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Anatomical description of the larva of Mansonia Richardii (Ficalbi) found in Danish freshwaters.

From the Freshwater biological Laboratory of Copenhagen University.

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By
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Introduction.

On an excursion in September 1914 to one of the little ponds near Donse in the north-eastern part of Seeland, a locality well known to botanists and zoologists, I was sitting in my boat near a sunlit, prominent point of the shore. Some plants were laid upon a tray half filled with water. While searching for larvæ of Coleoptera my attention was now and again attracted by some large mosquito larvæ which crept over the bottom in a serpentlike manner, when the tray was shaken. It struck me, that it was really a peculiar season to find full-grown *Culex*-larvæ. I caught one of them and placed it into a high cylinder-jar. To my astonishment I saw, that the animal undoubtedly was heavier than the water and that it sank slowly downwards and settled itself horizontally on the bottom. Moreover I saw, that the animal did not at all swim like a common *Culex*-larva, but it always swam horizontally; it was extremely sluggish and had a milky-white colour, very different from the brown colour characteristic for all our Danish *Culex*-larvæ. I could observe that the sipho was of a peculiar structure, but on using a lens with high power I immediately understood, that I had made one of the most remarkable discoveries we have made here in our freshwaters for a long time past.

Some weeks before, I had received a separate copy from Dyar and Knab (Entom. News 1910 p. 259) relating to a peculiar mosquito-larva, *Mansonia perturbans*; the paper was cited in my work on the Water Insects (1915), then just in press. The larva is recognizable at the first glance on account of its very characteristic sipho, which has been converted into a piercing organ by means of which the animal perforates living plant-tissues; the air

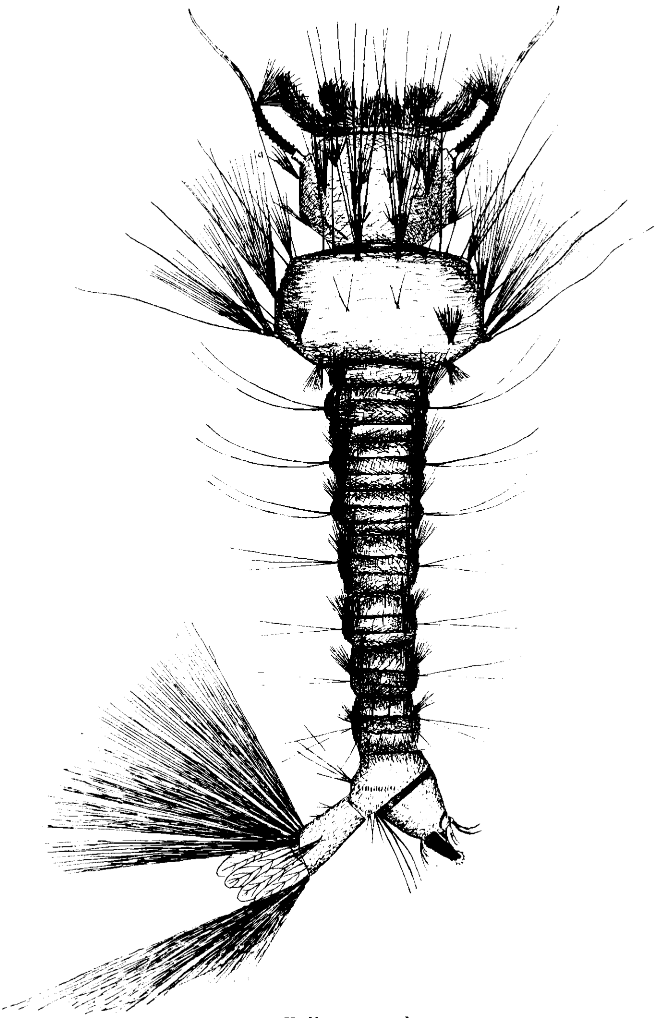


Fig. 1. Fully grown larva.

in the airrooms is used for respiration. The mode of life of the larva is therefore quite different from that of the other mosquito larvæ; it does not swim but, really, has to be regarded almost as a sedentary animal, sitting with the sipho bored into the plant-tissue near the bottom, often in a depth of one third of a meter (figs. 1—2). Really, the respiration takes place in quite the same manner as in the case of the *Donaciin* larvæ, the life of which has

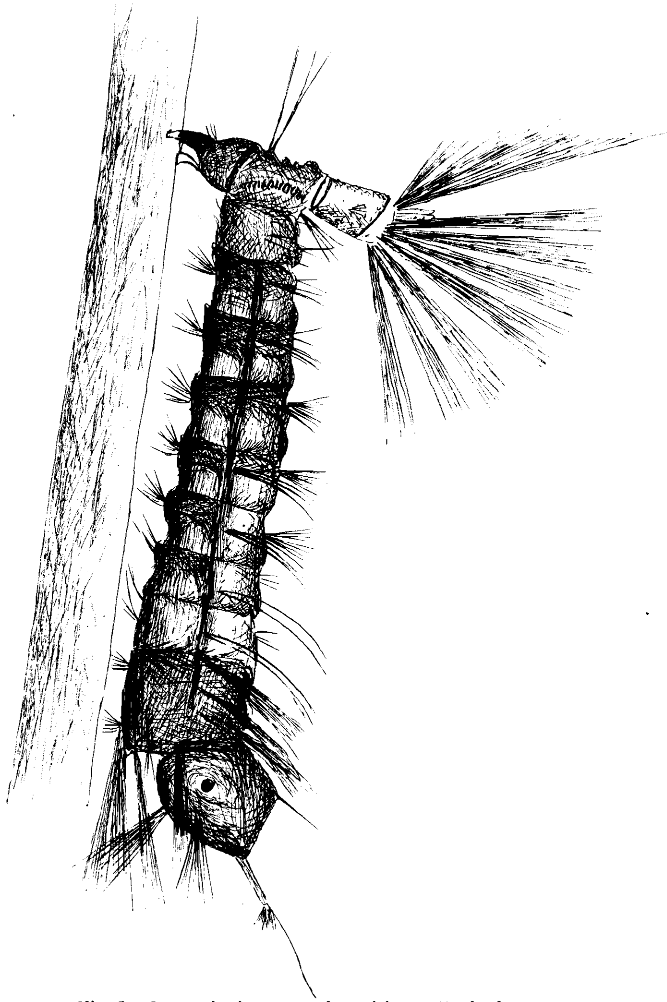


Fig. 2. Larva in its normal position, attached to a root.

been studied so admirably by my good friend Dr. Ad. Bøving upon almost the very same locality, where the *Mansonia*-larva was found.

Hitherto the *Mansonia*-larvæ have only been found in America, and as I knew that the genus *Mansonia* has an almost entirely tropical distribution, it will be understood, that, as I stood there with the larva in my hand, I could not have been more astonished even if I had drawn forth a representative of the Dipnoi from the mud of the Donse pond.

In the autumn of 1914 I made many excursions to Donse and I found many larvæ. Frequently I had 30—40 larvæ in my aquaria, where I had rich opportunity of seeing the larvæ creeping between the roots and piercing their tubes into the plant-tissues. In

Fig. 3. Larva in its natural position on the bottom of the aquarium, between the roots and twigs of water-plants. Note the inflated, thick body. Photo.

one of the last pages of my paper on the water insects I gave a microphoto (fig. 3) of the larva fixed to a root, and some drawings of the tracheal system and the sipho; better drawings of the objects may now be given.

The larva (figs. 4—5) was rare; the greatest number I was able to procure after searching for 4—5 hours was 10—15. Strangely enough I could never find it in any other locality than where I found it the first time. The vegetation was composed by *Acorus*, *Ranunculus lingua*, *Glyceria spectabilis*, and *Typha angustifolia*. I have no impression of the larva preferring any of these plants for the others; if so, it should probably be *Acorus*. In the aquaria the larva fastened itself to the most different plants and sat often for a fortnight or more fastened to the same spot. It was always restricted to very shallow water. I never found it deeper than $^1/_8$ meter. The best method to get the larvæ is to loosen the plants from the bottom with the roots and then to shake them in high cylinder jars. When the material has sunk to the bottom the larva will be found creeping slowly over the decaying material. More than once when examining the plants I saw the animals fixed in their normal position trying to detach themselves when the

Fig. 4. Larva in its natural position. Photo. — Fig. 5. Dorsal view of larva. Photo.

plant was brought onboard. I have never found more than two or three on one plant. Altogether I have probably caught about 100 larvæ.

It was my intention to keep the larvæ during the winter here in the laboratory, but in February they all died, probably because I had kept them at a too high temperature. As soon as the ice on the pond was melted, I went again to Donse to procure fresh material. Another great astonishment, but not so agreeable as when I found the larva. An enterprising man had bought the water in the ponds with intention of establishing an electricity work at the little brook. The still-born project gave the country electrical light for some months, and the water of the pond disappeared. The next year it was almost wholly dried up; not a single larva was to be found, the water being retracted far beyond that zone where they lived. On summer evenings I lay in the grass hoping that some mosquito, new for our fauna, would come and suck my blood. All was in vain. Neither in 1915 nor in 1916 the water reached the zone, where the larvæ were found in 1914. As long as the imago was not found I did not like to publish my observations.

Fig. 6. Larva creeping backwards. Photo.

There is only described two larvæ of the genus *Mansonia*; the one belongs to *M. perturbans* (Walker) Dyar; home: North America; the other is *M. titillans* (Walker) Blanchard; home: the tropical South America. Our larva is not identical with the latter; the ventral brush of the 9th segment being, in *M. titillans*, preceded by a row of small tufts reaching to the middle of the segment; these small tufts are not to be found in our larva. *M. perturbans* (H. D. K. 1915 p. 505 Plate 79) is known from North America from Canada to Florida and westward in the timbered country as far as British Columbia (H. D. K. 1915 p. 510). If *perturbans* and our larva are not identical they are in any case closely related.

After many excursions in 1915—16, always without result, I finally, in 1917, had the good fortune to catch the imago. On an early day in July I sat some 100 yards from that point where I for the first time got the larva. After a heavy rain the mosquitos stung vigorously. *Culex nemorosus* and *C. cantans* swarmed around me; then arrived three specimens of a dark-coloured mosquito, to which I immediately paid my attention. I could not get more than the three specimens; but when these were more thoroughly examined later on, it was established that I had found the *Mansonia* for which I had waited patiently for three long years. The next day I had to leave for my new laboratory at Tjustrup, and when I returned I found no more specimens. Still the animal could now be identified and the observations be published.

The Imago.

In 1891 Lynch-Arribálzaga founded the genus *Tæniorhynchus* including three species: *Culex tæniorhynchus* Wiedemann, *T. confinnis* Arribálzaga and *T. fasciolatus* Arribálzaga. Theobald (1901) supposed, that *C. tæniorhynchus* Wiedemann was erroneously identified and that it was really identical with *C. titillans* Walker, which Arribálzaga cites as synonym of *C. tæniorhynchus* Wiedemann. He proposed the name *Panoplites* for *titillans* and used the name *Tæniorhynchus* for *T. fasciolatus* Arribálzaga. Then the name *Panoplites* was found to be preoccupied and was therefore changed to *Mansonia* by Blanchard (1901). In 1915 Howard, Dyar, and Knab maintain, that the two genera *Mansonia* and *Tæniorhynchus* are not distinct, and the species were referred to the genus *Mansonia*.

According to Giles (1902), Blanchard (1905), and H.D.K. (1912—17), the home of the genus *Mansonia* is almost entirely restricted to the tropical or subtropical countries. The main localities are Brasilia, West-Africa, the neighborhood of the great African lakes, India, China and West-Australia. According to H. D. K. North-America possesses only two species, *M. ochropus* Dyar and Knab and *M. perturbans* (Walker) Dyar. In about 1900 European dipterologists show, that the genus also occurs in Europe, and that a single species lives far beyond the normal area of distribution. In 1896 Ficalbi describes a mosquito from Italy under the name of *Culex Richardii*. Theobald (1901 p. 194) refers the species to the genus *Tæniorhynchus* and remarks: "Ficalbi's *T. Richardii* comes in this genus in spite of the male ungues differing from those of Arribálzaga's species" (1901, p. 190). According to Theobald (1901 p. 197) a single specimen of this species was found in England near Sutton of Bradley and, probably, the species also occurs at Toronto (Canada); finally in 1903 (p. 269) Theobald states that the species "seems to be common in some parts of the Norfolk Broads, England".

Unfortunately the three *Mansonia* specimens caught by me are all females. They have been thoroughly compared with the descriptions of the English species *M. Ricardii* Ficalbi. I suppose that it is the same species which occurs here, but I regret that, owing to the war, it has not been possible to have the specimens identified by a specialist. In accordance with Theobald I give the following description of the animal.

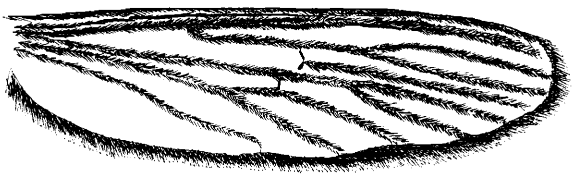
Thorax chestnut-brown, with small golden scales; abdomen without bands, dusky yellowish-black with scattered yellowish scales; lateral spots very indistinct. Posteriorly the abdominal segments carry a row of long golden hairs. Metatarsi and tarsi are provided with pale bands in the basal part; bands are also present in the middle parts of the metatarsi. Head brown with narrow, curved, pale scales; antennæ brown; the basal joint is pale ferrugineous, and so is the basal part of the second joint; palpi brown covered with dark, brownish scales; clypeus ferrugineous-yellow; proboscis brown with scattered black scales almost covering the apex.

Thorax bright chestnut-brown with scattered scales more or less distinctly arranged in rows; bristles black, scutellum pale yellowish-brown with scattered narrow, curved scales and bright golden-brown border-bristles; metanotum clear ochraceous brown; pleuræ pale yellowish-brown with a few pale yellowish scales.

Abdomen, when denuded, dull ochraceous-brown; under certain conditions of light it is dark shining, while in other cases it may be black. When covered with dusky scales it is almost black though with a few dull yellowish scales here and there; long yellow hairs encircling the segments. Five or six yellowish-white spots, rather inconspicuous, in the last five or six segments. Numerous golden-brown hairs along the sides and the hind margins.

Legs: the coxæ yellowish; femora yellowish, the upwards turning surface brown, the apex white, the white band not involving the tibia. Tibia brown with scattered black and dull yellow scales; metatarsi and tarsi yellowish banded in the following manner: fore-metatarsi and first two tarsi with traces of basal bands. In the mid-legs the bands are more distinct; the bands on the hind-legs are broader and still more distinct, but there is no broad, pale, median metatarsal band, such as Theobald states with regard to *T. Ricardii*; ungues equal simple.

Wing (fig. 7): the veins densely covered with rather broad, elongated oval, brown scales; besides there are a few scattered yellow scales, especially along the costal region; no long thin lateral scales. First submarginal cell almost as long as the second posterior cell; stem of the former about half the length of the cell; stem of the latter also about the same relative length; posterior cross-vein only about once its own length apart from mid cross-vein; halteres pale ochraceous; the length of the above named



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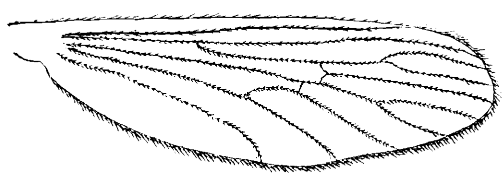


8.

