

XIX. CONTRIBUTIONS TO THE ANATOMY OF AQUATIC DIPTERA.

1. LARVAL AND PUPAL STAGES OF AN INDIAN *CHAOBORUS* AND *DIXA*.

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(With Plate XIX.)

In a previous communication¹ I described the anatomy of an Indian Chironomid larva of the genus *Polypedilum*. The present paper deals with the larval and pupal stages of two other Nematocera—*Chaoborus* and *Dixa*. It is hoped that it may be followed by others on various aquatic Diptera, our knowledge of the Indian forms being in a very unsatisfactory condition. Most of the material for the present investigation was put at my disposal by the Director of the Zoological Survey of India; some I had collected myself.

The larvae and pupae of the Corethrid *Chaoborus* were collected by Dr. Annandale in the *Limnocnida* pool in the river Yenna, at Medha in the Satara district, Bombay Presidency, during the first week of March, 1918; the material was well preserved, and both larvae and pupae were found in abundance. Besides this I had a large number of larvae collected in the third week of April, 1912, at the same place by Dr. F. H. Gravely. No pupae were obtained on this occasion, though larvae were abundant. I also had for comparison a single specimen collected by myself in a shady pool in the Lawrence Gardens, Lahore, in the month of November, 1916; observations were made on this living larva whilst it was kept in a small aquarium in the Zoological Laboratory of the Government College, Lahore, for a period of over two months; the larva even after this long period did not pupate and was preserved in formalin. A few remarks about the name of the fly to which the larvae and pupae belong would not be out of place here. Giles² in 1910 described the fly as *Corethra asiatica* as a new species from Shahjahanpur, and it was referred to as such by Theobald.³ Edwards, however, has recently⁴ shown that the form is specifically identical with the one described by Schiner in 1868 as *Corethra manilensis* (*Reise Novara, Diptera*, p. 30). Further, the species does not belong to the genus *Corethra* as now restricted, but is a *Chaoborus*. The name of the fly must, therefore, be *Chaoborus manilensis* (Schiner).

The larvae and pupae of *Dixa* were collected by Major S. R. Christophers, I.M.S., from the hill streams at Kasauli in February, 1914. A large number of flies was reared by him, and the whole collection of

¹ *Rec. Ind. Mus.*, XIV, pp. 71-74, pl. xxiii (1918).

² *Journ. Bombay Nat. Hist. Soc.*, XIII, p. 610 (1910).

³ *Genera Insectorum, Diptera*, p. 43 (1905).

⁴ *Bull. Ent. Res.*, IV, p. 242 (1913-14).

larvae, pupae and flies presented to the Indian Museum, Calcutta. The fly has been identified as *Dixa montana*, Brun., by Dr. Annandale after comparison with the type-specimen. Mrs. Adie¹ has recorded the finding of a large number of larvae of a species of *Dixa*, in a pond in the Lawrence Gardens, Lahore. On many occasions I tried in the same place to obtain specimens but without success.

LARVA OF *CHAOBORUS MANILENSIS*.

The larvae at Medha were found in seven to twelve metres of water, over a hard rock bottom covered with a thin layer of vegetable débris and fine gravel, the water was muddy and opaque, and a slight trickle of water was running in and out of the pool. The pond at Lahore is an artificial one, overhung by large trees, and is about twenty feet across and three to five feet deep; it is full of dead leaves and the water is of a muddy darkish colour; it is every now and then replenished from a canal.

