editionof 1752.]

ten been overlooked by later naturalists. Swammerdamm determined correctly the number of setae in the proboscis of the female, but he, erroneously, evidently supposed that the proboscis of the male had the same number of setae as that of the female. He erroneously thought the setae to be capable of protrusion from the end of the sheath, without flexion of the latter, and that the largest of the five setae formed an inner sheath for the other four. He writes (p. 147) in quaint old style, "I consider that these five setae serve, like so many sharp little awls, to make the opening in the sweat-pores of the skin. When this is done they are drawn back again into the inner sheath. This then enters (according to my idea) into the wound with its sharp cavity, and the mosquito sucks through it the blood, which ascends alongside of and between the little setae into the belly of the mosquito."

Leeuwenhoek, according to Réaumur, found only four setae in the sheath of the proboscis, and considered that the inner sheath, described by Swammerdamm, was a channel, and not a closed tube. Barth,[4] whose dissertation I have lately examined, thought the inner sheath was a closed tube. Réaumur,[5] in 1738, published a long description of the mouth-parts of *Culex*, and described with great accuracy its mode of biting. Réaumur found only five of the six setae which the proboscis contains. He favored the idea that the inner sheath, which Swammerdamm had described, was not cylindrical, but only a channel open on one side. Réaumur also arrived at the idea that the maxillary palpi of *Culex* could, in some cases, help to form the sheath which encloses the setae, but he does not clearly say that they always do so in the males.

Since Réaumur's time but little has been added to our knowledge of the mouth-parts of *Culex*, some writers following the statements of Swammerdamm, others those of Réaumur, or of Leeuwenhoek, in regard to the number of setae. Among others I will cite Sulzer,[6] who says, "four to five pointed tubules;" Fabricius,[1] who writes, "sheath exserted, univalvular, flexible, with five setae;" Jördens[7] describes four setae; Gravenhorst,[8] "The proboscis long, setiform, five-parted;" Meigen[9] describes four setae and figures five; Gerstfeldt,[10] "The sheath is formed of the under lip alone, and contains six setae;" Packard,[11] "These six bristle-like organs are folded together within the hollowed labium;" Claus[12] writes, proboscis "extended with four setae;" Muhr[13] figures six setae.

4 Barth, J. M. Dissertation de culice ... 1737.

5 Réaumur, R. A. F. Mémoires pour servir a l'histoire des insectes. ... [Edition 1737–1748, t. 4, part 2.]

6 Sulzer, J. H. Die Kennzeichen der Insekten... 1761.

7 Jördens, J. H. Entomologie und Helminthologie des menschlichen Körpers ... 1801.

8 Gravenhorst, J. L. C. Grundzüge der systematischen Naturgeschichte ... 1817.

9 Meigen, J. W. Systematische Beschreibung der bekannten europäischen zweiflügeligen Insekten ... 1818–1838.

10 Gerstfeldt, G. Ueber die Mundtheile der saugenden Insecten ... 1853.

11 Packard, A. S., Jr. Guide to the study of insects, ... 1869.

12 Claus, C. Grundzüge der Zoologie ... 1876.

13 Muhr, J. Die Mundtheile der Insekten dargestellt auf 5 Wandtafeln ... 1878.

The unsettled state of our knowledge of the anatomy of the mouth-parts of *Culex*, as can be seen by the preceding notes, led me to select this genus of diptera for careful study, with the results noted in the following pages.

IN THE FEMALE.

The mouth-parts which form the proboscis of the female *Culex*, as I have found them by study of *C. rufus*, *C. ciliatus* and *C. pipiens*, consist of a labrum (pl. 1, fig. 1, *lr*), an epipharynx (*e*), a hypopharynx (*h*), two mandibles (*m*), and two maxillae (*mx*), all sheathed, when in repose, in the labium (*l*), which receives them into a groove on its upper side. Each maxilla has a maxillary palpus (*mp*), which lies outside the labium; the latter has no palpi. The labium and maxillary palpi are covered with hair and scales; the other mouth-parts are naked, light brown, setiform and transparent; they all originate at the anterior basal portion of the head, and are, with the exception of the maxillary palpi, of about equal length, that is, about three to four times the length of the head. The maxillary palpi, in the females of *Culex* proper, are about the length of the head. The scaleless mouth-parts are not jointed, and are the ones which penetrate the skin in biting. The labrum and epipharynx are united in their whole length, forming a piece which is shown in section in fig. 6, *d*. The other mouth-parts are free to the base. A pumping organ, trianguloid in cross-section (fig. 10, *b*), is formed by a dilation of the oesophagus behind the oesophageal nerve-ring. Each of the above-mentioned parts will be described more in detail later. In comparative size and strength the mouth-parts would be arranged as follows, the largest and stoutest first: labium, labrum-epipharynx (the name by which I designate this compound piece in diptera), hypopharynx, maxillae and mandibles.