Figs. 7 and 8. Right wing of *Mansonia* sp. and *Culex* sp. *).

cells in relation to the stems varying a little in the three specimens. Length of the wing 8—10 mm.

The Danish specimens differ from *M. Ricardii* Ficalbi in the legs being not so conspicuously banded; especially the hind-legs lack the broad band on metatarsus. The main difference is to be found in the wings. The first submarginal cell is scarcely longer than the second posterior cell, and their petiole does not, as is stated with regard to *M. Ricardii*, reach $^2/_3$ of the length of the cell, but is less than half as long as the latter; finally, in the Danish specimens the posterior cross-vein is only separated from the mid cross-vein by a space a little more than its own length, whereas in *M. Ricardii* the distance is more than two and a half times the length of the former. In this regard the Danish specimens agree more with the North-American *M. perturbans*.

*) This and the following figures are drawn from camera outlines and represent the *Mansonia*, unless otherwise specified.

H. D. K. (1915 p. 506) state as follows: "Second marginal and second posterior cells much longer than their petioles, the petiole of the second marginal about half as long as the cell, cross-veins short, basal cross-vein more than its own length distant from anterior cross-vein."

In all other respects the Danish specimens are highly in disaccordance with the description of *M. perturbans*. I therefore refer, though with some doubt, the Danish specimens to *M. Ricardii* Ficalbi. As mentioned above, the only locality in this country where the species has been found up to now, is the Donse-ponds between Hørsholm and Hillerød, North-Seeland.

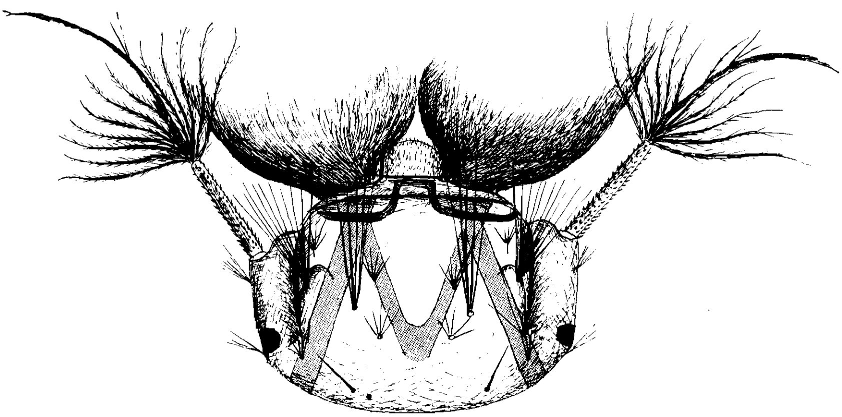
Among all the Danish *Culicidæ M. Ricardii* will immediately attract the attention on account of its size; only *C. annulatus*, *annulipes*, and *cantans* reach a similar size; the first of these three species is distinguishable owing to the spotted wings, and the two others have very conspicuous bands on the legs. *M. Ricardii* has unspotted wings and as far as I know the bands on the legs are not so conspicuous; it differs at the first glance from the other Danish *Culicidæ* in having an apparently very coarse nervature in the wings; this is due to the scale cover being much coarser than in our *Culex*-species.

Description of Larva.

Goeldi (1902 p. 23) gave the first description of a *Mansonia*-larva (*M. fasciolatus* from the tropical America); he hatched the eggs but could not keep the larva living; his rather deficient drawing shows the remarkable sipho. It was reproduced by Theobald (vol. IV p. 484). Up to that time (1907) we had no idea with regard to the life of the larva. First then the very peculiar biology of the larva and the pupa was cleared out through the investigations of Currie & Brakeley, Smith (1908) and Dyar & Knab (1910). Later, through the studies of Moore (1910) (see H. D. K. 1915 p. 519), we became acquainted with the biology of *M. titillans* Blanchard from South-America. It has now been demonstrated, that both species in the larval stage bore the sipho into submersed plants and fetch the air from the airchambers of these. Still we feel the wants of a more thorough examination of the structure of the sipho, and many details with regard to the anatomy and biology of the larva are unknown. It may be added, that no larva is known from the old world. We know, however, a pupa of *Mansonia uniformis* Theobald (figured by Theobald vol. III 1903 p. 270). Its home is Central-Africa. It is characteristic on account of its "very peculiar long curved siphos ending acuminately", a feature which is characteristic just in the American *Mansonia*-pupæ.

We may suppose, therefore, that the same peculiar structure of the siphos will be found in the pupa of the European species.

Head and mouthparts.



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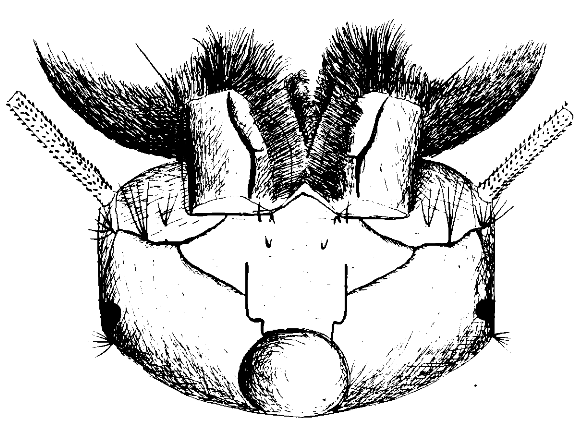


10.

Figs. 9 and 10. Dorsal and ventral view of head of a fullgrown larva.

Head (figs. 9—10), subquadrate, much wider than long; eyes very small, almost rudimentary, as compared with the eyes of the *Culex*-larvæ. H. D. K. (1915 p. 507) state, that the eyes in the larva of *M. perturbans* are rudimentary; that in *M. titillans* they are placed upon slight prominences near the posterior angles; further that the anterior division of the eye is narrow, transverse, curving around from upper to under surface. The eyes of the Danish larva are quite undivided and probably a little more developed than in the American larvæ. Antennæ of a rather peculiar structure, very long with a large hair-tuft beyond the middle arising from a notch; especially the terminal portion is very long and much drawn out, but it is thicker than in the American larvæ; two of the terminal hairs situated not far beyond the tuft. The apex carries two inconspicuous hairs, an outer hair very hyaline and an inner one more strongly chitinized and needle-shaped. On the dorsal surface of the head the scythe-shaped areas (Thompson 1904 p. 168) are strongly developed; dorsal hairs of the head all in multiple groups. Near the median line of the head we find two hairtufts, each with five long bristles; more laterally and in front there are two other tufts, each with about nine bristles. The head carries further four pairs of smaller tufts; the sides two pairs, one behind the antennæ, the other behind the eyes; near the hind margin of the head we find two long single and strong bristles. On the anterior border of the epistome (clypeus by H. D. K.) there are two other bristles, but these are shorter and stronger.

According to my opinion the *labrum* (figs. 11 and 12) of the larvæ of the *Culicidæ* is three-lobed, consisting of a median lobe (fig. 12 *b*) commonly called *labrum*, *scutum* of the first metamer by Meinert, *palatum* by Thompson (1904 p. 169) and two lateral lobes (fig. 12 *c*) which are supported by a somewhat complicated system of black-pigmented apodemes, which are connected with the so-called blackspot areas (Thompson 1904 p. 169, fig. 12 *d*): spots of thicker chitin "which involves part of the ventral face of the rostrum and bear a conspicuous patch of pigment". The two lateral lobes carry the two flabellæ, the well known brushes of the mosquito larvæ; they partly catch the animalcules and microscopical plants, partly they are locomotory organs. The structure as well as the use of the flabellæ of the *Culicid*-larvæ

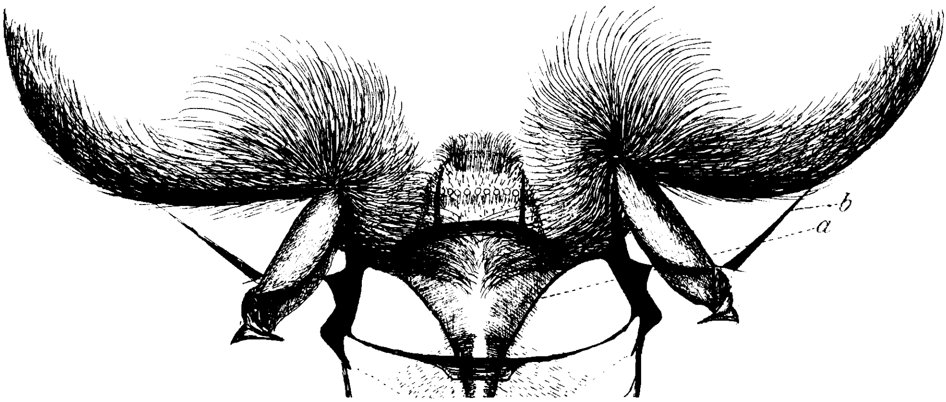


Fig. 11. The labrum with its three lobes; in the middle the palatum, and laterally the two flabellæ with the large brushes and their black pigmented chitinous apodemes. The whole organ is seen from below and very much forced outwards. — *a* the inner borders; *b* the thorn of the maxillæ.

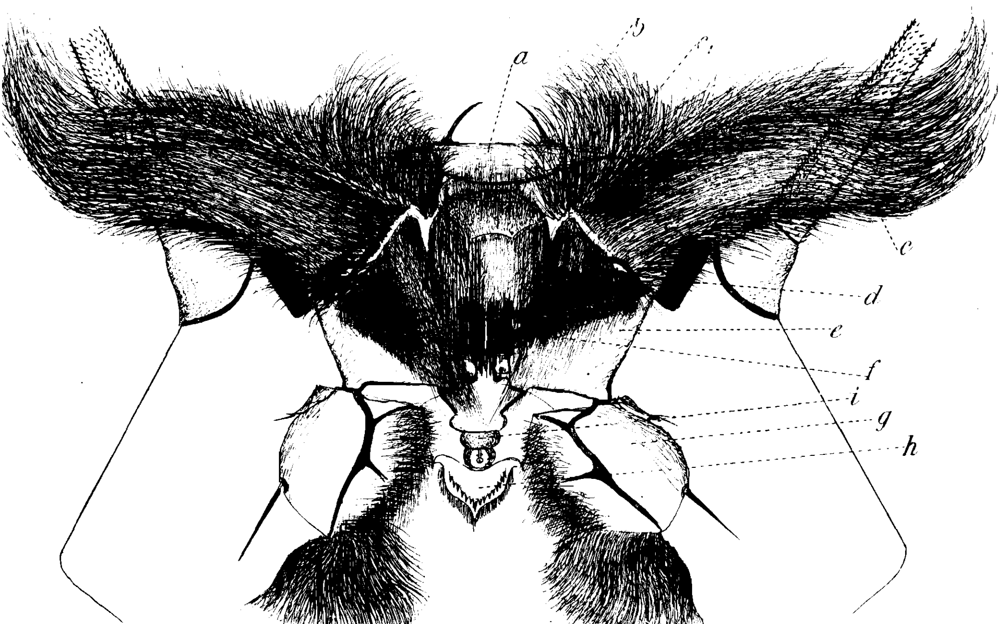


Fig. 12. Mouthparts seen from below; normal position of the labrum; the brushes are streched out; the maxillæ and the whole labium are turned downwards enabling us to look directly into the buccal cavity. The entrance to the pharynx in the centre of the figure: the position of the mandibles normal. The figure has been drawn especilly with regard to the direction of the different haircomplexes, the different chitin apodemes of the head omitted. —
a epistome (= clypeus): *b* palatum; *c c*. setæ of the flabellæ; *c* the outher *c*. the inner part of the brush; *d* black-spotted chitin area; *e* mandibles; *f* epipharynx; *g* maxillæ; *h* mentum; *i* hypopharynx.

are objects to much variation. In a following paper I shall try to elucidate this point more thoroughly; in the present paper I shall restrict myself to the following short remarks. The two lateral lobes arise as a keel on each side of the median lobe; they are covered with long yellowish hairs on the outer and inner surface. When the flabellæ are expanded but at rest, the hairs of the outer side form two excavated, cup-shaped hair-brushes; their length is very different in the different species. Those of the inner side form the two hair-brushes which are adjacent to the hair-brush of the palatum and converge into a point, situated a little below the hair-brushes of the epipharynx (fig. 12 *f*); the keels of the lateral lobes distinctly separate the two hair-brushes of the flabellæ from each other and are visible, when the organs are expanded but at rest, as two conspicuous lines. When the organ functionates, the two outer hair-brushes are rhytmically and contemporarily struck inwards; simultaneously with this motion the inner hair-brushes are incessantly raised and lowered. By means of this motion the water with its contents of microscopical nutritive organisms and particles of detritus is hurled down into the buccal cavity; the particles are caught by the inner hair-brushes of the flabellæ and then seized by the mouthparts.

The labrum of *Mansonia* differs but very little from the type described above; the median lobe, probably a little more prominent than in the *Culex*, is especially along the borders fringed by long soft hairs reaching to and partially covering the epipharynx; the outer hair-brushes of the flabellæ are very large and more luxuriously developed than in any of our Danish *Culex*-larvæ; the apodemes supporting the flabellæ are shaped in accordance with those of the *Culex*-larvæ, but are at the whole weaker and consisting of chitin of a lighter colour.

The mandibles (fig. 13) are not very much different from those of the *Culex*-species, especially of *C. ornatus*; but, as far as I am aware, the structure and the function of these organs are not sufficiently understood. The border turning inwards is furnished with complexes of hairs with very different appearances and functions. Uppermost we find here by *Mansonia* three long and one shorter stiff, curved, thorn-like bristles (the comb-teeth); they are movably inserted on the mandibles, and constitute the combing part of the

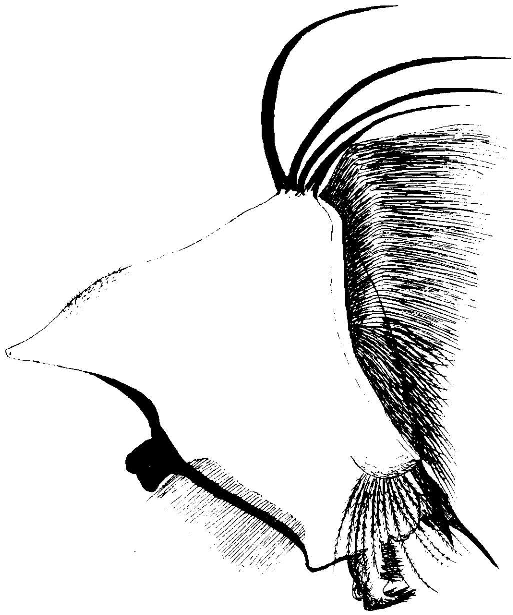


Fig. 13. Left mandible.

