OBSERVATIONS ON THE BIOLOGY AND MORPHOLOGY OF THE IMMATURE STAGES OF *AULACODES PERIBOCALIS* WLK. (HYDROCAMPINAE.—LEPIDOPTERA.)

By HEM SINGH PRUTHI, *Zoological Survey of India.*

(Plate XI).

INTRODUCTION.

The aquatic larvae and pupae of certain Lepidoptera, an essentially terrestrial order, have naturally attracted the attention of several investigators. The aquatic species can be roughly divided into two categories, namely, those that inhabit still water, and those that live in rapid water alone. The species belonging to the first category have been pretty thoroughly investigated (Miall (1), Müller (2), Welch (3), Nigmann (4), etc.), and it is with regard to those in the second category that but few works exist and the present communication deals. Poulton (5) in 1909 gave an account of the observations of Kershaw and Muir on the Chinese species *Aulaccdes simplicialis* Snell. Lloyd (6) described the habits of the American species of the genus *Elophila.* Recently, Hora (7) in his article on " Animal Life in Torrential streams " made a brief reference to an Indian species, which is most probably *Aulaccdes peribocalis.* A perusal of these works shows that there are many interesting points which still require elucidation. For instance, whereas most of these authors have given very elaborate descriptions of the intricate and strong pupal case, no one has touched on the closely connected and important question as to how the moth comes out of this tenaceous cocoon. Then again, hardly any worker has described the morphology of the larvae and pupae with a view to seeing if their structure has undergone any modification as a result of the peculiar habitat of the organism. I have, therefore, thought it desirable to publish the notes that I made on the biology and morphology of the immature stages of *A. peribocalis,* which I collected in large numbers while surveying the fauna of the Nerbudda river in January-March and November-December, 1927.

HABITAT AND HABITS OF THE LARVAE.

The caterpillars were met with in the Nerbudda wherever the river was shallow and the current rapid. They spin thin, silky shelters, which are irregular in outline and usually greenish in colour, in the crevices of rough stones (pl. xi, fig. 1). The shelter, which invariably lodges only one individual, is loosely attached to the substratum, leaving numerous openings by which water can enter or leave it, and thus there is a free circulation of water round the caterpillar. According to Hora, the caterpillar comes out through these openings for the purpose of feeding. My own observations do not agree with Hora's account.

The caterpillars do not appear normally to leave their shelters, and if an individual be forced out of one, it seems unable to find its way back to it, and this means certain death for it, especially if it is mature, inasmuch as at this stage its power of secreting silk for making a fresh shelter is very much limited. Moreover, in view of the nature of its food, which most probably consists of minute bits of algae floating in the surrounding water, (*vide infra*), one cannot conceive the necessity on the part of the caterpillar for leaving the shelter because, as described above, there is always round it, inside the shelter, an ample supply of fresh water laden with food materials.

The caterpillars show negative phototropism. If the shelter of an individual is torn away, it at once creeps towards the underside of stones, leaves, etc.

The caterpillars, aquatic though they are, cannot swim. If an individual is thrown into a bowl containing water, it remains floating in a helpless fashion, just like any terrestrial caterpillar, until it gradually sinks to the bottom of the vessel when it begins to crawl.

As regards the food of the larvae, the places which they usually inhabit—stones lying under rapid running water—have hardly any plant growth. I examined the gut-contents of several individuals at different times, and they mostly consist of, besides water, extremely minute particles of vegetable matter which are quite different in appearance and size from those usually found in the gut of a typical terrestrial caterpillar. It is highly probable, therefore, that the larvae depend for their nourishment on minute bits of algae suspended in the surrounding water.

As is described hereafter, the caterpillars are provided with well-developed gills for aquatic respiration. If, however, an individual is taken out of water, it does not die rapidly like a true aquatic organism, but can live as long as four days, and it is very difficult to say whether even at the end of this period it dies of defective respiration or of starvation because the moment it is taken out of water it is automatically deprived of its food as well. The above observation certainly suggests that the larvae of this species have not yet completely changed their ancestral mode of terrestrial respiration.

Morphology.