The general arrangement of the mouth-parts, relative to each other, is shown best in fig. 8, which is a figure of a cross-section through the middle of the proboscis of a female *Culex rufus*, while in repose, with the setae sheathed in the labium. The labium (*l*), clothed on the outer side with its scales and hairs, is wrapped nearly around the other mouth-parts. In it lie the two maxillae (*mx*), partly enclosing the parts above them, and thus helping to bind the parts together; above the maxillae are the two mandibles (*m*), and immediately above the mandibles, in the median line, is the hypopharynx (*h*), with a thickened middle portion. Resting on the hypopharynx is the labrum-epipharynx; the epipharynx (*e*), is omega-form in section, and above it, delicately attached, is the labrum (*lr*). The changes in relative position which the mouth-parts of *Culex* undergo as they approach the head can be best described in the subsequent description, in detail, of each separate part.

The labrum-epipharynx (figs. 1, 5, 6, 7-8; *lr* and *e*) of *Culex* consists of the thin labrum resting upon and fastened to the epipharynx; it tapers gradually from base to apex. The epipharynx is omega-form in cross-section, being a channel

rather than a tube, a tube being formed by the pressing of the hypopharynx upon its under side. The tube thus formed is the channel through which the blood, which *Culex* sucks, passes into the pharynx. At its base or proximal end the epipharynx is supported and moved by strong muscles having their insertions on the upper side of its wings or lateral portions, and upon the upper side of its tube. These muscles extend upward and posteriorly, and have their origin on the inner surface of the clypeus. (See figs. 9 and 11.) These muscles (*pm*), by their contraction, elevate, and perhaps slightly retract, the epipharynx and the labrum to which they are attached. These muscles probably *aid* in suction for when the setae are all stuck firmly in the skin, the contraction of these muscles would only serve to raise the base of the epipharynx from that of the hypopharynx; this action would tend to produce a vacuum between the two (see fig. 9), and thus cause the blood to be drawn up in the tube of the epipharynx. The probability that these muscles aid in suction is augmented by the fact, the explanation of which I have more fully developed in the part of my dissertation devoted to a comparison of the mouth-parts and suctorial apparatus in the different families of diptera upon which I have worked, that the corresponding muscles are devoted to suction in other flies, which cannot raise their epipharynx from their other mouth-parts so freely as is seen in fig. 1, and further, that in the male *Culex*, which does not possess — as does the female — a pumping apparatus behind the oesophageal nerve-ring, these muscles are the ones that must serve for suction. The section represented in fig. 9 was taken near the base of the clypeus; a few sections further on, posteriorly, the channel for the passage of food turns upward and then backward again, passing in its course a place (fig. 11, *v*) where its walls approximate dorsally and ventrally. This narrowing of the walls is probably a valve to prevent the return of fluids to the mouth during the pumping process. The pharynx with its surrounding muscles in *Culex* is the equivalent of what has been termed the fulcrum in *Musca*. Macloskie[14] writes of the fulcrum, "It seems to be general in diptera; even the mosquito possesses it," but he does not further describe it, in other diptera than *Musca*.

The tip of the labrum-epipharynx seems to turn upward (fig. 1, *lr-e*), although the opening is upon the ventral surface, as may be seen in fig. 6, *b*, which represents the ventral view of the tip of this part. The tip of the labrum-epipharynx is comparable to a quill-pen with three tips near each other, the middle one of these three tips being slightly shorter than the other two. The two lateral portions of the epipharynx, as seen in section, when they near the tip, lay themselves closely upon the sides of the tubular portion, passing upward upon it, as seen in fig. 5, *lr-e;* they thus serve to strengthen the two outer points of the

14 Macloskie, G: The proboscis of the house-fly. (Amer. naturalist, March 1880, v. 14, p. 153–161, fig. 1–3.)

tip of the epipharynx, while the labrum continues to a sharp point at the tip, and, united with the upper surface of the epipharynx tube, forms the middle point of the tip. The channel, or slit, along the under side of the epipharynx, widens toward the tip (fig. 6, *b*), leaving thus an opening for the passage of fluids into the tube of the epipharynx.