Observations made on the living larva at Lahore showed that its habits are identical with those of the European species described by Miall.² It may be mentioned, however, that those described by him (*op. cit.*) and by Wiesmann³ as *Corethra* belong, like the form considered in this paper, to the genus *Chaoborus*, Lichtenstein. The larva of the genus *Corethra*, Meigen, is quite distinct, and is what is described by Miall on page 121, as the larva of *Monochlys*. Very good figures of the larvae of *Chaoborus* and *Corethra* are given by Howard, Dyar and Knab.⁴

The full grown larvae are 7—8 mm. long. When living they are transparent with the four air-sacs opaque and coppery. The alimentary canal has a faint reddish tinge, especially in the middle region of the abdomen. In older larvae the mass below the abdomen was tinged with orange. The preserved specimens are milky white, the air-sacs brownish black, the head round the eyes dark brown, elsewhere of the same colour as the body; the eyes themselves are of a dense black colour. The division of the body into head, thorax and abdomen is very distinct; the neck is very small and in many specimens, owing to the head being drawn underneath the thorax, cannot be seen. The *head* is a very small structure, narrower than any of the body segments except the last abdominal. Seen in a side view it is more or less triangular, while in a dorsal view the basal part appears quadrangular with the eyes at the anterior angles. The anterior part of the clypeus is of the shape of a very much elongated and vertically flattened process, with the extremity of which the antennae are articulated; there being no pre-antennal portion of the head. On the ventral side a little behind the point of attachment of the antennae there is a large bunch of setae hanging down from the vertical process of the clypeus mentioned above. Behind the group of setae there are two elongated triangular flaps attached to the same process; these flaps are mobile and have their pos-

¹ Patton and Cragg, *Entomology*, p. 190 (1913).

² *The Natural History of Aquatic Insects*, pp. 113-122 (1903).

³ *Zeits. f. Wiss. Zool.*, XVI, pp. 45-127, pls. iii-vii (1866).

⁴ *The Mosquitoes of North and Central America and the West Indies*, I, p. 168, pl. viii (1912).

terior margin fringed with minute hairs. Further back is the *labrum* (fig. 2), which is an elongated structure and has a large number of setae arranged in a brush-like manner at its tip. The *mandibles* (fig. 3) are large, plate-like, with a narrow base, and have six large teeth on their anterior and upper margin and five small rounded serrations on the inner; besides there is near the upper margin on the outer side a small projection with six very long and broad bristles arising from its surface. The first pair of *maxillae* are reduced to small protuberances, each with two setae at the tip, and the *labium* is only a very small plate. The *eyes* are rather ovoid structures with a single large ocellus lying in a depression on the posterior margin of the eye. The *antennae* are large prehensile organs, consisting of a single joint; the line of attachment to the head is nearly straight; the outer margin of the antennae is concave; along the inner margin there is a deep notch close to the base, beyond which the line is straight; the tip is armed with four very long bristles. A few scattered setae are to be seen on the clypeus and just behind the eyes.

The *thorax* is a fairly massive structure; in full grown specimens it is thrice as broad as the head. On the dorsal surface of the thorax there are three groups of setae on each side; the first or the prothoracic group has two plumed setae, the second a simple and three plumed and the third only three plumed ones. The *air-sacs* are more or less kidney-shaped with the pigment arranged in small triangular or squarish areas; they are rather small as compared with those of the common European and American forms, being about one-sixth of the total thoracic length.

The *abdomen* consists of nine segments. The first six segments increase regularly in length and breadth, and the seventh and eighth gradually taper to the ninth segment. Each of the segments I—VIII bears a single plumed seta on each side dorsally and two plumed setae ventrally. The *air-sacs* on the seventh segment are, like those of the thorax, of a comparatively small size. The ninth segment has, close to its base, a papilla in the mid-dorsal line with two setae arising from it; posterior to it are two more papillae but without any setae; ventrally there is the large fin formed of nineteen long fringed bristles of the same type as described by Miall, *op. cit.* At the tip of the abdomen (fig. 4) there are four small triangular gills close to the anus. Above the gills are four very long feathered bristles arising in groups of two; below the gills is a large area something like the abdominal feet of *Chironomus*, and covered like these with two kinds of hooks (fig. 5), which are arranged, the larger and slightly curved ones in the centre and the smaller and more curved ones at the edges.