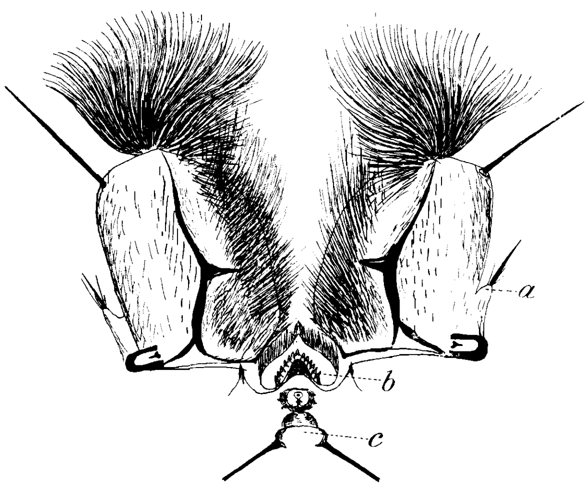


Fig. 14. The two maxillæ. — a palp; b mentum; c hypopharynx.

latter. Below these bristles we find a coarse fringe of long, very fine, kneed hairs representing the brushing part of the mandible; they are inserted in an arch beginning beneath the comb-teeth, bordering the inner edge of the mandible, and then, at about the middle of the same, turning in over its flat side. At about the point where the bow turns inwards, another series of bristles begins, placed along with the inner edge, and reaching down to the masticatory part of the mandible. Finally, further below, at the entrance to the pharynx, the tearing masticatory part of the mandible is situated, constituted by short and strong chitin daggers or teeth. Against them acts a peculiar palpe-like projecting lobe; its apex is furnished with a bunch of short bristles inserted at a right angle to the long axis of the lobe. The lobe forms a crooked arm, covered on its inner side by a series of bristles. Above the masticatory part of the mandible we find a series of 10—12 long feather-like bristles; the teeth, the right-angular lobe and the feather-bristles together with those from the opposite mandible encircle a room and effect, that every particle swept down into the lower part of the buccal cavity by the combing-teeth and the brush, is caught within this room from which it is not able to escape.

The above mentioned three parts of the mandible: the combing the brushing, and the masticating part, may be pointed out upon all the figures of mandibles designated on the plates 136—138 by Howard, Dyar and Knab; most probably they will be refound in nearly all *Culicid*-larvæ, but they are differently shaped in the different species.

The maxillæ (fig. 14) are constructed in accordance with the common ground-plan for the maxillæ of the *Culicidæ*. The fore-edge carries a large bunch of long strong haires; laterally (fig. 14, fig. 11 *b*) a very long bristle is found. The inner edge and the sides are covered with short hairs, the palpe (fig. 14 *a*). is fairly small but more highly developed than in the Danish *Culex*-larvæ; it carries a few hairs.

On the ceiling of the buccal cavity a little below the labrum, we find the organ commonly called *epipharynx* (Thompson 1904 p. 169) (fig. 12 *f*, fig. 17 *b*), a prominent, more strongly chitinized fold of the skin furnished with four strong, short hairs with stubby apex; laterally it is bordered by two long acute dusks of hair.

According to Meijere (1916 p. 253) the *labium* (fig. 12 *h*, *i* 14 *bc*, 15—16) of the *Diptera* larvæ is divided into four parts: the *submentum*, the *mentum*, the *præmentum*, and the *hypopharynx*. In most of the *Nemocera* and probably in all *Culicidæ* there is no limit between *submentum* and *mentum*. The latter has the shape, common among the *Culicidæ*, and is furnished with 6 sharp teeth on each side and one large tooth in the median line. The *mentum* is covered by a fringe of long soft hairs bordering a free prominent fold of the skin (fig. 15).

Beneath the mentum is found the very peculiar organ which has been figured by Meinert (1886 Pl. I. fig. 5) and better by

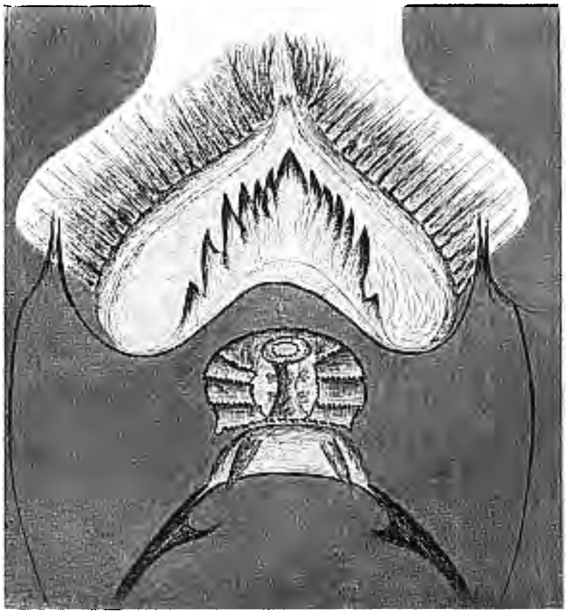


Fig. 15. Mentum and hypopharynx.

Raschke (1887 p. 133) but never thoroughly described; it consists of a tube which is collar-like expanded; probably it has a central pore; it is surrounded by a collar-like part, consisting of plates of chitin, which overlap each other and are furnished with teeth along the edges. The organ rests upon a dome-like body supported by two lists of chitin and inwardly provided with a thorn-like process. Thorns of chitin are also present on the dome-like part. Meinert's drawing exhibits a circle of hairs rising from the apex of the tube; I have not been able to find such hairs; when cut horizontally the organ (fig. 16) shows a cushion-like layer of cells with very large nuclei beneath the dome-like part. Two pairs of divergent muscles are running to the organ serving to push it forward and to retract it. Its appearance differs a little within the different *Culex*-larvæ.

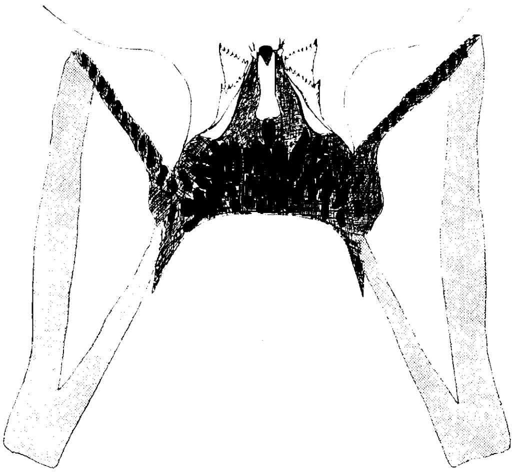


Fig. 16. Horizontal section through hypopharynx.

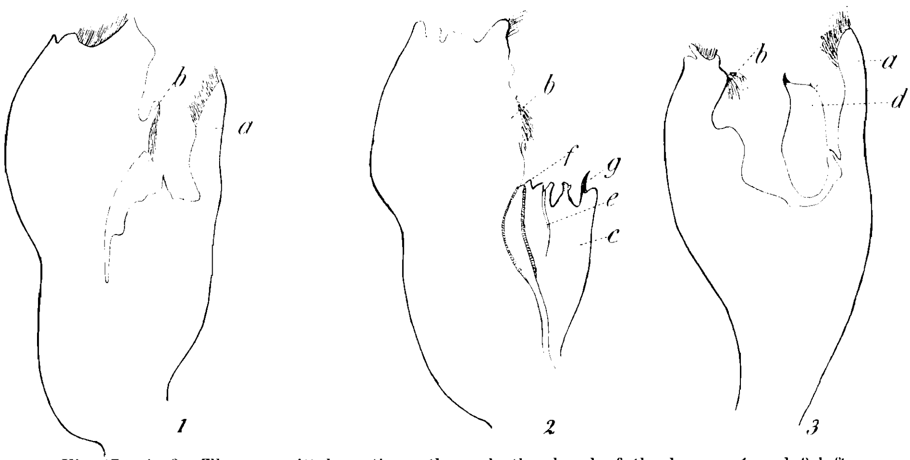


Fig. 17. *1*—*3*. Three sagittal sections through the head of the larva. *1* and *3* left and right to the median line; *2* in the median line: *a* maxilla; *b* epipharynx: *c* labrum with mentum: *g* and *e* hypopharynx: *e* salivary duct: *f* entrance to the pharynx.

In collaboration with the *hypopharynx*, the *epipharynx* gards the entrance to the *pharynx* (fig. 17 *f*). Immediately behind the organ described above is an almost flat plate-shaped part, perforated by the salivary duct (fig. 17 *e*). It is this part which is commonly designated as *hypopharynx*. Behind this begins the *pharynx* which, as in all *Culicid*-larvæ hitherto examined, is covered above and below by two peculiarly formed chitin plates. The ventral plate is perforated by the oesophagus. As for the understanding of the buccal cavity and the *pharynx*, see fig. 17.

It is rather peculiar, that we have hitherto had but a slight intelligence of the manner in which a *Culex*-wriggler takes its food, and the mode of action of the many different organs in the buccal cavity during the process. By means of the exellent binocular aquarium-microscope which has been presented to the laboratory by the Carlsbergfond, I have been able to study the catching of the prey and the masticating process much more thoroughly than my predecessors. The experimental object was for a long time the *Mansonia* larva; later on I used *Culex*-larvæ. As most of the observations have been made on the last mentioned organisms I have thought it most correct to postpone the publication of these observations for a paper deeling with the structure and biology of the *Culex*-larvæ, appointed for printing immediately after the present paper.

Thorax.

The broad flat thorax (fig. 1) is subquadrate; laterally it carries three pairs of hairs-tufts and, in front, a pair of large bristles with their points reaching beyond the flabellæ. In each bunch of bristles we usually find a single, more conspicuous and stiff bristle. Smaller bunches of bristles are implanted on the dorsal as well as on the ventral side.

Abdomen.

The abdominal segments are uniform; dorsally and ventrally each segment has a small chitinized part (fig. 3). On each side of this there is a broader band more weakly chitinized. Laterally, nearest to the ventral side, a rounded prominence extents covering the origin of the long lateral hairs. Of these we find two or three long bristles, the foremost curved with the arcuation forwards. According to H. D. K. the American species possess only one bristle. Dorsally a little above these bristles each segment carries a pair of dusks with short bristles. A series of quite similar bristles is found on the ventral side. The seventh segment is somewhat more luxuriously equipped; the bristles radiate almost coronary into all directions (fig. 2).

The *Mansonia*-larva is a more hairy animal than our *Culex*-larvæ. The importance of these hairs cannot be understood from a mere dorsal view of the larva (fig. 1). The hair-cover of the animals, especially with regard to the aquatic ones, always ought to bee studied upon living specimens and in their natural attitudes. Thus we will regard fig. 2, reproduced after a drawing made from a living specimen examined under the above-mentioned binocular microcope. In my aquaria I have almost always found the animals in the attitude presented in the figure. It will be seen, that the many different hairs of the body point almost towards every direction. Every motion of the water, everything that happens in the surroundings, will be brougth to the knowledge of the animal before it reaches the body itself. On account of their great length the antennæ master a relatively considerable body of water in a forward and downward direction. The two long bristles on the epistome protrude forwards. The hairs of the dorsal side of the head are directed obliquely forward and upward, and the large bundles of bristles on the thorax extend partly over the head, partly along the sides of the same. The bundles of bristles on the dorsum play a part as supporting hairs, but besides they serve as indicators af movements of the body of water between the animal and the stem of the plant; those on the ventral side have a similar function with regard to the water beneeth the animal. The large swimming-brush extends backwards far beyond the hind end of the body; the four large bristles arising from the 8th segment get information of everything that happens above the animal. Without bristles the animal would only be able to get information relating to variations within a very small area of the surrounding medium. Other animals, enemies etc. are not able to force their way unobserved into the very body of the wriggler. If we try to approach a needle within a distance of some millimeters from the animal, we will immediately understand this; instantaneously the wriggler will make some very conspicuous curvations of the body, but usually it will not let go the hold of the plant. It is like a man-of-war with its torpedonets folded out. Probably the very small eyes have but a slight importance as sensitive organs. Living concealed between the roots of the plant or in the angles between leaf and stem the animal is surely never exposed to any considerable amount of light. Such rudimentary eyes may be found in most of the *Sabetini*, a tropical division of the *Culicidæ*, the wrigglers of which live in the small water spaces found in the leaves of *Bromeliaceæ* etc., where, probably, the supply of light is likewise very slight. Also these larvæ possess a very highly developed system of bristles.

With regard to the respiration the larvæ of the *Culicid*-families may be referred to four groups. 1. Larvæ which hang down from the surface by means of the sipho and, in this attitude, breath the air of the atmosphere; the majority of all *Culicid*-larvæ belong to this group. 2. Larvæ which take the air from the airchambers of submersed plants by means of different organs (sipho: *Mansonia*, antennæ: *Aëdeomyia*). 3. Larvæ which live a pelagic life in the water layers and mainly or exclusively breath dissolved air by means of the outer skin (*Corethra*, *Mochlonyx*). 4. Larvæ which possess air-tubes but mainly live on or near the bottom of stagnant pools and are furnished with very large blood-gills.

It is very interesting to observe the extremely high degree of transformation of the different hair complexes of the *Culicid*-larvæ in accordance with the mode of life of the organism and the use it makes of the hairs.

Among those larvæ which hang down from the surface we find large bundles of bristles on the head, the thorax, and the abdomen. Their number, position, lenght etc. differ in the different species. Their principal importance is undoubtedly to augment that bulk of water which belongs to the sensitive domain of the animal. The significance of these hairs as outriggers contributing to support the larva in the water is probably very slight. In those larvæ which are horinzontally supported by the surface-film (*Anopheles*) the dorsal bundles are peculiarly modified; they are transfigured into palmated hairs arranged in two series on the dorsal side of the abdomen. Thus we find certain parts of the hair complexes serving as a supporting apparatus keeping the animal to the surface-film. With regard to these larvæ it may be supposed, that the long thoracal and abdominal hairs may play a part as outriggers;

they are very long and forward directed. All these larvæ have well developed eyes.

With regard to the second group (*Mansonia*) we might think, that the hair-cover had been highly impressed by the sedentary life so strongly different from the free-swimming habits of the larvæ belonging to group 1. This, however, does not seem to be the case. It must be remembered, that in both groups the hair-cover is particularly used as a sensitive organ. The sedentary life and the incapability of escaping from a danger only involves some richer development of the whole hairy system and another direction of some of the bristles; special attention might be paid to the bristles of the antennæ. Very peculiar kinds of hairs are the crooked bristles above the sipho, being the most important climbing apparatus of the larva.

In opposition to the above-mentioned groups the pelagic group (*Corethra*, *Mochlonyx*) is almost whithout bristles. It is a well-known fact, that the plancton organisms are very often provided with complexes of long bristles which increase the cross-section resistance and, therefore, diminish the speed of falling through the water. The possibility of pelagic life of the *Culicid*-larvæ is almost wholly due to the hydrostatic apparatus; the combination of a hydrostatic apparatus with long bristles, frequently found in the plancton organisms to increase the cross-section resistance, is unknown in the case of the pelagic *Culicid*-larvæ, where the bundles of bristles have all been reduced. The body of water, which these larvæ demand according to the development of their sense of touch, is probably much smaller than that required by the other *Culicid*-larvæ; hyaline as are these pelagic larvæ, they are also much better protected against enemies; and the eyes being higher developed than in any other *Culicid*-larva, the sight is probably of great importance.

The fourth group, which possesses a sipho, but seldom rises to the surface, mainly consists of tropical species. Still it must be remembered that the mode of life under the ice of the hibernating larvæ of the temperate zones resembles, as far as their respiration is concerned, very much the mode of life of the tropical larvæ; they respire the dissolved gases through the skin and especially through the gills. H. D. K. state, that the tropical larvæ lie on their back on the bottom of the water pools; many of these species, especially those of the *Sabetini*, possess dorsally on the apex of the sipho some highly developed crooked bristles, upon which they rest when lying on the bottom; similar bristles may also be found on the dorsal side of the seventh segment. The number and direction of the bristles in the swimming-brush of the ninth abdominal segment and of those which belong to the sipho, are likewise very much different in the various species. Our knowledge of the biology of the animals is, howerer, still very small so that we are at the present incapable of demonstrating the presumed accordance between structure and function of the hair-complexes.

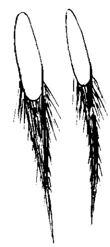


Fig. 18. Two of the small scales on the eight segment. Leitz. Obj. 6. Prism-ocular.