The larva (pl. xi, fig. 2) is thick-set and is distinctly compressed in the vertical plane. When freshly hatched, it is pale in colour, but soon turns greenish and remains so throughout the larval stage. When fully mature, the caterpillar measures about 2·3 cm. in length, its greatest breadth (0·4 cm.) being in the region of the thorax. The head (pl. xi, fig. 3) is well developed and highly chitinized. The epicranial plates (*ep*) are large and separated from each other by a soft membranous area. Each epicranial plate bears six ocelli, some of which seem to be rudimentary. The adfrontals (*adf*) are triangular in outline and are fairly well chitinized. The frons (*f*) is well developed. The clypeus (*c*) is very narrow. The mouth-parts (pl. xi, fig. 4*a*-4*c*) are well developed. The labrum (*l*) is deeply notched in the middle line of the anterior

margin. The mandibles (*md*) are hard and strongly toothed. The large maxillae (*mx*) bear two jointed palpi. The labium (*lb*) is small, narrow, and has two jointed palpi.

It is interesting to point out that though the food of the caterpillar most probably consists of minute particles of vegetable matter suspended in the surrounding water its mouth-parts have not undergone any corresponding modification, and they are exactly like those of a typical terrestrial caterpillar suitable for masticating tough leaves, etc. This, coupled with the fact that the caterpillars can live out of water for about four days, suggests that this species has taken to water only recently.

The first thoracic segment is only slightly less chitinized than the head, but the remaining thoracic and all the abdominal segments are very soft. The most important point, however, in which the larva differs from its terrestrial relative is that its body bears eleven pairs of gills borne respectively by the 2nd and 3rd thoracic and the nine abdominal segments (pl. xi, fig. 2). Each gill (pl. xi, fig. 3, *g*) consists of about 20 filaments, which are arranged around the rims of a protuberance (*pt*) arising from the lateral regions of the above named segments. The gills are internally connected with the lateral tracheal trunks by means of short but well developed tracheae. The spiracles are also present, but their openings seem to be closed, and the lumen of the tracheae connecting them to the lateral tracheal trunks are more or less obliterated.

When the caterpillar is full grown, it starts making, under its shelter, a tough and complex cocoon in which it is to pass the pupal stage. Only a part of the larval shelter is utilized in the formation of the cocoon, and the rest is washed away when the cocoon has been constructed. The latter (pl. xi, figs. 5 & 6), unlike that of most Lepidoptera, is two layered, and is highly compressed, its lumen being just big enough to lodge the caterpillar. The cocoon is dome-shaped and is firmly cemented to the substratum along its rims (*r*), and this attachment is further strengthened by means of vertical pillars and strands (pl. xi, fig. 6, *p* & *st*). Whereas the dorsal wall of the outer layer is very tough, its ventral wall and both the dorsal and ventral walls of the inner layer are extremely thin. The central cavity of the cocoon, enclosed within the inner layer, communicates with the exterior by means of an extremely narrow and crescent-shaped slit (*em. sl.* pl. xi, fig. 5), situated in the anterior region of the dorsal surface. The head of the larva or of the pupa points towards this opening. It is through this opening that the moth emerges. The slit is so narrow that for all practical purposes hardly any water can go in through it. This opening appears to have escaped the notice of almost all previous workers. Near the anterior and posterior ends of the cocoon there are a series of holes by which water can go in and leave the cocoon, but as will be evident from an examination of fig. 7 (pl. xi), which is a diagrammatic median longitudinal section of the cocoon, this water does not come in contact with the pupa itself. It is highly probable that the gases dissolved in this water can reach the pupa through the two intervening thin membranes, if this be so, the formation of the cocoon illustrates an ingenious device by which the pupa remains almost dry and at the same time well supplied with air.

The pupa (pl. xi, fig. 8) is much smaller than the larva, being 1·25 cm. only in length. Its greatest breadth, 0·5 cm., is in the region of the 5th abdominal segment, beyond which the body tapers to a more or less pointed posterior end. The head is small. The body is of a uniform brown colour with the exception of the eyes which are black. The cases of the hind legs reach the posterior extremity of the body. The length of the various body appendages varies with age. There are no gills. The spiracles are well developed, especially those on the 3rd-5th abdominal segments, where they are surrounded by deep black areas. The eighth abdominal segment bears a pair of prominent lateral tubercles.

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