The labrum itself is a thin lanceolate lamella of chitin, concave along the under side from the basal portion to the tip, and its concavity rests upon and fits to the convexity of the tubular part of the epipharynx, to which it is so lightly attached that they readily separate by application of caustic potash. The outer edges of the labrum roll slightly inward toward the epipharynx along most of its length. (See fig. 6, *d*.) At its base the labrum sends a chitinous support beneath the clypeus, where it separates more from the epipharynx and has its own muscles, indicating that the labrum has a degree of motion independent of the epipharynx, a motion allowed, perhaps, by the elasticity of the connection between the labrum and epipharynx. The muscles of the labrum (fig. 9, *pm*) are inserted upon the upper side of its base and have their origin on the inner surface of the roof of the clypeus. These muscles are, at least in the females of *Culex rufus*, divided into three portions in their upper part, as shown in fig. 9.

The hypopharynx of the female of *Culex* is a linear, lanceolate, transparent lamella of chitin, with a longitudinal rod through the middle, the nature of which will be discussed later. At its base the hypopharynx forms the continuation of the under wall of the pharynx. (See fig. 11, *h*.) The hypopharynx is closely pressed upon the under side of the epipharynx, completing the tube nearly formed by the epipharynx. No muscles have their insertion on the base of the hypopharynx. Its tip is simply lanceolate (fig. 5, *h*). In *Culex pipiens* and *C. rufus* nothing further is visible (with a magnifying power of five hundred diameters), in sections of the thicker middle portion of the hypopharynx, than a simple rod of chitin; but, in *C. ciliatus*, a North American species of which the mouth-parts are larger, this rod appeared to be tubular. Is it a rod or is it a tube? Menzbier[15] writes (p. 25) that in diptera "neither the labrum nor the hypopharynx possesses a completed tube, but only a channel" which leads into the salivary duct. That Menzbier is incorrect in affirming that the hypopharynx has no complete tube I have clearly proved in my observations on *Bombylius* and *Eristalis;* but the question still remains unsettled whether *Culex* has any passage, either tube or groove, through the hypopharynx. Réaumur[5] (tome 4, part 2, p. 396) discusses the probability of a poisonous fluid being secreted by *Culex*, to cause the blood to flow more readily when it bites, and since his time writers have, on the one hand, accepted this statement, without proving the presence of such a fluid or of the glands to secrete it, or they have, on the other hand, denied the existence of such a

15 Menzbier, M. A. Ueber das Kopfskelet und die Mundwerkzeuge der Zweiflügler. (Bull. Soc. impér. natur. de Moscou, 1880, t. 55, no. 1, p. 8–71, tab. 2–3.)

fluid, and affirmed, as Leeuwenhoek did, that the swelling subsequent to the bite of *Culex* was due to the irritation produced by the tearing of the mouth-parts in the skin, without the aid of a poisonous secretion. After having experimented a large number of times with the living mosquito, I am convinced that there is use made of a poisonous saliva; for, when biting, if the mosquito fails to strike blood, which it often does on parts of the back of my hand, it may have inserted its proboscis (labium of course excepted) nearly full length, in from one to six directions, in the same place, and withdrawn its proboscis; indeed it may have inserted its proboscis, as often occurs, in extremely sensitive parts; yet in such cases, if no blood be drawn, no more effect is produced upon my skin than is produced by the prick of a sharp needle; a red point appears only to disappear in a few hours. Certainly there has been as much tearing of tissues in such a case as the above-mentioned, as there is when *Culex* settles on a place richer in blood, and, with a single probing, draws its fill. When the insect is allowed to draw its fill on the back of my hand, the subsequent swelling lasts from forty to forty-eight hours, and the amount of poisonous effect upon me, as proved by numerous experiments, is in direct proportion to the length of time which the *Culex* has occupied in actually drawing blood. The above-mentioned facts would indicate a constant outpouring of some sort of poisonous fluid during the blood-sucking process, and would necessitate a tube or channel for its conduction. Now no other channel exists through which saliva could pass from the base to the tip in the mouth-parts which *Culex* inserts in the skin, and this, together with the position occupied by the salivary duct in other diptera, leads me to believe, without as yet being able to give anatomical proof for it, that the hypopharynx of *Culex* contains a duct that pours out its poisonous saliva. Having no fresh specimens of *Culex ciliatus*, and the extreme minuteness of the hypopharynx in the species of *Culex* available, has precluded my determination of the actual presence of glands in connection with this mouth-part.