In *Mansonia* the lateral comb of the eighth segment consists of about 20 teeth placed in a single row; the teeth are long and very acute. Fig. 18 shows two of them highly enlarged. In the American species the number of teeth is smaller. At the end of the row of teeth we find a tuft of 3—4 hairs and, at the base of the sipho, four tufts each consisting of 3—4 rather conspicuous hairs.

The anal segment (fig. 19) is much longer than broad, at the base provided with a band of chitin and furnished with a chitin plate which completely surrounds the segment. Laterally the plate has a tuft of 5 bristles, and along the edges it bears two small tufts each consisting of two bristles.

The ventral brush is large, but there are no small tufts of hairs in front of it. Dorsal tufts divided into four. The whole organ differs but at little from that of other *Culicid*-larvæ (fig. 20), and is most in accordance with that of *M. perturbans.* The system of transverse stripes of chitin supporting the tufts (fig. 21) is very similar to that of other *Culicid*-larvæ.

One of the most peculiar features in the structure of the *Mansonia* larva is the high development of the swimming-brush on the 9th segment; this brush is here, in the almost sedentary larva, larger than in many of the free-swimming *Culex*-larvæ. Most observers would be inclined to think that it were a powerful organ of locomotion; this is far from being the case; even the strongest use of the organ is unable to bring the larva to the surface; it

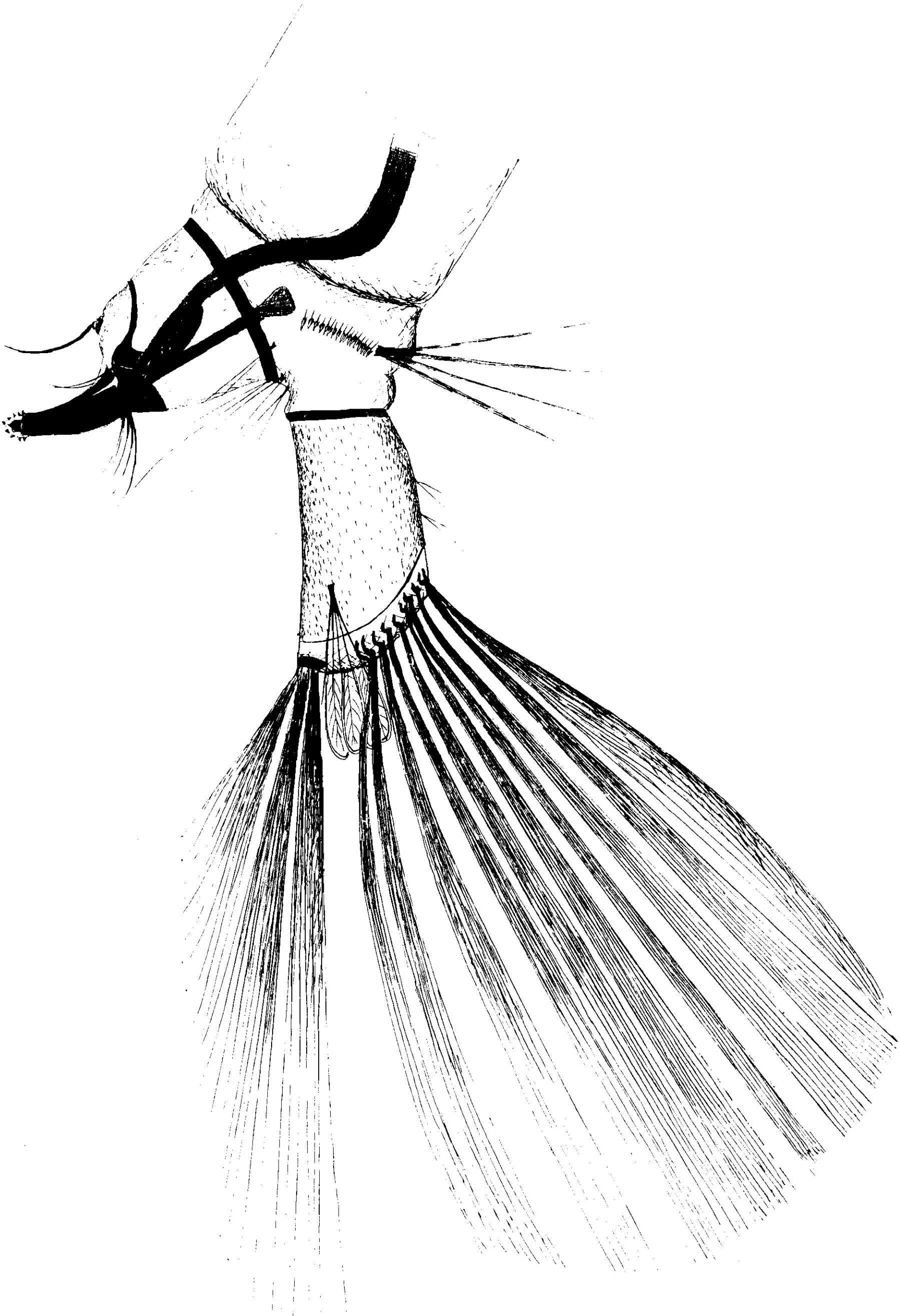


Fig. 19. 8th and 9th segment.

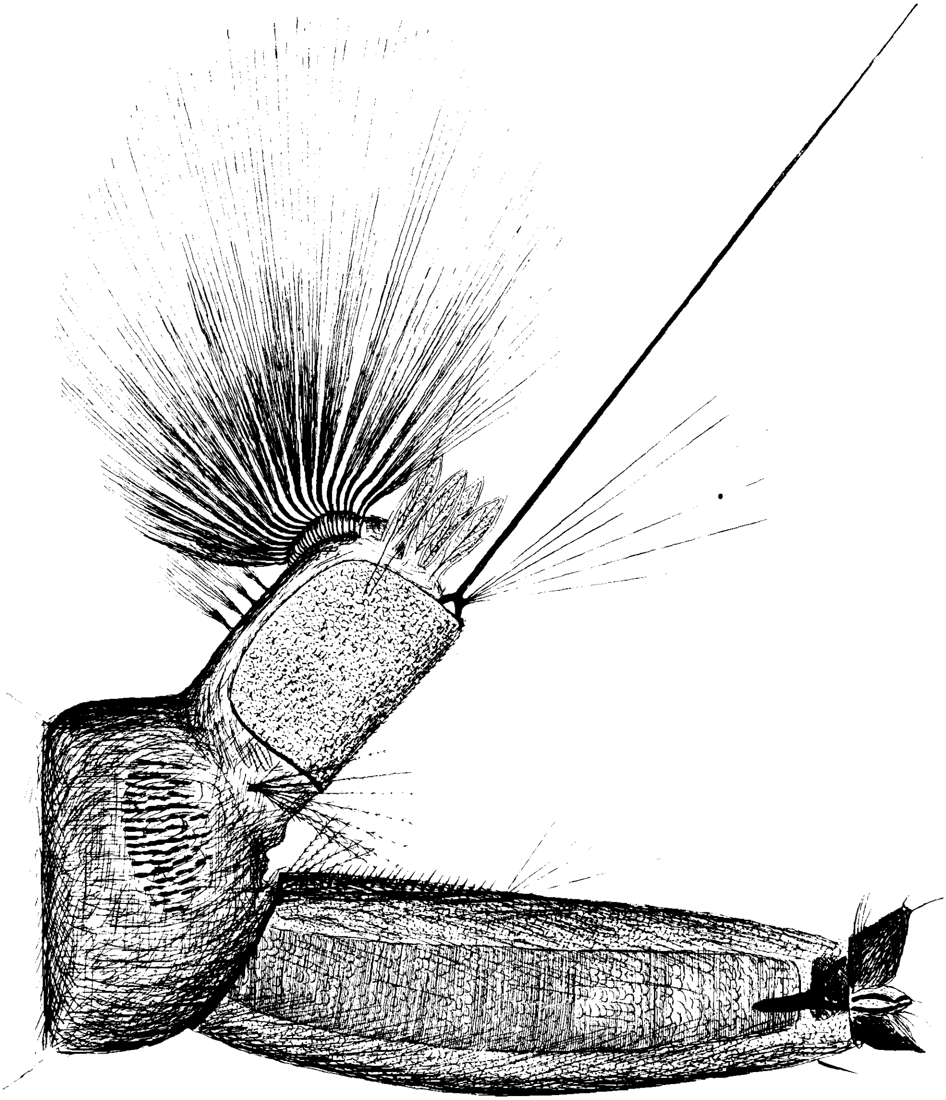


Fig. 20. 8th and 9th segment of *Culex* sp. for comparison with those of *Mansonia*.

unvariably sinks to the bottom over which it serpentizes in its idle and sluggish manner, until it has got hold of a plant.

At the first moment we are unable to understand what may be the use of the large tail. As we know that the tail of the *Sabetini* from the water-spaces in the leaves of *Bromeliaceæ* undergoes a high degree of reduction, we should be inclined to think, that the tail had been still more reduced in the case of the present almost entirely sedentary larvæ. It is only when studying the

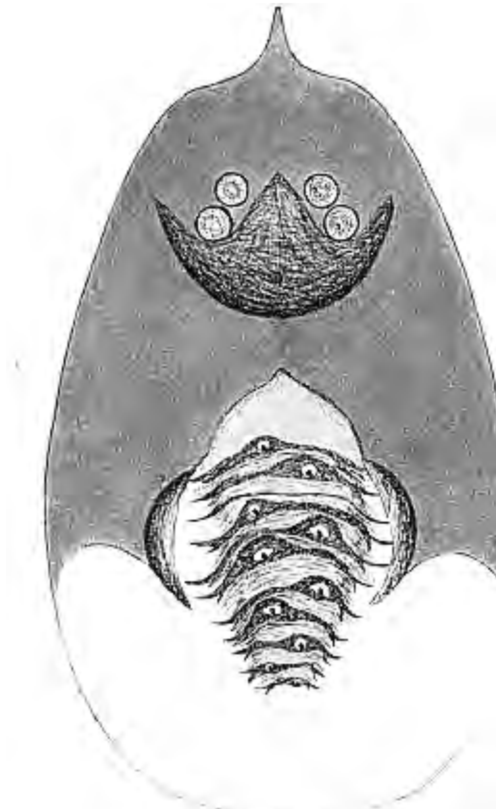


Fig. 21. The apex of the anal segment; the brushes and the tracheal gilles are omitted: the drawing shows the chitinous parts which support the dorsal and ventral brush; a bunch of bristles is inserted in each of the holes.

manner in which the sipho penetrates the plant tissues that we understand the importance of the tail. Later on we will return to this point, and it will then be demonstrated, that a change has taken place with regard to the function of the organ, and that this fact fully explains its high development.

Sipho.

The most peculiar organ of the larva is the sipho (figs. 22, 23, 24), by means of which the larva may immediately be distinguished from any other *Culicid*-larva. The sipho is short, no longer than the anal segment; anteriorly it is limitid by a dark, strongly chitinized ring. It may be described as consisting of two parts, an anterior part almost as broad as long, and a posterior

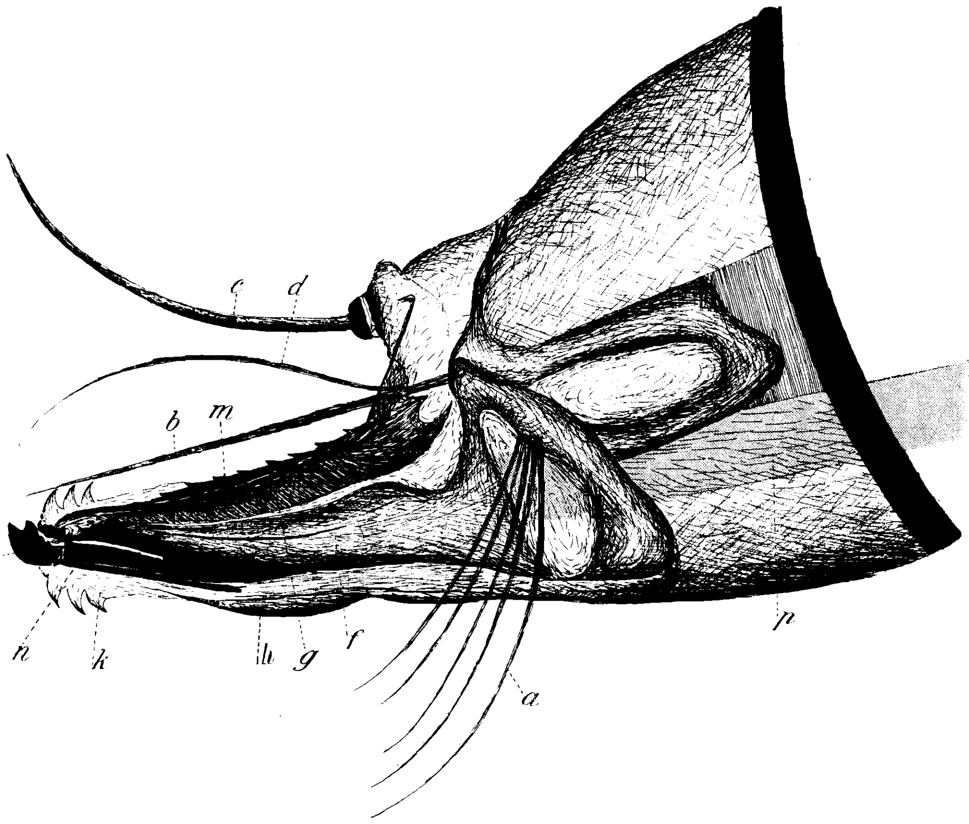


Fig. 22. Sipho seen laterally.