PUPA OF *CHAOBORUS MANILENSIS*.

A point in which the habits of these pupae differed from those of Palaearctic species was that they did not rise to the surface but remained floating in a vertical position close to the bottom; the large balloon-shaped breathing trumpets keeping them in this attitude. The very minute openings of the breathing trumpets, to be described later, seem to be due to the peculiar habitat in which they live, as finely powdered mud would choke up open trumpets, there being no large setae to guard

the openings as there are in other Culicidae; and the gradual closing of the openings of the trumpets seems to have been evolved as a direct response to the surroundings in which these pupae are found. In captivity the adults were hatched only late at night and no observations were therefore made on the manner in which they rose to the surface. The pupa (fig. 6) is easily distinguished by the very long abdomen, and the comparatively small cephalo-thoracic mass, the peculiar breathing trumpets and the well-developed tail-fins.

The pupa is 6.9 mm. long, and the size of the cephalo-thoracic mass is 2.1 mm. by 1.7 mm.

In the cephalo-thoracic mass of the advanced pupae the large compound eye of each side with the single ocellus behind it and the antennae can be distinguished. The legs, the wing and the halter of each side can also be seen in their envelopes. Near the upper edge, arising from the dorso-lateral margins, a single seta is present on each of the pro-, meso- and metathoracic regions. The nymphal *breathing trumpets* are large swollen structures appearing balloon-shaped in the living pupae. They are broadest in the middle gradually narrowing to the point of attachment. The wall of the trumpet is formed of small quadrilateral areas. The outer openings are very minute slits on the upper margin.

In the abdominal portion, the segments regularly increase in length from the thorax onwards, except for the last one, which is very small. Dorsally each segment bears two setae one on each side, and there is a similar arrangement ventrally. From the last segment two triangular flaps hang out below the tail-fins. The tail-fins (fig. 7) are large, broad structures with a very thick inner margin owing to a tracheal tube running along the edge; this edge is setose; the outer edge is thinner and has no setae; in the substance of the tail-fins of each side four other thickenings due to tracheal tubes can be distinguished.

LARVA OF *DIXA MONTANA*.

The larvae were collected in mountain streams at Kasauli in the Western Himalayas.

Full-grown larvae (fig. 8) measure about 9 mm. in length, smaller ones from 3—6 mm. are also present in the collection. The general colour of the preserved specimens is brownish-black alternating with paler areas on the dorsal surface, while the ventral surface is light yellow. The head and the tail-fins are dark brown.

The *head* is a small but massive structure formed of thick chitin. The post-antennal portion is quadrilateral, the anterior pre-antennal, which is much darker in colour, being triangular with the apex rounded off. The *eyes* are rather small, ovoidal, situated ventro-laterally behind the point of insertion of the antennae. The *antennae* (fig. 9) are slightly curved single-jointed structures about two-thirds of the length of the head, with the shaft and tip covered with closely-set minute spines.

Mouth-parts.—The pre-antennal portion of the head ends in the large *labrum* which, with its very well developed pair of feeding brushes, overhangs the mouth-opening. The *mandibles* (fig. 10) are large and elaborate in structure; from the outer angle of the upper margin arises

a stout curved bristle hanging freely forwards. Internally the apex of the margin, which in the natural position faces that of the mandible of the other side, bears a large fringe of setae arranged on a crescentic ridge a little behind the edge; these setae together with the feeding brushes of the labrum are constantly in motion and sweep the food particles into the buccal cavity. A little above the middle there are two large teeth while the lower half is finely serrated. The first pair of *maxillae* (fig. 11) are quadrangular in outline with a well developed palp inserted near the base on the outer side; the palp like the antennae is spinose and of the same shape, though a little smaller. The inner margin of the plate of the maxillae is beset with long hairs, those at the apex being specially well developed and curved. The *second pair of maxillae* are united to form a triangular *labium*, which forms the floor of the buccal cavity.