The mandibles (figs. 1 and 8, *m*), the most delicate of the mouth-parts of *Culex*, are two very thin linear-lanceolate lamellae of transparent chitin, which rest with their inner edges beneath each half of the hypopharynx, their outer edges projecting beyond its outer edge, on each side. At the base of the proboscis they appear to have no muscular attachments. They are slightly tapering from the base to the tip, but are of equal thickness throughout their breadth; at the tip they have a slight thickening, in form of a letter V, with its opening turned toward their very delicate, almost invisible tip. (See fig. 5, *m*.)

The maxillae (mistaken by Gerstfeldt[10] for the mandibles, but correctly figured by Muhr[18] on his diagram as maxillae) are tapering lamellae of chitin, apparently serrate at the tips. Each maxilla is thicker near the inner edge, the thickening being formed by a solid chitinous shaft, which is fixed longitudinally upon the upper side. (See fig. 5 and 8, *mx*.) The bases of the maxillae join the stouter

maxillary palpi just before passing under the clypeus, and immediately afterwards they join the labium, and become imbedded, with the mandibles, in connective tissue. (See fig. 9, *mx*.) Their continuations in the head are two delicate chitin-supports, each of which ends in a strong muscle; this muscle, the retractor maxillae (fig. 10, *rm*), passes backward and downward through the head, beneath the infraoesophageal ganglion, and has its origin in the posterior basal part of the head. The maxillae probably have no protractor muscle, their forward motion being due to the elasticity of the chitin frame-work of the head. The shaft of the maxillae is very transparent, except near the inner side where the chitin-rod runs; here it is brownish and more opaque. Out from the above-mentioned chitin-rod extends a very delicate feathering, or corrugation, of chitin to the edge of the most transparent portion of each maxilla, as seen upon the basal portion of fig. 5, *mx*. The tip of the maxillae (fig. 5, *mx*) is very acute, has none of the before-mentioned chitinous corrugations, but, in their place, near the outer edge, is a row of papillae, which have their tips slightly recurved toward the head, and consequently appear serrate. These papillae are upon the upper surface of the maxillae, as can be readily seen, by preparing the mouth-parts by lateral pressure, as in fig. 1.

The maxillary palpi (figs. 1, 2, and 9, *mp*) are four-jointed in some species of *Culex*, five-jointed in others. At first sight they appear to be three-jointed, but more careful examination serves to show that the apparent basal joint is made up of two joints, and oftentimes to reveal a very short, knob-like joint at the extremity of what appears to be, at first, the apical joint. At their base the maxillary palpi join the maxillae just before the latter pass beneath the clypeus, and, with the maxillae, join the other mouth-parts, as shown, in section, by fig. 9.

The function of the maxillae is, probably, to draw the other mouth-parts into the skin, when *Culex* bites, for if one watches the maxillary palpi of *Culex*, while the setae are entering the skin, the setae seem to pierce the skin, and enter it with a slow gliding motion, as if drawn from below, instead of pressed from above; meanwhile, if one observes carefully, with a lens, the maxillary palpi can be seen to be in an alternating motion, as if the maxillae to which they are attached, pressed, first one then the other, into the skin, and then pulled the other parts after them. The muscles, retractores maxillarum, already described, lend weight to this view of the functions of the barbed maxillae.