Signification of letters in figs. 22—34: *a*—*d* various bunches of bristles; *e* e_1 e_2 the two main-tracheæ and the part derived from the junction of the two stems (e_2); *f* ventral lateral pieces of outer tube: *g* dorsal lateral pieces of outer tube: *h* ventral piece of outer tube; *k* teeth on the apex of outer tubes: *m* dorsal piece of inner tube: *n* ventral piece of inner tube; *o* teeth on inner tube; *p* chitin rod; *r*—*s* the lateral pieces of the inner tube: *t* the muscles of the chitinrod: *u*—u_1 muscles; v_1 muscles with its ligament; *x*—*y* muscle which communicate with those (*y*) of the anal segment; *z* oblique muscles to the flaps: *æ* ganglion.

part shaped like a curved tube. The first part is covered by a yellowish, rather friable chitin, the other part is almost black and evidently very hardly chitinized. The tube is much narrower than the anterior part. Laterally, between the two parts, there is a bundle of five long bristles (*a*); further, on the dorsal side, two very stiff, long bristles (*b*). Dorsally on the hindedge of the anterior part we find two slightly chitinized, almost cushion-shaped

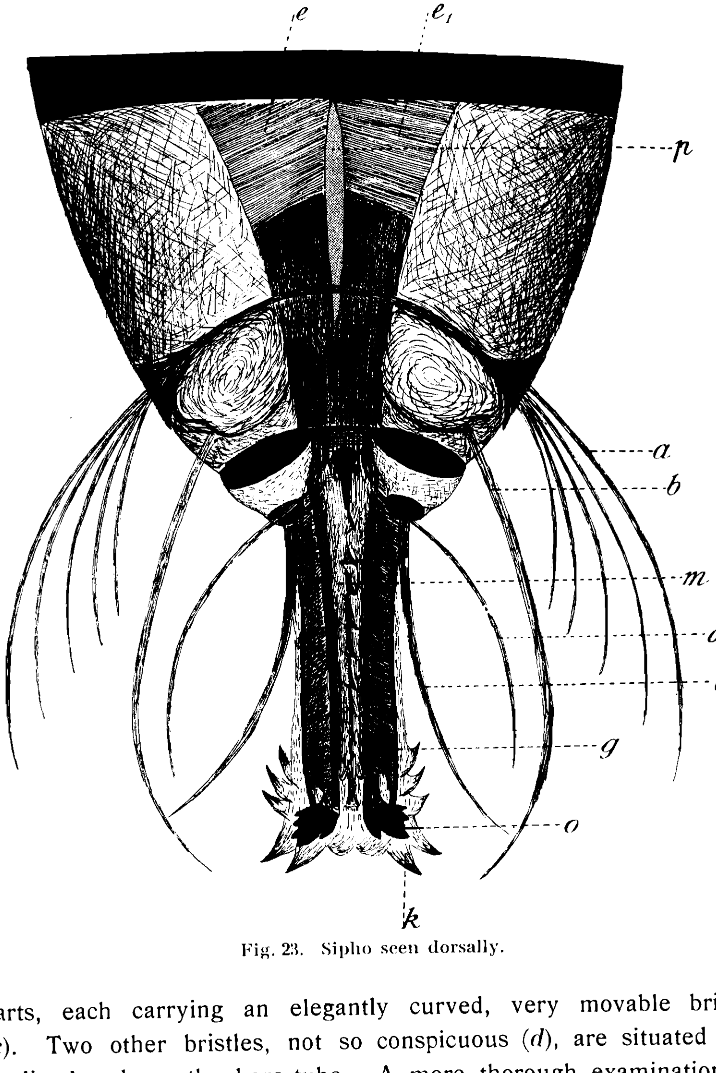


Fig. 23. Sipho seen dorsally.

parts, each carrying an elegantly curved, very movable bristle (*c*). Two other bristles, not so conspicuous (*d*), are situated immediately above the bore-tube. A more thorough examination of the organs is rather difficult owing to the very hard chitin. The two strong tracheal trunks (e, e_1) are in the sipho united in a common trunk transformed into an internal tube (e_2) (fig. 25) acting partly as a piercing organ partly as a respiratory tube; when it has forced its way into the airchambers of the plant, the air will pass through the stigma, i. e. the apex of the tube, and

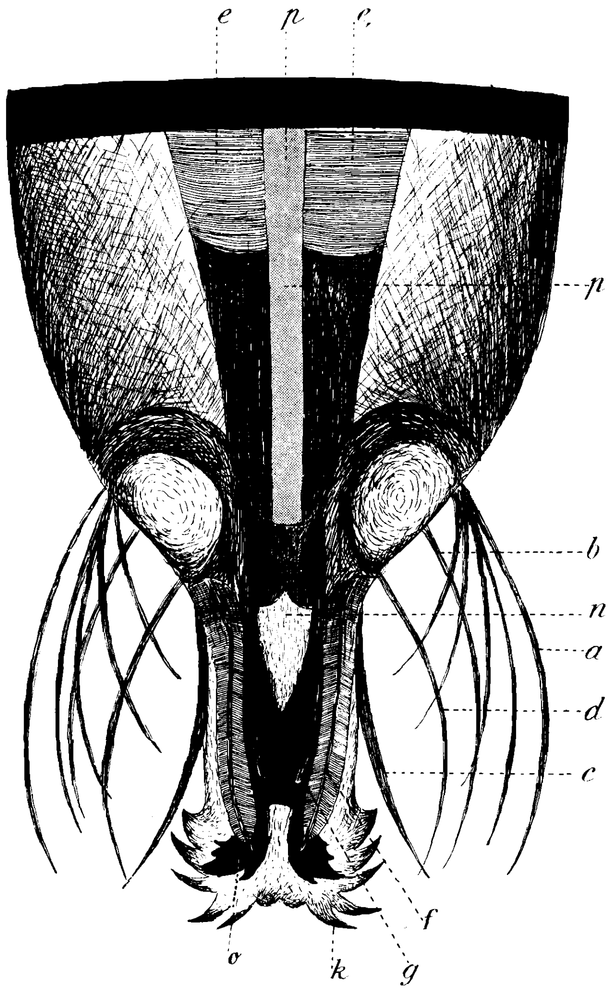


Fig. 24 Sipho seen ventrally.

further into the tracheal trunks. This inner tube is surrounded by another (figs. 22—24) formed by the five flaps which are found on the apex of every normal sipho of a *Culicid*-larva; in the present case they have only been highly elongated.

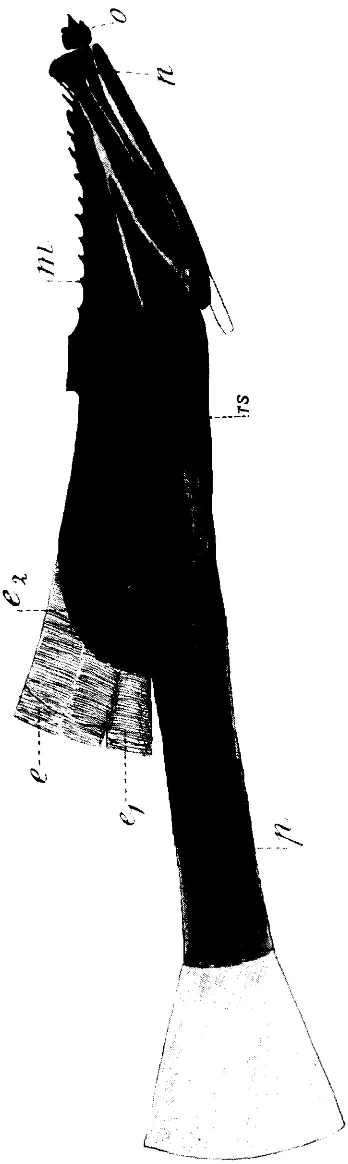


Fig. 25. The chitinous rod.

As mentioned above the outer tube consists of five pieces of which two pairs are laterally situated (fig. 22 *f g*) while one piece is ventral (*h*) [1] The ventral pieces (*f*) of the two lateral pairs are peculiarly transformed: in front they are bow-shaped, posteriorly they are prolonged as two long chitin sticks; partly connected with them are the pieces of the second pair (*g*), which are narrower, and the chitin of which is constructed similar to the vane of a feather. These two pairs of chitin pieces build together the flanks of the outer tube. Near its posterior edge the bow-shaped part of *f g* is furnished with the above named bundle of five long hairs (*a*), and on its dorsal side we find the two long bristles (*b*). Above the real bore tube, the posterior part of the whole sipho, we find the above-mentioned two cushion-shaped pieces with the two long curved bristles (*c*). The tube is dorsally split; the long median plate (*m*), which belongs to the inner tube, can slide forward and backward in that furrow. This plate is furnished with a series of very hard saw-teeth. Ventrally the tube is closed by a lancet-shaped plate (*h*), the apex of which consists of more light-coloured chitin. The five chitin pieces mentioned above lie as dark-coloured lists within a tube of soft hyaline chitin carrying on its apex a number of sharp, dark thorns of chitin (*k*).

The inner tube (fig. 25). As stated above, the two tracheal trunks are united to a common long tube, furnished anteriorly with a large bow-shaped curve, posteriorly with a number of ex-

[1]) In fig. 24 erroneously significated *n*.

tremely hard prolonged chitin pieces; the median dorsal piece is furnished with numerous saw-teeth; the two lateral pieces carry two thick, outward curving thorns on the apex (*o*). Ventrally to the point of union of the two tracheal trunks a long straight chitin staff is placed (*p*) reaching nearly to the middle of the eighth segment. The staff is flattened, black, dilatated into a broad plate of

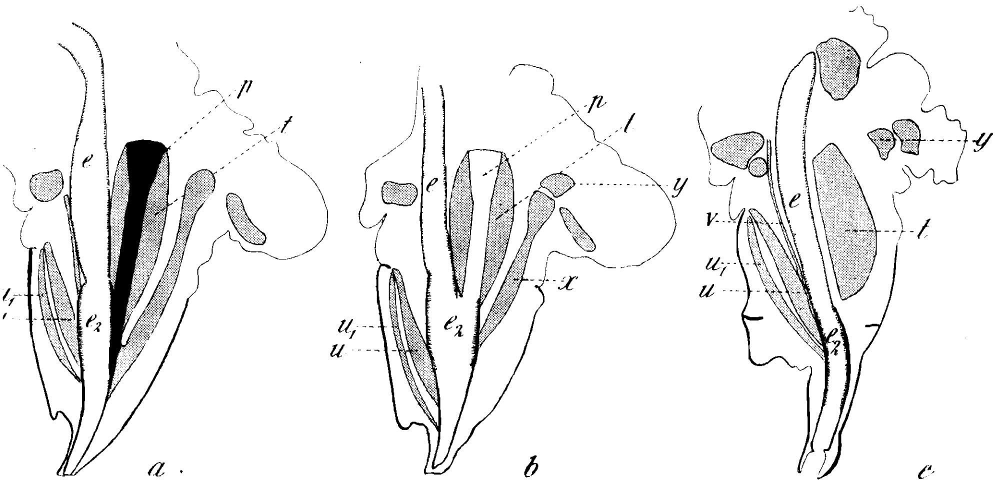
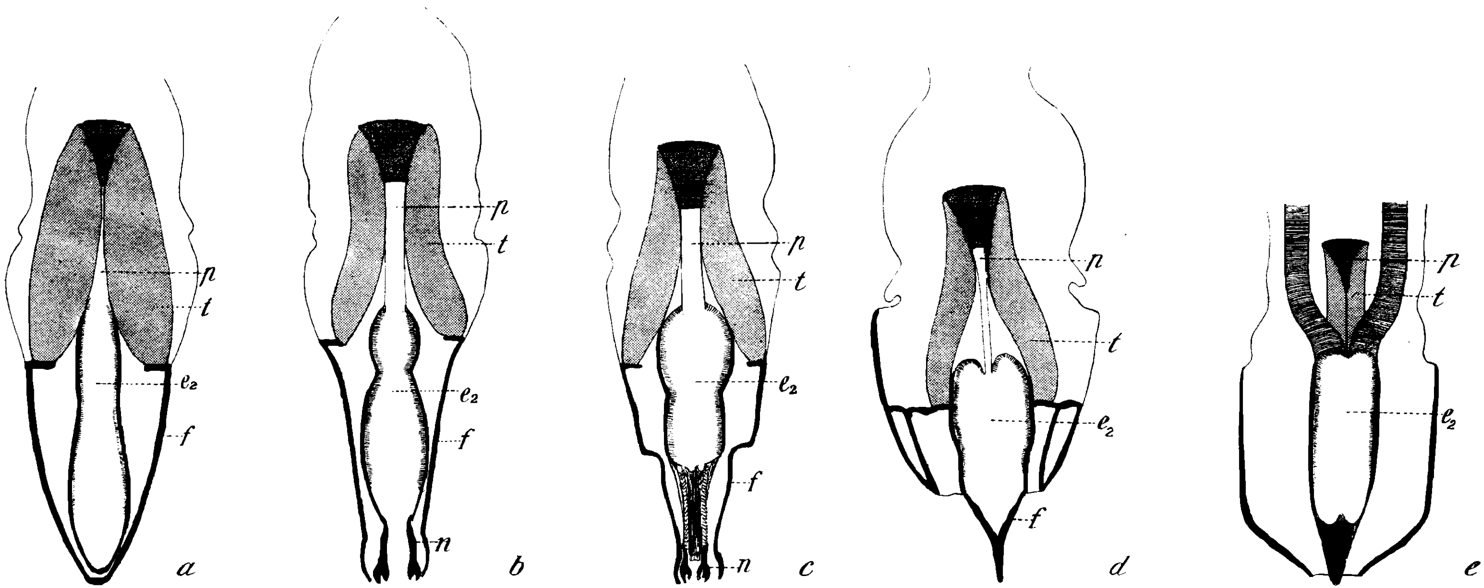


Fig. 26 *a*, *b*, *c*. Sagittal sections through the sipho.

lighter chitin at the anterior end. A series of sagittal cuts (fig. 26) through the sipho shows (fig. 26 *b*), that the staff is hollow, its lumen communicating with that of the tracheæ. The inner side of the common trunk of the two tracheæ is equipped by a coarse hair felt beginning near the point where the trunk is covered with chitin pieces. i. e. where the trunk is used as a piercing organ; anteriorly the hair felt reaches the point of union of the two tracheæ. Fig. 27 represents a series of horizontal sections. In *a* the chitin staff (*p*) and the lumen of the tracheal trunk (e_2) have just been hit. The section *b* represents a cut through the whole of the lumen of the united tracheæ; the figure shows, that the trachea terminates with a single orifice surrounded by chitin pieces. In *c* the cut has reached the bottom of the inner tube. In *d* the cut has passed almost entirely outside the piercing tube and met with the edge of the broad part of the sipho. The cut *e* has had another direction, exhibiting the point where the two tracheæ debouch into the large common trachea; its lumen may be regarded



27. Horizontal sections through the sipho.

as a large air-chamber; the hatching indicates the felt cover of the walls.

The transverse sections fig. 28 *a—j* give the same picture of the arrangement. Section *a* has struck the sipho at its point of

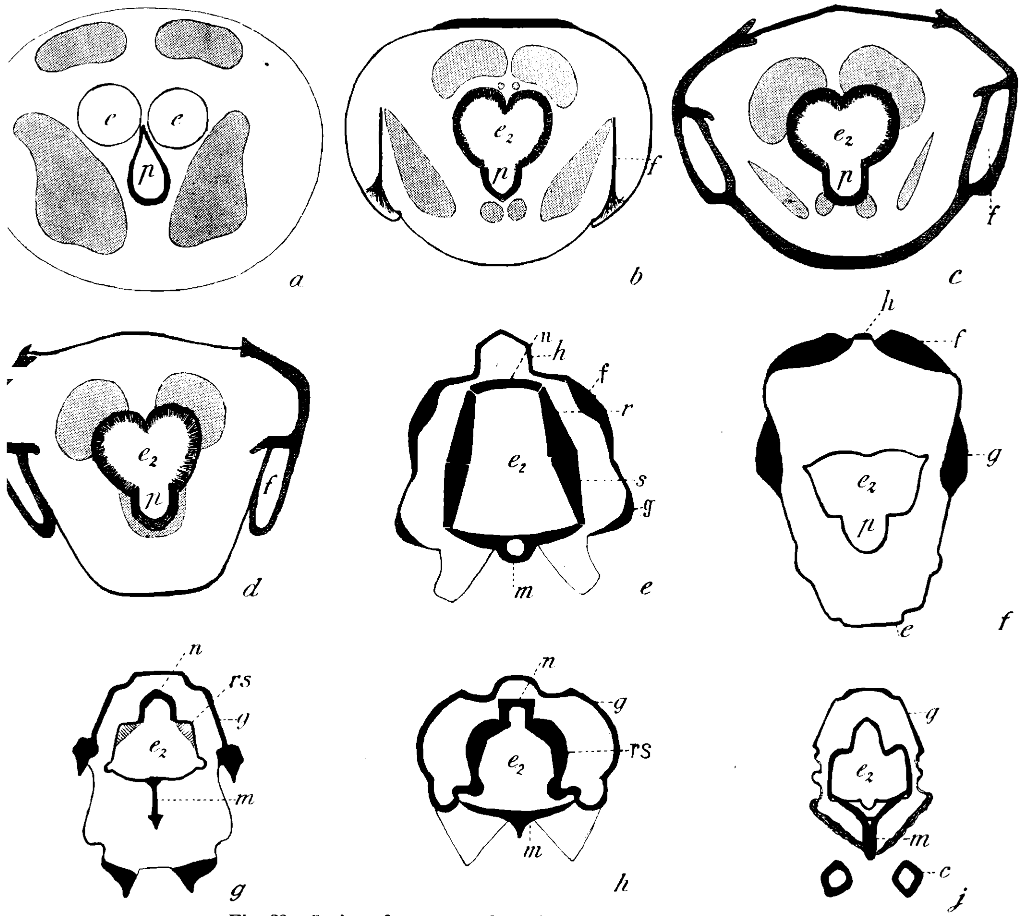


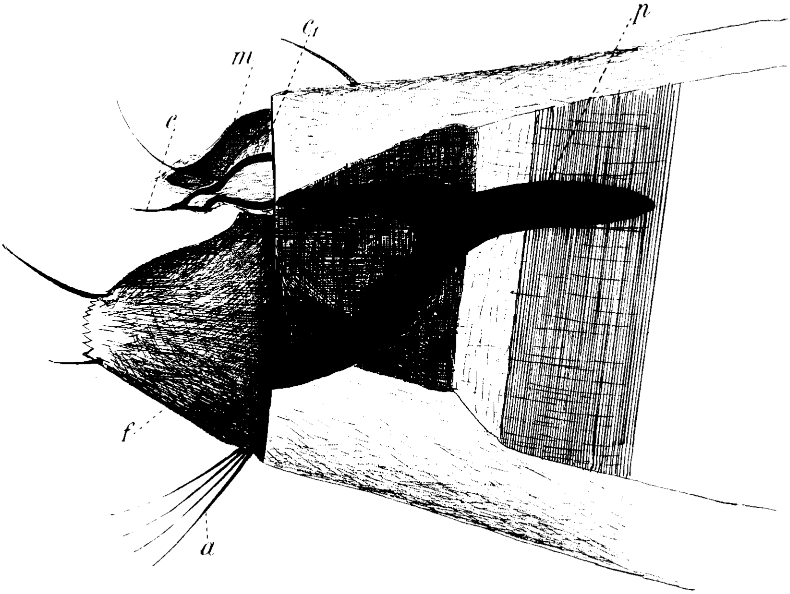
Fig. 28. Series of transversal sections through the sipho.