The three segments constituting the *thorax* are quite distinct. Seen from above the segments are rectangular in outline. The middle segment is the largest of the three. The first segment has five simple setae on each side, arising near the anterior edge, and a single one behind this group. The second bears laterally two setae on each side; the third has no setae.

The eight segments of the *abdomen* are quite distinct. The first and second segments are peculiar in having two small feet, one on each side; these feet bear two types of hooks, the arrangement of which is the same as those described in *Chaoborus*, the larger ones in the centre and the smaller ones along the edges. The second to the seventh abdominal segments bear the so-called "shields" (Miall, *op. cit.*) on their dorsal surface. These are only the dorsal surfaces of the segments marked off as ovoid or nearly circular structures by the setae arranged along their margins. The setae are both simple and plumose, and are of use in supporting the surface-films of water, when in the looping movements the larva brings it above the surface. The absence of these shields in certain other species of *Dixa* larva suggests that they, together with the setae, may be efficient suckers of use to larvae living in rapid torrents in the hills, but I have no definite facts to support this assertion. On the ventral surface of segments five to seven there is, in addition to the shields mentioned above, a comb-shaped structure formed of minute brown spines attached in a transverse axis near the posterior margin of the segments. The structure of the eighth segment is very peculiar, having special bearings on the relationships of *Dixa*, and has, so far as I know, not been adequately described for any species. The segment itself is very large, the basal part being rectangular, with an elongated conical portion of a brownish colour projecting from the basal part. The tip of this conical portion bears three long setae on each side. On the two sides, and arising from the hind edge of the rectangular portion, are two triangular chitinous plates of a dark brown colour; these will be referred to again in the account of the respiratory or breathing portion. With each of these plates a rather elongated ovoid fin of a dark brown colour articulates; both the plates and the fins have a fringe of long setae along the inner and outer margins.

The spiracles, or the openings of the respiratory system of the larva are two in number, one on each side, situated in a slight depression on the dorsal surface of the eighth segment near the posterior margin of its rectangular portion. The spiracles are surrounded by six chitinous plates. When the larva is floating on the surface, the plates are spread out (fig. 8), and expose the spiracles to the air; when, however, the larva goes down from the surface, the plates, as in the larva of *Anopheles*, fold and with the fringes on their margins form a nearly closed cavity over the spiracles, enclosing air, which prevents water from entering the spiracles. The arrangement and shape of these plates is as follows: Anteriorly there is a large transverse plate bearing seven or eight groups of four to five setae each; from its position and the attachment of setae this thick plate appears capable of being turned over the spiracles, which from their situation would then be drawn underneath it. Arising behind the spiracle on each side is a chitinous plate of the shape of a tennis-racket; it is attached by the base of its handle; the broader portion, which stands free outside, is setose all along the margin. The chitinous plates further behind consist of a large crescentic plate, broad in the middle and drawn out along the two edges; these drawn-out portions are supported by the triangular plates with which the fins articulate.

This arrangement of the breathing mechanism of *Dixa* appears to be homologous with that of *Anopheles*, only it is on a lower grade of organization, all the essentials being the same. Both the mouth-parts and the breathing apparatus of *Anopheles* can be very easily derived from those of *Dixa*; and the resemblances do not seem to be of the nature of convergence, but rather to show a near relationship.

PUPA OF *DIXA MONTANA*.

The pupa (fig. 13) is comma-like in appearance owing to the abdomen being bent under the large cephalo-thoracic mass. It is of a dark yellowish colour.

The cephalo-thorax measures 2 mm. by 9 mm. The divisional lines between the various abdominal segments are very well marked, and there are well developed ridges on the abdominal segments; there being no hairs or setae anywhere. The opening of the breathing trumpets is small, more or less squarish and lateral in position as usual. The tail-fins (fig. 14) are peculiar in being very much reduced triangular flaps, which are produced into a long regularly tapering spine a little smaller than the fins.