The labium (figs. 1, 2, and 3, *l*), the largest of the mouth-parts of *Culex*, and the only one of them, helping form the proboscis, which contains muscles, forms a sheath opening along the upper side, and receiving in its channel the other mouth-parts (excepting the maxillary palpi), as seen in cross-section in fig. 8; it tapers from base to tip, is flexible, has a delicately annulated structure, and is clothed with hair and scales. At its base it unites with the maxillae, mandibles, and hypopharynx, and con-

tinues into the under surface of the head. Throughout its length it contains, on each side, muscles, which have their origin in the base of the head and serve to control the motions of the labium. (See figs. 8 and 9, *ml.*) At the sides of the tip of the labium are attached two lobiform appendages, the labellae, which are seen at *lb* in fig. 3 with the true tip of the labium proper between them. These terminal lobes are jointed to the labium, a little distance behind its tip, as can be seen in fig. 7, which is a cross-section of the labium a trifle anterior to the actual centre of motion of these joints. The section of that portion of the labium which extends forward to form its tip is seen in the middle of the figure, just below the section of the maxillae (*mx*). Outside the section of each lobe is seen the section of a portion of the exterior edge of the labium itself, which here forms a double socket, or pair of acetabula, into which the heads of the two labellae are set. Each of the lobes of the labium, — the labellae, — is provided with an extensor and flexor muscle (fig. 7, *me*, and *mf*), and is attached to the labium by a true joint.

The labium has for function, for the most part, the protection of the fine setae which form the true piercing organ of *Culex*. In the females of *Culex* proper, the protective sheath is formed by the labium alone. When the mosquito has found a place which suits its taste for piercing, it plants its labellae firmly upon the spot, and a moment later the labium flexes backward in its middle, the setae, firmly grouped together, remain straight and enter the skin, while the two labellae guide them, much as a carpenter guides his bit with his fingers, while boring a piece of plank. When the setae of *Culex* have entered the skin to nearly their full length the labium is bent double beneath the body of the insect, the labellae still holding the base of the setae at the point where they enter the skin. When the mosquito wishes to withdraw the setae it probably first withdraws the two barbed maxillae beyond the other setae, that is, so that their barbs, or papillae, will be kept out of action by the mandibles and hypopharynx; then it readily withdraws the setae, perhaps aiding their withdrawal by the muscles of the labium, for, during the process of extracting the setae from the skin, while they are slowly sinking back into the groove upon the upper side of the straightening labium, the mosquito keeps the labellae pressed firmly upon the skin.

The mouth-parts of *Culex*, as above described, are suspended under a clypeus, or epistom, which is figured from the side in fig. 1, *c*, from above in fig. 2, *c;* in length-section in fig. 11, *c;* and in cross-section in fig. 9, *c*. This clypeus is the hood-shaped forward continuation of the lower part of a ⅄-shaped piece of chitin which forms the framework of what may be termed the "face" of *Culex;* right and left of the upper portion of this framework pass out the antennal nerves, the antennae being supported by the framework itself.

The pharynx (fig. 11, *p*), the tubular continuation of the epipharynx above and the hypopharynx below, as it passes backward, beneath the centre of the ⅄-

shaped framework, turns somewhat upward, is narrowed to the valve previously described, then widens slightly again, and, as oesophagus (fig. 11, *oe*) passes through the oesophageal nerve-ring, in which it is supported by three delicate chitinous rods, which lie, one longitudinally on its ventral surface, and two to the right and left on its dorsal surface. Just posterior to the oesophageal nerve-ring, directly above the nerve-commissure which connects the infraoesophageal ganglion with the first thoracic ganglion, the oesophagus suddenly expands into an oesophageal pump, or bulb, the longitudinal section of which is shown in fig. 11, *b;* the cross-section in fig. 10, *b*. This bulb, which is the chief sucking organ in the female *Culex*, and which I have found in no other dipteron, is supported by three longitudinal chitinous rods, which are stouter continuations of the three rods supporting the oesophagus through the nerve-ring. These rods (fig. 10, *r*) have between them chitin-plates (fig. 10, *t*) which are suspended from the rods by elastic membranes. On the dorsal plate is inserted a double muscle, or a pair of muscles (*bm*), the origin of which is in the dorsal part of the chitinous shell of the head. Each of the lateral plates has inserted on it a muscle (*bm'*), the origin of which is in the chitin of the lower lateral regions of the head. The origin of each of these muscles is in the so-called occipital region of the head, that is, behind the eyes. By the simultaneous contraction of these muscles (*bm* and *bm'*), the lumen of the oesophageal bulb is enlarged, and the blood flows into the bulb from the pharynx, and, upon their relaxation, the elasticity of the chitinous walls of the bulb drives the blood, which cannot return to the pharynx because of the closing of the valve at *v* (fig. 11), into the stomach.

IN THE MALE.