insertion in the 8th segment; we see the two tracheæ and the chitin staff (*p*). In *b* the common trachea (e_2) has been cut at the point where it coalesces with the chitin staff (*p*). Section *c* is cut through the bow-shaped chitin piece *f* near the point of origin of the piercing part of the sipho. The following transversal sections *d—j* have been cut through this part, *e* just at its origin. In section *e* the two lateral pieces *f* and *g* of the outer tube are still distinct, and the section has struck the spot where the chitinization of the inner tube is most heavy. The inner tube is compounded by 6 pieces. The section has passed between two teeth of the ventral piece; in *g* and *h* they have just passed through one of the following saw teeth. Near the apex of the outer tube the walls are very thin and furnished with stronger chitin teeth. The section *j* has just passed through the mouth of the tube; the section shows, that there is only one spiracle in the *Mansonia*-larva (Raschke points out the same fact with regard to the *Culex*-larva). The section shows, further, that the one side of the outer tube is groove-shaped; the saw teeth may be moved to and fro in the groove. When pushing the inner tube forwards and backwards within the outer tube the larva saws an opening in the plant tissue, which at the same time is pierced by the chitin thorns on the apex of the outer tube.

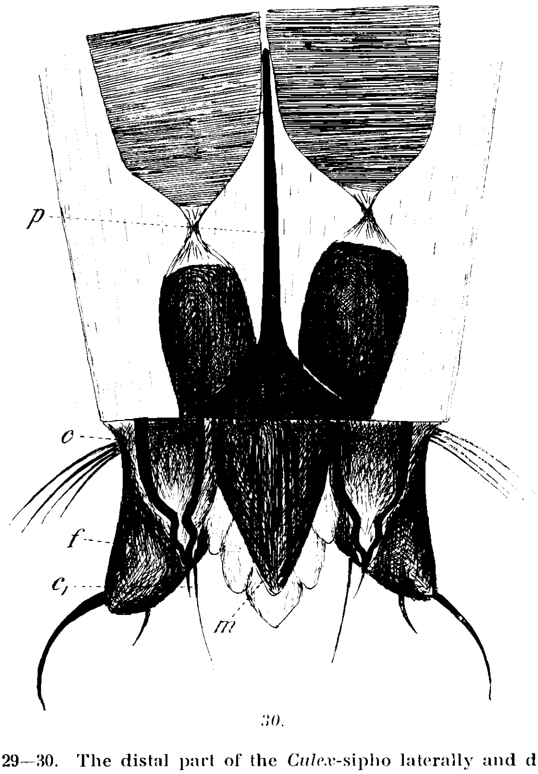
If we will try to understand the peculiar modification of the sipho of the *Mansonia* enabling the tube to be used as a passage for the plant-air and, at the same time, as a piercing organ, we must regard the sipho of the *Culicidæ* more thoroughly.

Originally the sipho of the mosquito larva carries on the apex 6 chitinous elements surrounding the spiracle. We find an anterior piece, a pair of lateral flaps, and three posterior pieces. This arrangement is the most primitive found among the mosquito-larvæ; hitherto it is only known in the case of *Anopheles*. The breathing tube of the other mosquito larvæ has developed from this type; it has only five pieces. Especially Nuttal & Shipley (1901 p. 64) and H. D. K. (1912 p. 92) have contributed to the understanding of this problem. Through the study of the sipho of *Uranotænia* the last mentioned authors have tried to demonstrate that the large triangular plate of the *Anopheles* larva is identical with the peculiar stirrup-shaped piece within the tube of the *Culex*; through that piece the tracheæ communicate with the outer air. Unfortunately the authors give no drawings of the facts in *Uranotænia*. The five flaps, surrounding the margin of the tube in most mosquito larvæ, correspond with the five other pieces in the *Anopheles*. Sections through the tube of *Anopheles* have convinced me of the correctnes of the opinion of H. D. K.

If the figures 29 and 30, representing respectively a lateral and a dorsal view of the apex of a *Culex*-sipho, are compared with



29.



30.

Figs. 29—30. The distal part of the *Culex*-sipho laterally and dorsally from an offthrown skinn.

the sipho of *Mansonia* (figs. 23 and 27), we will understand the transformations which have taken place.

Among the five normal flaps of a *Culex*-sipho the two largest, the ventral ones, are homologous with the ventral pair of the two pair of long pieces in the *Mansonia* tube. These two pieces carry a bunch of bristles (*a*), and so do the two ventral flaps in the *Culex*. We see, further, that the posterior edge of these flaps is serrated in the *Culex*. In all the hitherto known mosquito larvæ the two next lateral pieces are more hyaline and not so strongly chitinized; interiorly they are furnished with a peculiar chitin bow (c_1), carrying a short bristle on its apex (fig. 29*c*). They may possibly be homologized with the two dorsal lateral parts (*g*) in the outer tube of *Mansonia*. Still I am more inclined to homologize them with the two peculiar hyaline cushions carrying the two long curved climbing-bristles in *Mansonia*. According to my opinion, the single dorsal piece in the *Culex* is identical with the single dorsal piece provided with sawteeth in the tube of the *Mansonia* (*m*). According to the use of the extreme part of the sipho as a piercing organ, this piece has been displaced to the inner side of the tube and united with the inner tube; it is therefore best described in connection with this. The single, short, lancet-shaped piece (*h*) on the ventral side is the only new addition which has no parallel in the *Culex*. Another difference is the fine hyaline chitin between the pieces prolonged together with these, and the fact that the apex of the tube carries a number of thorns.

It is a wellknown fact, that the two main tracheæ in a common mosquito larva run into the sipho, terminating by the spiracles on its apex. According to previous authors as well as to H. D. K. there are two spiracles. They open in the bottom of the cup-shaped impression on the edges of which the closing apparatus is placed. As stated by Raschke the two tracheal trunks lose their spiral-thread structure towards the end and are transformed into firm cylindrical cups, provided with a considerable constriction at their bases. This is clearly shown in fig. 30. Between the two trunks there is a stiff, hollow chitinous rod, the "stirrup-shaped piece" of H. D. K., which is united with the two cups at their point of meeting, and partake in the limitation of the hollow space thus formed; accordingly this hollow space is formed by the cups on

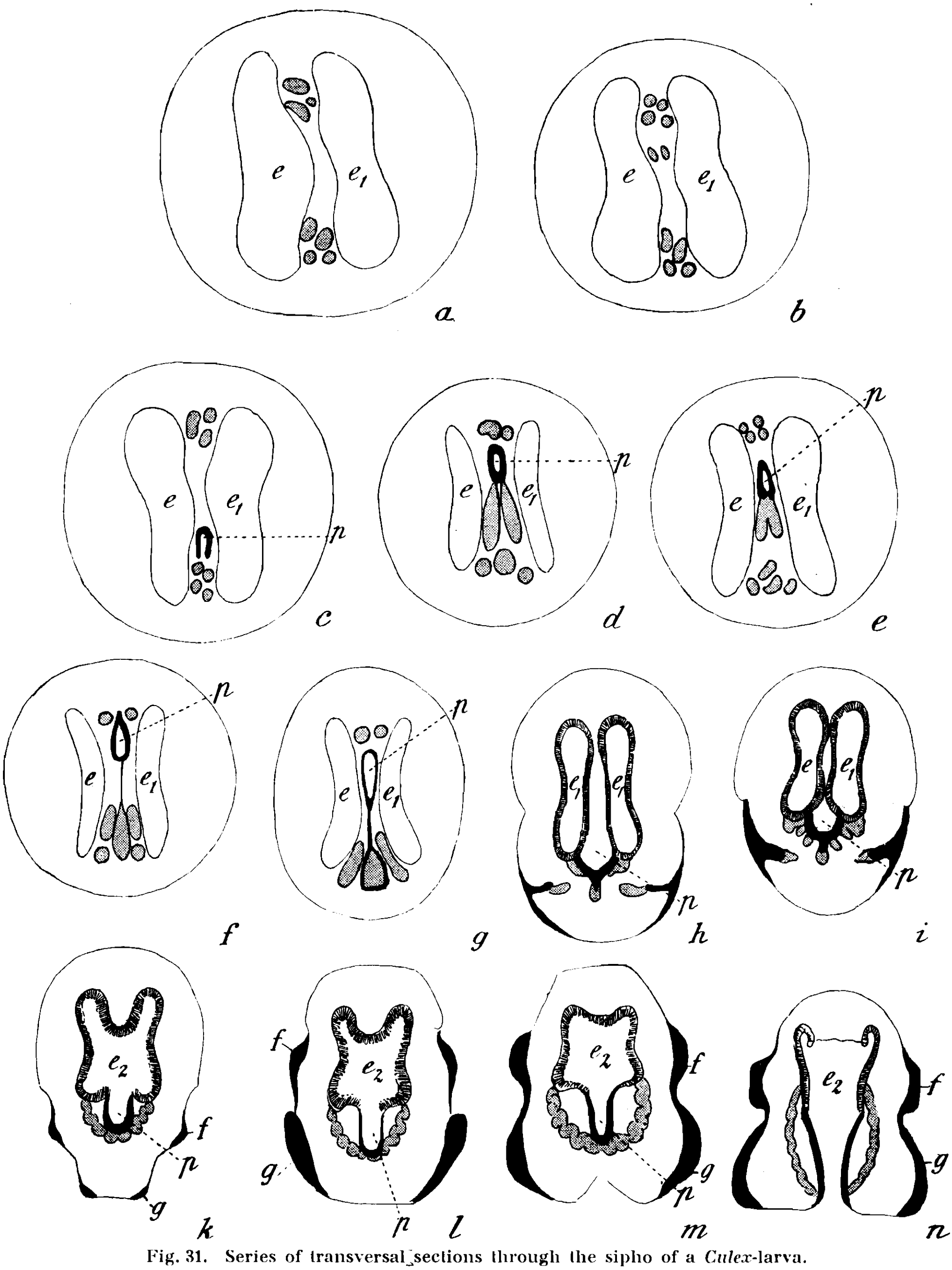


Fig. 31. Series of transversal sections through the sipho of a *Culex*-larva.

the right and left side and by the hollow rod above and below. Really the two tracheal trunks do not open separately to the outside, but, as stated by Raschke, through a single orifice. To the rod are attached: the long muscles which run through the whole of the sipho, further two slanting muscles going from the apex of the rod down to the two ventral, lateral flaps. The chitin rod is most clearly seen in fig. 30, drawn from a thrown-off skin of a *Culex*-larva.

Fig. 31 shows a series of transversal sections through the *Culex*-tube. Fig. 31 *a* and *b* show the two tracheæ and the muscles between them; in *c* the apex of the chitin rod may be seen; *d*—*g* show some different sections of the rod and the muscles attached to it; the sections *h*—*i* show the edges of the respiratory cup and the flaps, which appear in the drawing as thickenings in the walls of the outer tube. The sections *k*—*m* are cut through the respiratory cup itself; in *n* the section has struck a little outside the two ventral lateral flaps; sections *h*--*j* show that stay-bars of chitin lead inwards from these flaps and serve for attachment of muscles. As shown by the section these muscles are arranged rosary-shaped around the one side of the inner tube.

If we will try to understand the structure of the inner tube of the *Mansonia*-sipho, we only have to compare the transversal sections of this sipho with those of the *Culex*. It will then be obvious, that the only change which has taken place in the *Mansonia*-tube is a considerable prolongation of the cup-shaped impression in which the tracheæ terminate in the case of *Culex*; this also holds good with regard to the chitin rod. The section fig. 31 of the *Culex* is exactly in accordance with the section fig. 28 of the *Mansonia*. It must only be noted, that all muscles as well as the coarse hair cover of the inner lumen are absent from that part of the *Mansonia* tube used as a piercing organ; moreover the chitin of this part is very thick.

This will be further confirmed by a comparison of the series of horizontal cuts of the *Culex*-tube (fig. 32) with the corresponding series of *Mansonia* (fig. 27). The chitin rod is seen in *p*. In the *Culex* the felt cover is restricted to a very short part at the point of union of the two tracheæ.

We may imagine ourselves the transformation from the common

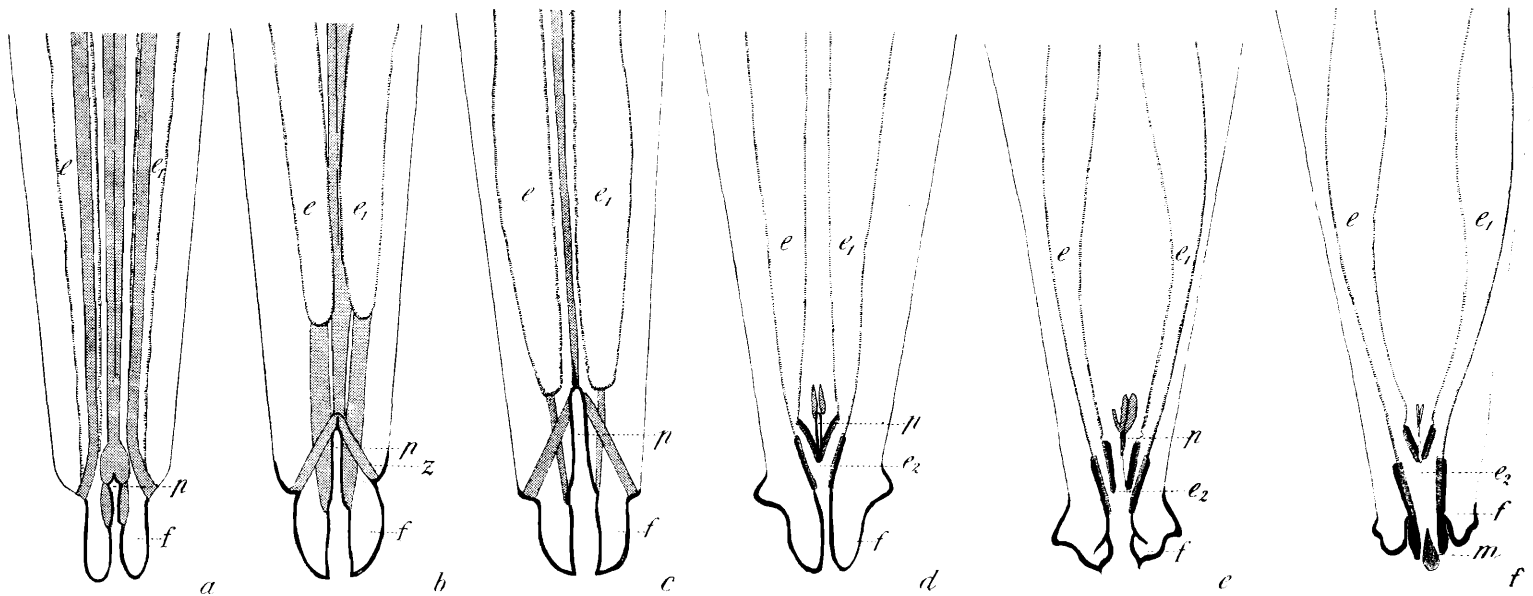


Fig. 32. Series of horizontal sections of the sipho of a *Culex*-larva.

sipho of the mosquito larva to the piercing organ of *Mansonia* by a mere prolongation of the felt covered part by e_2, i. e. the respiratory cup of the common mosquito larva in connection with the closing apparatus of the sipho; the cup is used by *Mansonia* as the proper piercing organ which in a telescope-like manner is inserted into the outer tube, built up of the 5 flaps of the closing apparatus; the walls of the piercing tube are strengthened by pieces usually not found in the mosquito larvæ.

It now remains to demonstrate the piercing action of the apparatus. When a larva is going to fix itself on a plant, it will go down into the thick texture of stalks, submersed leaves, roots etc. covering the bottom in most of our shallow ponds and smaller lakes. Where the vegetation is so dense that the larva may be steadied in all directions by means of its bristles, it will first try to bring its longitudinal axis parallel to a little green, living twig; then it makes some vigorous strokes with the tail and creeps backwards along the twig. By means of the binocular microscope it is possible to observe the points of the bunches of bristles on the back all acting as supporting points in relation to the twigs; simultaneously the sipho wrings in all directions, and the two long, curved bristles (*c*) above the sipho move upwards and downwards, the bristles acting as legs. The animal, secured in all directions by means of the bristles, climbs upwards.

Then the larva stop climbing. The sipho is now going to be used as a piercing organ, and is consequently dirigated vertically towards the twig; the two bristles are pressed into the tissue, and the anal segment is going to functionate. The large swimming-fan is moved to and fro, regularly as a clock-work; while the point of the sipho with the piercing teeth is pressed against the twigs the motion of the anal segment drives the point into the tissue. If the reader will throw a glance upon the microphoto (fig. 4) and imagine himself the above mentioned motion of the tail, and remember that the point of the sipho is pressed hard against the plant, he will understand, that by this motion combined with the action of the teeth on the apex the tube must be forced through the epidermis of the plant. The only condition still remaining is the possession of organs for transmission of power from the tail to the sipho. We will return to this point later on. We are now able to under-

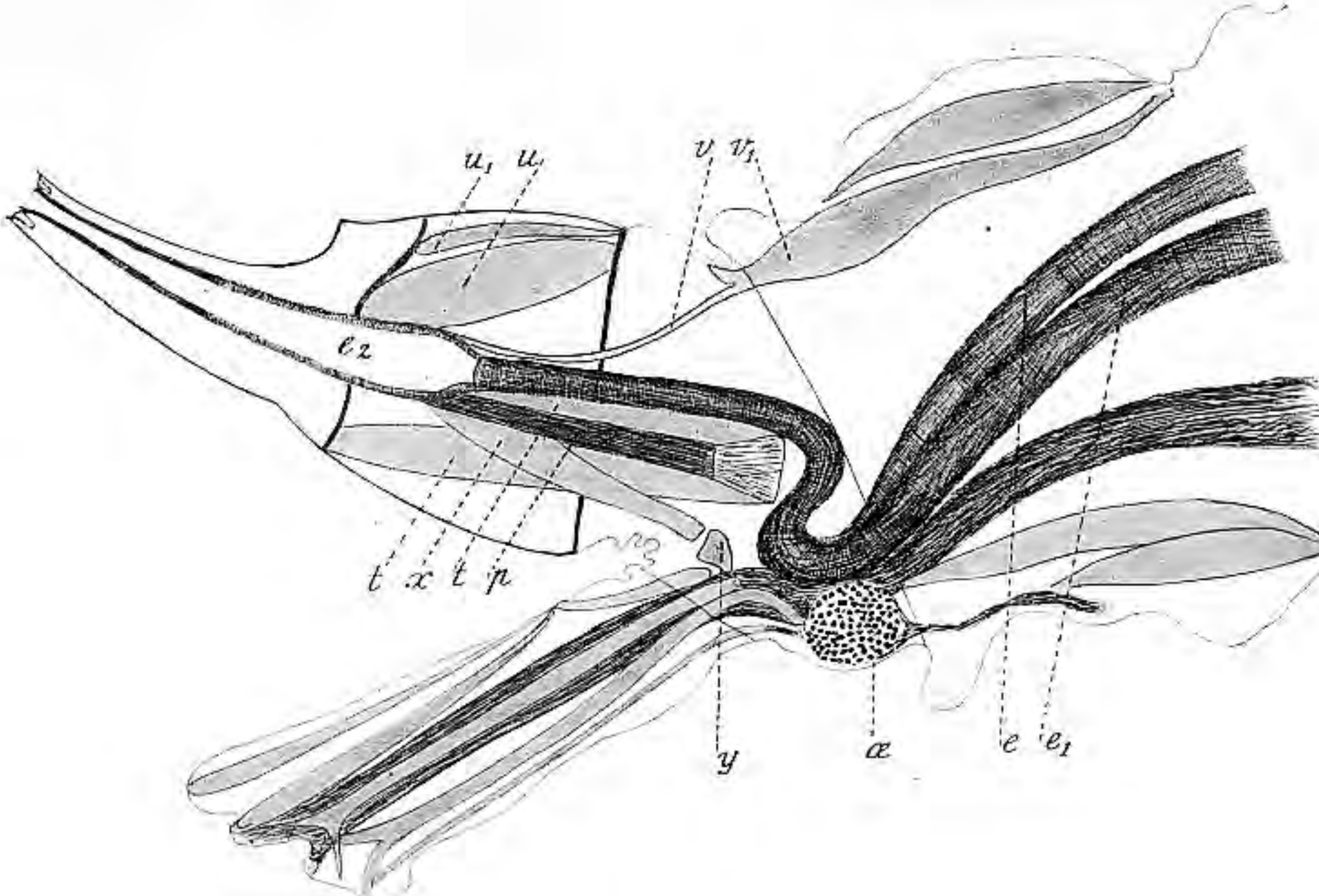


Fig. 33. **Sagittal section through 7th, 8th, and 9th segment: to show the most important muscles.**

stand the great development of the swimming-brush in an animal, the whole life of which may almost be regarded as sedentary. The brush has changed its function; from an organ used for swimming motions by the other mosquito larvæ, it has, in the *Mansonia*-larva, got quite another significance: viz. to force the sipho into the tissue.

It is impossible to observe directly what happens after the outer tube of the sipho has fixed itself on the plant. We only see, that the slender part of the sipho has disappeared into the plant. The animal is fixed very firmly; if suddenly disturbed, it is almost incapable of leaving its hold, and if cut in two that part with the sipho will remain hanging down from the plant till it decays. After all, however, there can be no doubt with regard to the piercing process after the fixation of the outer tube. The series of horizontal cuts shows, that two powerful muscles run along with the chitin rod (figs. 27 and 33 *t*); the one end of each muscle is fastened to the broad, flattened end of the rod, the other is fixed to the chitin bow which separates the broad part from the slender; a little above that point two other muscles issue (fig. 33 u u_1), running to the strongly chitinized posterior edge of the broad part of the sipho. A long ligament *v* fastens to the point where the tracheæ lose their tracheal structure; this ligament runs through the whole of the 8th segment; in the seventh segment it continues as a strong muscle (v_1). The same facts are shown by the section (fig. 28). Ventrally, opposite to this ligament, another muscle (fig. 33 *x*) is placed; this is connected with the muscular system in the ninth segment by another, shorter muscle (*y*). There is no doubt but that contractions and dilatations of these long muscles, especially those of the chitin rod, push the inner tube to and fro within the outer.

The muscular system of the *Mansonia* tube may be thought to have arisen from the corresponding muscles of a common mosquito larva through quite small modifications (fig. 33 and 34).

Raschke states, that the sipho of the *Culicidæ* is furnished with five pairs of muscles: two ventral pairs, two dorsal, and one attached to the chitin rod; the ventral and the dorsal pairs are fastened to the two pairs of flaps in the closing-apparatus; they traverse the long sipho through the whole of its length and are con-

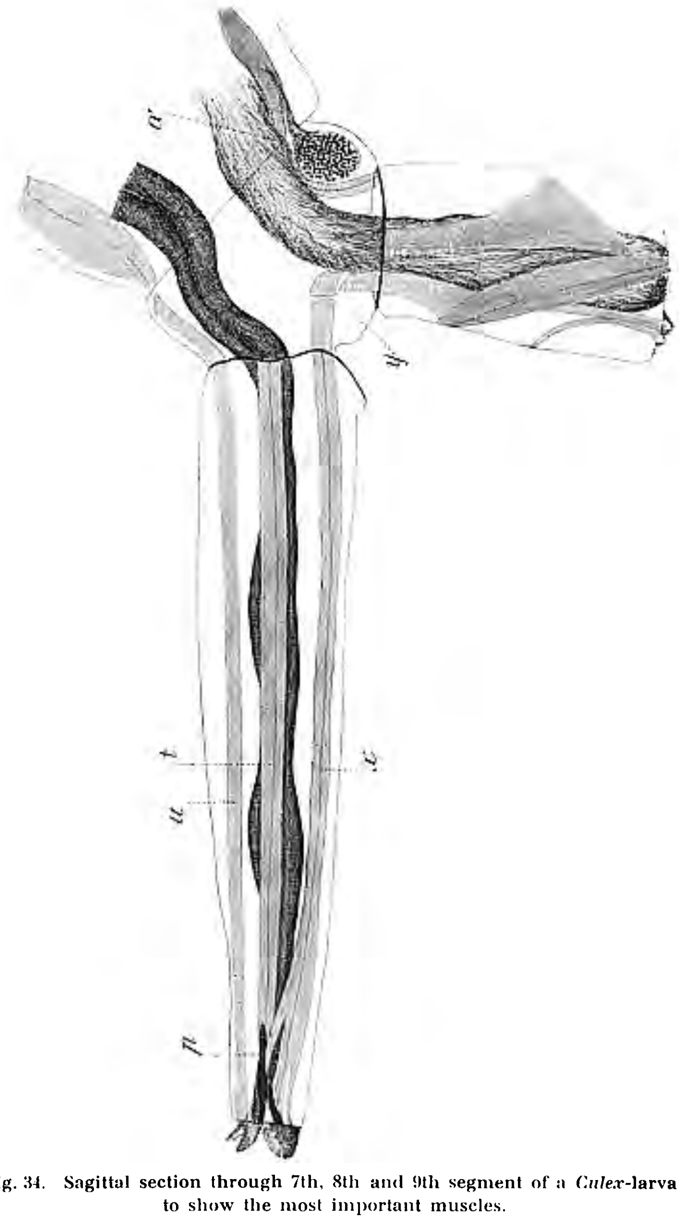


Fig. 34. Sagittal section through 7th, 8th and 9th segment of a *Culex*-larva; to show the most important muscles.

nected with the muscles in the 8th and the 9th segment. Their only function is to open and shut the closing-apparatus. My transversal and horizontal sections are exactly in accordance with the statements of Raschke; the sections only show that two muscles, and not but one, are fixed to the rod. The horizontal sections present a *Culex* sipho with the two muscles fixed to the rod and further the two ventral muscles; the next section passes through the tracheæ, and a later cut would have struck the dorsal pairs of muscles. Fig. 32 *z* shows two slanting muscles running to the ventral flaps.

Thus, in the *Mansonia* tube we find quite the same muscles as in the *Culex* tube. We find the same two long muscles (figs. 33, 34 *t*) fastened to the chitin rod. The dorsal and the ventral pairs of muscles are found even in the same position (figs. 33, 34 *x* and *u*). Only with regard to the above-mentioned long ligament found in the *Mansonia* I have been unable to find any correspondence with the *Culex*.

The muscle-apparatus of the *Culex* moves the flaps of the closing-apparatus; in *Mansonia* the corresponding muscles act in the same manner, but owing to the peculiar structure of the sipho this very action produces the piercing motion of that organ. In the case of *Mansonia* the modified closing-apparatus is not directly used in view of closing the spiracle; but, on the other hand, it may be supposed, that the spiracle is really closed, when the inner tube is pushed into the outer one. According to our interpretation of the tube of *Mansonia* as builded by the closing-apparatus of a *Culex* sipho, it is of interest to observe, as stated above, that the slender part of the *Mansonia* tube is fully destitute of muscles. This is just what should be expected if our supposition were correct. When regarding the sagittal section through the sipho of *Mansonia* we will observe, that the ventral muscle (fig. 33 *x*) which fastens at the point of origin of the cup, the point where the tracheal structure disappears, is connected with another, smaller muscle (fig. 33 *y*) in the 8th segment; this small muscle is further connected with the muscles in the 9th segment. This segment is traversed by a number of muscles beginning in the 8th segment and fixed to that system of chitin rods which support the dorsal and ventral part of the swimming-brush. As stated above, it will now be understood, that the motion up and down of the anal segment, when the larva is sitting with the tip of the sipho pressed against the plant, will be transferred through the muscular system to the chitin rod, and from this to the inner tube. By the strokes of the tail the tip of the sipho is forced into the plant-tissue.

If we regard the sagittal section of a *Culex* sipho (fig. 34) we will find the same small muscle (*y*) connecting the muscular system of the sipho with that of the tail (9th segment). We will understand, therefore, that also in the caese of the *Culex* a transmission of power takes place; but here it has quite another importance. When the *Culex*-larva, super-compensated, with the sipho upward directed, arises towards the surface, the closing-apparatus is closed; when the animal arrives to the surface, the bristles on the flaps break the surface-film, and by contraction of the muscles the flaps are separated and spread out upon the surface; then there is free passage for the atmospherical air to the tracheæ; the larva hangs down from the surface supported by the surface-film. During the ascent the tail is not used at all.