The mouth-parts of the male of *Culex* have not been described, as far as I know, with any degree of accuracy although, since Swammerdamm's time, the males have been distinguished from the females, by all scientific entomological writers on the subject, by means of their feather-like antennae and maxillary palpi.

The proboscis of the male of *Culex pipiens*, the only species the male of which I have studied, is slightly longer and slenderer than the corresponding organ in the female. The setae are fewer in number and less completely sheathed by the labium than in the female; they consist of a well-developed labrum-epipharynx and two slightly developed maxillae. The mandibles are absent, and the hypopharynx coalesces with the labium (fig. 12, *h* and *l*). The labium and maxillary palpi are more densely covered with hair and scales than they are in the females, and they contain muscles; the other mouth-parts, the setae proper, are naked, chitinous, and contain no muscles. In comparative length the mouth-parts may be arranged, longest first: maxillary palpi, labium and labrum-epipharynx, maxillae; — in comparative size they may be arranged, largest first: labium, maxillary palpi, labrum-epipharynx, maxillae. The relative position of the mouth-parts of the male is different from that in the female (compare fig. 8–9 with 13–15) in that the short, rudimentary maxillae are

pushed out sidewise to allow the hypopharynx to coalesce with the labium. In the male the oesophageal pump, or bulb behind the nerve-ring, fails, and the sucking of fluids must be done by the pharynx alone, as it is done in most diptera.

The labrum-epipharynx is nearly the same in general form and structure in the male *Culex* as it is in the female, it is a trifle longer and slenderer, but the same figures (5 *lr-e*, and 6) will serve for the tips of both. In section (fig. 12, *lr-e*), the labrum shows a groove on its upper surface, which deepens as it nears the base (fig. 13, *lr-e*). The apical four-fifths of the labium contains no other seta than the labrum-epipharynx, as seen in fig. 12, which is a section at about the middle of the proboscis. At the base of the labrum-epipharynx are pharyngeal muscles similar to those found in the female, and with similar insertions and origins, except that the median muscle (fig. 15 *pm'*) is not divided into three parts as in the female (fig. 9, *pm'*).

The hypopharynx is, throughout its whole length, joined to the labium, and thus necessarily pushes the maxillae, which would normally lie between it and the labium, to one side. (See fig. 13, *h* and *mx*.) The hypopharynx shows, in section (fig. 13–15 *h*), the same chitinous rod through the middle as in the females, but I was unable to detect any channel for saliva through this rod.

The maxillae are very thin lamellae of transparent chitin, about one-fifth as long as the labium, and so delicate as to be easily overlooked. Although as broad at the base as is the tube of the epipharynx, they taper regularly from their base to their fine tips.

The maxillary palpi are five-jointed, very hairy toward the tip, much longer than they are in the female, and when at rest their basal portions cover the labrum-epipharynx and maxillae in the sheath of the labium.

The labium of the male *Culex* is similar in general structure to that of the female, if one considers it together with the hypopharynx. It is, however, slenderer, more densely covered with scales, has a shallower groove for the reception of the labrum-epipharynx, and has a joint near the middle. The slenderness of the labium in the male extends itself to the labellae. (Compare fig. 4, *lb* with fig. 3, *lb*.) The groove of the labium of the male increases in shallowness from tip to base; at the middle of the proboscis (fig. 12) it is so shallow that it fails to fully protect the labrum-epipharynx, and at its base (fig. 13) it is so shallow that the other mouth-parts rest only on top of the labium. To make up for this deficiency of protection by the labium, the maxillary palpi, as was previously mentioned, cover over the upper side of the enclosed parts (see fig. 13), and thus, although free from the labium, form a part of the protective sheath, which, in the female, is formed by the labium alone. Whether the joint near the middle of the labium of the male *Culex* is true or false I cannot say, since I have never seen it bent by the insect itself; its appearance is that of a true joint. Like the labium of the female, that of the male has two longitudinal main tracheal stems (figs. 12–14, *tr*), and two rows of longitudinal muscles.

EXPLANATION OF PLATE I.

The following letters always have the same signification:

c, clypeus.
e, epipharynx.
h, hypopharynx.
i, infraoesophageal ganglion.
l, labium.
lb, labellae.
lr, labrum.
lr-e, labrum-epipharynx.
m, mandibles.
mp, maxillary palpi.
mx, maxillae.
oe, oesophagus.
p, pharynx.
pm, *pm'*, pharyngeal muscles.
s, supraoesophageal ganglion.
tr, tracheal stem.