The process is quite different when the sipho is going to be relaxed from the surface. Then we see very often, and especially when the larva is frightened, the animal making some very vigorous strokes with the tail. These strokes just relax the closing-apparatus from the surface. Altogether the swimming-brush in the *Culex* has quite the same function as in the *Mansonia*. The only difference is to be found in the medium from which the air has to be taken. *Mansonia* is obliged to p i e r c e the sipho into plant-tissues; the common mosquito larva must p u s h it through the surface-film; the swimming-brush of the *Mansonia* tail is the main organ enabling the animal to force its way into the air; in the case of the other mosquito larvæ the organ is, in this regard, often unnescesary, and the only importance of the tail is that of a swimming-organ. But whatever the *Culex*-larva shall leave the surface or the *Mansonia* its twig, we see in both cases the larva getting free from the supporting medium by means of the tail.

Finally it must be added, that the earlier decriptions of the sipho of *Mansonia* have been rather incomplete. As stated by H. D. K., the shape of the sipho is rather different in the two *Mansonia* larvæ hitherto described. With regard to *M. perturbans*

H. D. K. (1915 p. 507) state as follows: "Air tube about twice as long as wide, the basal part broad and strongly convex, the apical portion attenuated, anterior apical third channeled; two filamentous hairs arise from near base of attenuated portion, the anterior wall of which is thick and finely dentate, ending in terminal hooks; no pecten, a single pair of hair tufts at basal third." That of *titillans* is decribed as follows H. D. K. (1915 p. 519): "Air tube short, conical, the apical portion attenuated, bearing a tuft of four hairs on each side near the middle and a pair of filaments at base of apical projection; this consists of two thick lamellæ with a group of hooks at the tip and two or three stout teeth on the anterior aspect medially." As far as I can see, none of the two descriptions are in full accordance with the sipho of *M. Richardii.*

The tracheal system.

If we regard a living larva (fig. 35) the attention will immediately be attracted by the tracheal system. Between the thorax and the first abdominal segment two large bladders are situated; the half part of the bladders reaches into the thorax and occupies a great deal of its cavity. At the first glance these bladders resemble those of the *Corethra*-larva, but differ from these in being connected with the two main tracheæ by two smaller, right-angularly curved tracheæ. The point of insertion is situated at the limit between the thorax and the abdomen. Fig. 36 illustrates the description. It will be seen that the front parts of the bladders are furnished with some few short, slender tracheæ, and that the two large longitudinal stems of the body are broad, band-like in the thorax and the first part of the abdomen. In fact, these main tracheæ are double, consisting of two associated trunks, still indicated by a longitudinal fold; in the thorax each of the two trunks is further divided by another longitudinal fold. The

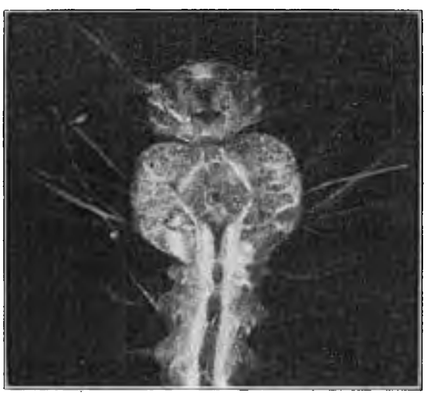


Fig. 35. Microphoto of living larva to show the flattened tracheal stems and the two large bladders (the white spots between thorax and abdomen).

result is two broad, flat, band-like bodies, terminating in front (fig. 37) in three tracheæ the first of which has a lateral course, while the second is forward directed and sends branches to the head; the third, inner branch is smaller and communicates with that from the other side. In the abdomen each of the main tracheæ sends a smaller branch to the alimentary canal and a larger, outer one which branches in a star-like manner; one of these branches

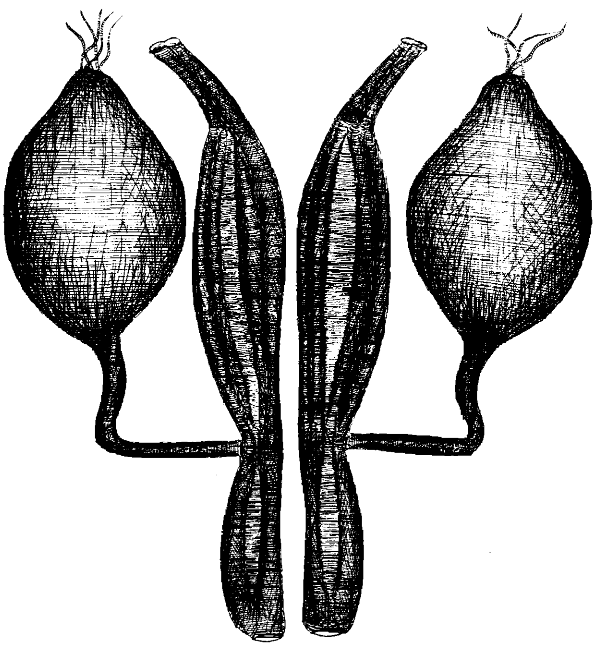


Fig. 36. The bladders and adjacent parts of the tracheæ.

is stronger than the others and runs into the preceding segment. In the 8th segment a strong trachea branches off, running into the anal segment, sending out branches to the gills.

The two large bladders in the thorax make one of the most peculiar structures in this larva. Perhaps they may best be compared with those of the *Mochlonyx*-larva, but while these are to be regarded as mere expansions of the main tracheæ, the bladders of the *Mansonia*-larvæ are freely placed laterally on long, angular branches inserted to the main tracheæ. It must be remembered, that air-bladders are extremely rare among insect larvæ; as far as

I am aware, they have only been described in *Corethra* and *Mochlonyx*; it was, therefore, of great interest to find an entirely new type in another larva. As in *Corethra* and *Mochlonyx*, the bladders in *Mansonia* are transversally striped, a fact to which we must pay attention, because the bladders on the tracheal system of imagines are without transversal stripes, the walls being of a homogenous appearance.

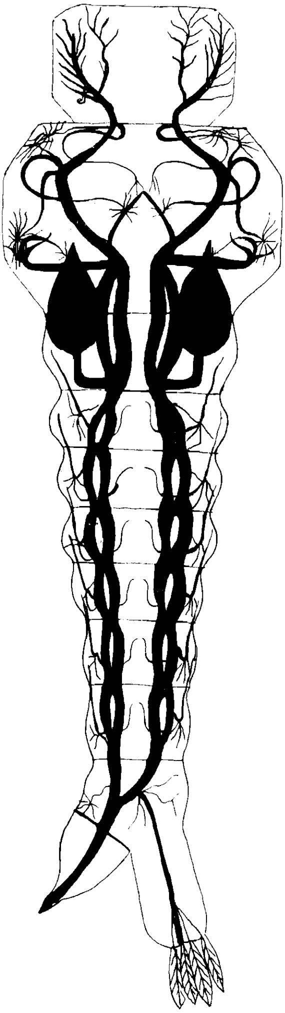


Fig. 37. The trachael system of the larva.

I have tried to understand the mode of action of this peculiar tracheal-system, being, as far as I know, unique among the insects. Later on Prof. A. Krogh has been kind enough to read my manuscript and has discussed the problem with me. — Out from the very broad band-like tracheal trunks it can only be concluded that the larvæ must be able to produce a very powerful respiration. This must probably be of great significance for the larva because the air in the plant, from a respiratorical point of view, is a very bad medium, by no means being rich on oxygen. This has been stated by Ege (1915 p. 183). The main result of his investigations is, "that the composition of the air in the intercellular spaces of different aquatic plants is very variable. The oxygen percentage is low, rarely higher than 10 % and can especially during winter sink to about 1—2 % and even still less." When we remember, that the larva probably not fixes itself to the plant until in September and probably detaches itself in May, the animal living as imago or egg during the time May-September, it will be understood, that the larva is dependent on the plant-air especially at the season when the oxygen percentage is lowest.

Being unable to procure living animals for experiment, we must restrict ourselves to remark, that we are, at this moment, quite unable to understand the significance of the bladders. Most probably they have some relation to the peculiar respiratory process.

It is of some interest to remember, that the *Mansonia*-larvæ probably not are the only mosquito-larvæ which make use of the air in the intercellular rooms of the plants. According to H. D. K. (1917 p. 894), the larvæ of the genus *Aëdeomyia (A. squamipennis* and *catasticta)* are to be found in shallow ponds covered with the water-plant *Pistia* "from which they probably derive their supply of air although their habits have not been exactly determined." They do not come to the surface but hide between the water plants. The sipho presents no peculiar structure, being shaped as a sipho of a common mosquito-larva; only the tracheæ of the tube are said to be rudimentary. On the other hand, the antennæ have a very peculiar appearance in comparison with those of the other mosquito-larvæ, being strongly curved, inflated hollow, with a stout, spinose digit on the tip. H. D. K. (1917 p. 898) suppose, that these inflated antennæ may play some part in the respiratory process.

Pupa and Eggs.

Owing to the peculiar misfortune, that the pond was dried up, I was unable to find the other stadia: the pupa and the eggs. The pupa is known in the cases of *M. titillans* (H. D. K. 1915 p. 519—520), and *M. uniformis* (Theobald 1903 p. 270).

The pupæ resemble the common mosquito-pupæ, but differ from these in their siphos being very long and "the orifice furnished with a flap on the outer side half as long as the tube with lateral membrane on each side not quite reaching tip". It has been presumed, that nor the pupæ come to the surface but remain submersed, attached to aquatic plants by their respiratory siphos, the chitinous spine on the top of the trumpets being used as a piercing organ. The peculiar hairs on the first abdominal segment, used by most *Culicid*-pupæ as supporting organs in relation to the surface-film, are wanting in *Mansonia*. As far as I am aware, nobody has hitherto found the pupa attached to plants, but owing to the structure of the trumpets and the want of the above-mentioned hairs, it must be regarded as very probable, that the supposition is correct.

The eggs of *Mansonia* have been described by different authors (see Dyar and Knab 1910 p. 259). Further they have been thoroughly described by the said authors in a special paper (1916 p. 61). The following remarks are taken from that paper. The eggs of the three American species *M. fasciolatus*, Arrib., *arribálzagœ* Theob., and *perturbans* Walk., do not differ very much in shape, arrangement, and manner of disposal from eggs of typical *Culex*. The egg-boats float upon the surface of the water, one end usually resting against an aquatic plant; still there is some difference in the arrangement of the eggs of the three species. The eggs of *M. titillans* found by Moore, are of quite another type; they are placed on the under-surface of the leaves of *Pistia* and deposited in a mass, generally between ribs of the leaves. They are attached to the leaves with their bases very closely crowded together and apparently kept by a cement secreted by the female. The number of eggs in a cluster exceeds 150. Moore has observed directly, that at least the abdomen was submersed when ovipositing. "The lower half of her abdomen was submerged and bent or curved back, the segment somewhat extended, and was being moved slowly from side to side the eggs seeming to issue forth in rapid succession and to be as rapidly set up each in its place . . . air bubbles were entangled in the abdominal scales and on the leaf itself. According as the cluster enlarged in her direction she drew her abdomen more and more up, so that when she finished at 6,35 not much more than the tip of it was curved under the leaf. When she first started more than half of her abdomen would have been under the water. The freshly laid cluster was white". Dyar and Knab call attention to the fact, that the abdomen of the female of *M. titillans* is unusually hairy, the hairs being well distributed and coarse. This is no doubt an adaptation that, by entangling, the air between the hairs prevents the body itself from becoming wet while immersed. Moore supposes that the female, when at work on *Pistia*, really works in a globule of air, for, owing to the dense pilosity of the leaf, the under-surface is simply aglow with air-bubbles, so that the leaf probably rests more on air than on water. The egg-shell of this species presents no special structure; it resembles that of most other *Culicidæ*.

In the same paper Dyar and Knab describe another egg also forwarded to them by Moore. The egg is furnished with a small neck from the upper edge of which four pairs of horns project upon very short stalks; these horns appear to consist of solid chitin and taper into a sharp point. Later on, Moore found the species which laid these eggs; it was described as a new species, *M. humeralis* Dyar and Knab. These eggs are of interest, because they resemble the eggs of *Nepa* and *Ranatra*; as well known, these water bugs pierce their eggs into half decaying plant material, and the crown of spines round the tip of the eggs are commonly regarded as a respiratory organ. Dyar and Knab also regarded the spines of the egg of *Mansonia* as in some way connected with the problem of air-supply.

We must here finish our remarks relating to the biology of these very interesting mosquito-larvæ. As a matter of fact, their biology is still very incompletely known. From the material in hand we are unable to trace the ways of this peculiar genus enabling the larva to emancipate itself from the atmospherical air above the surface of the water and seek the air stored within the air-chambers of submersed water-plants. It seems as if the grade of adaptation is not exactly the same in the different species. The peculiar fact, that at least one species does not construct egg-boats but lime the eggs to the plants, and that the egg-shells of another species are constructed similarly to those of animals the eggs of which are pierced into plant-tissues, let us presume, that further studies will also let us know larvæ in which the modus of respiration as well as the shape of the sipho represent the "missing link", transmissions to the normal facts in the common mosquito larvæ. Undoubtedly we must search in the tropics if we want to solve these questions. It would be unreasonable to expect, that it should be possible to find the solution of the problems in a little pond in North Seeland far away from the center of the geographical distribution of the genus.

Finally I have to bring the Carlsbergfond my heartiest thanks for a dotation for which the figures have been reproduced.

The Danish Freshwater Biological Laboratory, Hillerød, January 1918.

Literature.

1905. Blanchard, R. Les moustiques. Paris 1905.

1910. Bøving, A. Natural History of the larvæ of *Donaciinæ*. Internationale Revue. Leipzig. p. 1.

1910. Dyar, H. and Knab, F. The genus *Mansonia* Entom. News. **21**, p. 259.

1916. — — — Eggs and Oviposition in certain species of *Mansonia*. Insec. Inscitæ Menstruus **4**. p. 61.

1915. Ege, R. On the Respiratory Conditions of the Larvæ and Pupa of *Donaciæ*. Vid. Medd. Dansk Naturh. Foren. **66**. p. 183.

1902. Giles, G. A handbook of the gnaths or mosquitoes. London.

1905. Goeldi, E. Os mosquitos no Pará. Mem. Mus. Goeldi. Hist. nat. eth. **4**.

1912—1917. Howard, L., Dyar, H., Knab, F. The Mosquitoes of North- and Central America and the West Indies. Washington.*)

1911. Krogh, A On the hydrostatical Mechanism of the *Corethra* Larva with an account of Methods of Microscopical Gas Analyses. Scand. Arch. Physiol. **25**. p. 183.

1886. Meinert, F. De eucephale Myggelarver. Danske Vidensk. Selsk. Skr. Math. Nat. Afd. Ser. **6**. Vol. **3**.

1916. Meijere, J. C. Beiträge zur Dipteren-Larven und Puppen. Zool. Jahrb. Abth. Syst. **40**. p 177.

1901—1903. Nuttall G., & Shipley, A. Studies in Relation to Malaria. Journ. Hyg. **I**. p. 45; p. 269. p. 451. **2**. p. 58. **3**. p. 166.

1887. Raschke, E. Die Larve von *Culex nemorosus*. Archiv f. Naturges. **53**. p. 133.

1901—1910. Theobald, F. A Monograph of the *Culicidæ*. London. British Museum. Vol. I—V.

1908. Smith, J. Notes on Larval Habits of *Mansonia*. Entom. News. **19**. p. 22.

1905. Thomson, M. The Alimentary Canal of the Mosquito. Proceed. Boston Soc. Nat. Hist. **32**. p. 145.

1915. Wesenberg-Lund, C. Insektlivet i ferske Vande. København.

*) Commonly abbreviated to H. D. K.

15—3—18.

Andelsbogtrykkeriet i Odense.