The number of diameters enlargement is indicated against each figure.

Shaded parts of sections are portions filled with connective tissue, nerves, air-spaces, and other parts, which have no significance in connection with points discussed in this paper.

Fig. 1. Side view of head of *Culex rufus*, with extended mouth-parts; *a*, antennae.

Fig. 2. Same from above with mouth-parts partly cut away.

Fig. 3. Tip of labium of female *Culex*.

Fig. 4. Same of male *Culex*.

Fig. 5. Tips of separated setae of mouth-parts of *Culex*.

Fig. 6. Tip of labrum-epipharynx of *Culex*, seen from beneath and in section.

Fig. 7. Cross-section through the labellae and tip of labium of female *Culex*.

Fig. 8. Cross-section near the middle of the proboscis of female *Culex*.

Fig. 9. Cross-section through pharyngeal region of the forward part of the head of female *Culex*.

Fig. 10. Cross-section through the posterior part of the head of female *Culex*, to show the sucking bulb of the oesophagus. *b*, lumen of the oesophageal bulb. *bm*, *bm'*, muscles to dilate the bulb. *r*, chitinous rods which support the oesophageal bulb. *rm*, retractor muscles of the maxillae, at the point of origin of their muscles. *t*, elastic plates of sides of bulb.

Fig. 11. Longitudinal section of the head of female *Culex*. *b*, oesophageal bulb. *g*, point where the clypeus appears nearly cut off from the rest of the head. *v*, valve between pharynx and oesophagus.

Fig. 12. Cross-section near the middle of the proboscis of male *Culex*.

Fig. 13. Cross-section at the base of the proboscis of male *Culex*.

Fig. 14. Cross-section further into the base of the proboscis of male *Culex*.

Fig. 15. Cross-section through the pharyngeal region of the head of male *Culex*.

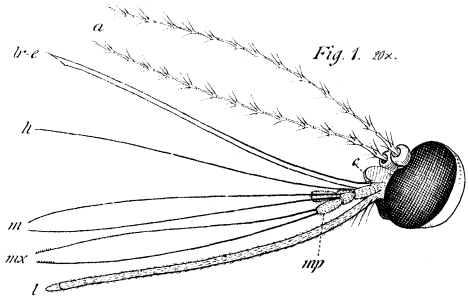


Fig. 1. 20×.
a
lr-e
h
m
mx
l
mp

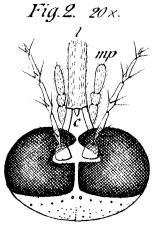


Fig. 2. 20×.
l
mp
c

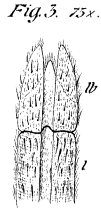


Fig. 3. 75×.
lb
l

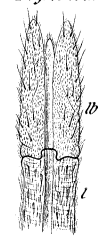


Fig. 4. 75×.
lb
l

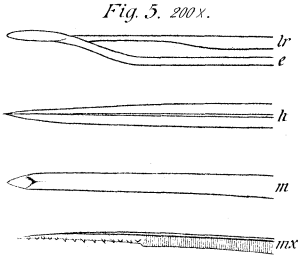


Fig. 5. 200×.
lr
e
h
m
mx

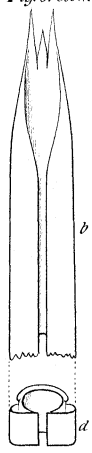


Fig. 6. 500×.
b
d

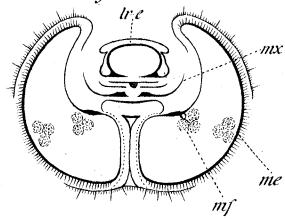


Fig. 7. 300×.
lr-e
mx
me
mf

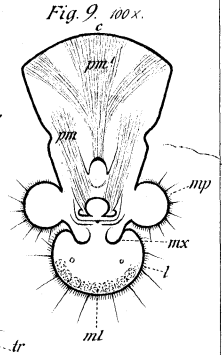


Fig. 9. 100×.
c
pm'
pm
mp
mx
l
ml

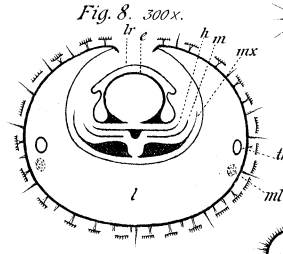


Fig. 8. 300×.
lr
e
h
m
mx
tr
l
ml

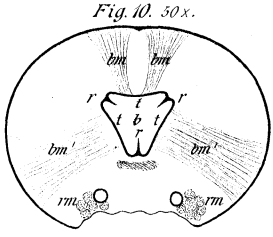


Fig. 10. 50×.
bm
bm
r
r
t
t
b
t
bm'
bm'
rm
rm

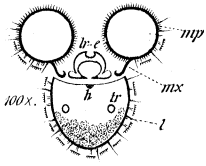
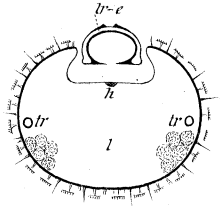


Fig. 13. 100×.
mp
lr-e
mx
h
tr
l


lr-e
h
tr
tr
l
Fig. 12. 200×.

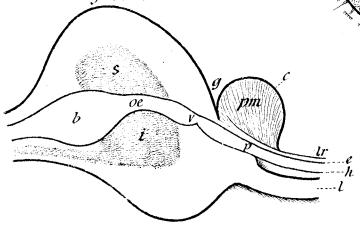


Fig. 11. 50×.
s
g
c
pm
b
oe
i
v
lr
e
h
l

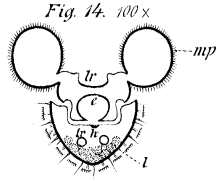


Fig. 14. 100×.
mp
lr
e
h
l

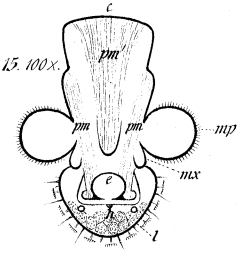


Fig. 15. 100×.
c
pm'
pm
pm
mp
mx
e
h
l

Whether the male *Culex* can bite, or not, is a question to which I can give no decisive answer; but I do not believe it can. I have often taken male mosquitoes, with all possible care to prevent disturbing them, beneath a glass cover upon my hand, letting them remain long enough to be as tranquil as they were when upon the leaves and grass of the field, but they would neither bite nor show any desire to do so, nor have I been able to feed male mosquitoes with water, saliva or fresh blood, all of which liquids the females often drink with avidity.

Upon anatomical grounds I believe that male mosquitoes take liquid food, although I have never dissected their stomachs to see what this food was. They have mouth-parts and pharynx developed sufficiently to suck liquids; but the absence of barbed maxillae, of a free hypopharynx, and of an oesophageal bulb, leads one to suppose that they take a smaller quantity of food than the females do, and that they do not obtain it by piercing the skins of animals.

THYRIDOPTERYX EPHEMERAEFORMIS HAWORTH. ITS HABITS AND METAMORPHOSIS.

BY HELEN SELINA KING, SAN ANTONIO, TEXAS.

THIS insect, whose range embraces Europe and Australia, is also found in certain parts of the United States.

Near Dallas, Texas, hundreds of cedar trees may be seen stript of all foliage and killed by this insect, with their branches laden with its cases. Near Austin, Texas, its favorite food is a species of wild bramble, *Smilax rotundifolia* Young, but many other trees and shrubs furnish ready substitutes. Among these are the scrub-oak, the peach pomegranate, the Judas tree (*Cercis*), and even weeds of certain kinds, while the variety of cedar found there does not seem to be molested.

The habits of this insect have already received the careful attention of entomologists and my object is to fill, as far as I can, any blanks which may have occurred in previous observations, by giving such items as have rewarded my personal attention to its habits and metamorphoses.

The perfect insect is bisexual but is supposed to be occasionally parthenogenetic. I have not yet demonstrated this latter trait.

The male has short, sub-hyaline wings, sparsely scaled, of a dull brown color, and quickly expanding as in hesperians, which it also resembles in its broad head and large eyes. The antennae are deeply pectinate on their basal half, with minute pectinations on the terminal portion. The abdomen, usually short, showing the tip of the terminal segment is retractile and capable of great extension.

The female is apterous, apodous, and almost acephalous, the small head, bent slightly forward, being scarcely distinguishable as such but for its relation to the other members, and its two minute ocelli. There are no antennae, and no visible organs of manducation. This small head and the gradually enlarging thoracic segments are acutely carinated on the median dorsal line, and are en-