

University of Udaipur
College of Agriculture
Department of Entomology
Jobner (Jaipur), Rajasthan, India

B. P. SRIVASTAVA & C. P. S. YADAVA

Morphological studies on the head and mouth parts of *Leucinodes orbonalis* GUENÉE

Part II — The Imago

(Lepidoptera : Pyraustidae)

With 5 textfigures

The study of the head sutures and mouthparts of the imago has attracted the attention of a larger number of workers than that of the larva. The works of earlier authors, like BURGESS (1880), JACKSON (1889), KELLOGG (1893) being old are less authentic and are not easily available. Recent workers like PHILPOTT (1927), SNODGRASS (1928), SCHMITT (1938), PRADHAN & AREN (1941), SHORT (1951) and EASTHAM & EASSA (1955) have studied only some particular aspects of the morphology. MADDEN (1944) and FREEMAN (1947) gave brief account of the external morphology of lepidopterons belonging to families Sphingidae and Tortricidae respectively. VASUDEVA (1956) made exhaustive studies on the head of *Papilio demoleus*. But there is no general agreement among workers on the metamerism of the lepidopteron head and there exist many controvercies which need clarification. The authors have made an attempt to solve some of the controvercies. For reasons given in the Part I of this paper, dealing with the morphology of the head of mature larva, the terminology used in this account, unless otherwise stated, is that of SNODGRASS (1935).

The techniques employed for this study have already been described in the Part I of this paper.

Observations

The head of the moth is hemispherical and has very few sutures. Two large and prominent compound eyes are situated on its lateral sides.

Anterior aspect (Fig. 1). The two most prominent structures on the anterior aspect of the head are the compound eyes and the clypeus. Other structures which are visible on the facial aspect are a pair of antennae arising out of the big circular antennal fossa, a portion of the frons, one pair each of maxillary palpi, labial palpi and pilifers, a proboscis, ocular sutures and the epistomal suture.

In between the compound eyes are two big sclerites, the frons and the clypeus. They are separated by the median arms of the epistomal suture running between the two antennal sockets. The median arm of the epistomal suture is indistinct in this insect and can be recognised only by the absence of the scale bases in a

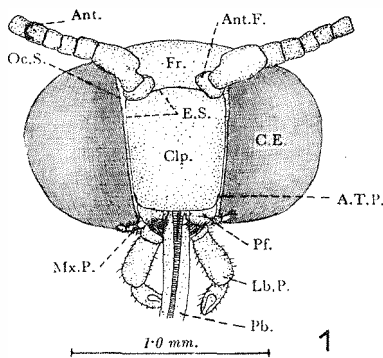


Fig. 1. Anterior view of the head: *Ant.*, Antennae; *Ant. F.*, Antennal fossa; *A.T.P.*, Anterior tentorial pit; *C.E.*, Compound eyes; *Clp.*, Clypeus; *E.S.*, Epistomal suture; *Fr.*, Frons; *Lb. P.*, Labial palp; *Mx.P.*, Maxillary palp; *Oc. S.*, Ocular suture; *Pb.*, Proboscis; *Pfl.*, Pilifer

KOH treated specimen. It is this median arm of the epistomal suture which MADDEN (1944) and FREEMAN (1947) have wrongly identified as the frontal suture. The cranial area between the compound eyes has the form of an arch and the whole of the clypeal sclerite is very convex; consequently it appears bulged out like a dome or cone. The large bulging compound eyes which occupy the lateral margins of the clypeus are surrounded all round by an ocular suture. The other sutures which extend on each side from the anterior tentorial pits to the antennal fossa represent the lateral arms of the epistomal suture, the median part of which separates the frons and the clypeus. On the ventral part of the clypeus the labrum is seen as a narrow strip, and a lancet-shaped pilifer is attached to each of its lateral margins. Each pilifer projects inwards and downwards and bears numerous bristles. A pair of maxillary palpi are also present near the pilifers. The proboscis and the labial palpi project below the labrum and in between the two pilifers.

Posterior Aspect (Fig. 2). The occipital foramen occupies the major portion of the posterior aspect of the head. The occipital suture running transversely and extending between the ocelli, marks the limit of the vertex. The occiput extends from the curved occipital suture between the ocelli forming its anterior margin and is bounded laterally by post-genae. The post occipital sclerite, lying ventral to the occiput, bounds the occipital foramen and is separated from the occiput by a postoccipital suture. The postoccipital sclerite is a little broader dorsally to form a roughly semicircular structure projecting over the occipital foramen while ventrally its two lateral ends enlarge to form a pair of occipital condyles with which the distal apices of the lateral cervical sclerites articulate. The posterior arms of the tentorium end in the lateral extremities of the post-occipital suture. The postgenae occupy the space between the postocciput and the eyes. Their inner margins are extended to form a hypostomal bridge which FREEMAN (1947) has wrongly described as the labrum. MADDEN (1944) and FREEMAN (1947) have wrongly labelled the tentorial bar as the hypostomal bridge and the true hypostomal bridge as the labrum.

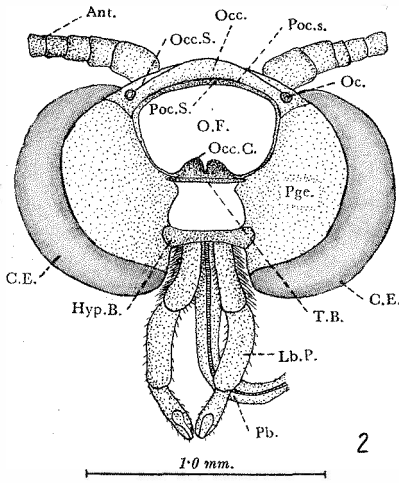


Fig. 2. Posterior view of the head: *Ant.*, Antennae; *C.E.*, Compound eye; *Hyp. B.*, Hypostomal bridge; *Lb. P.*, Labial palp; *Oc.*, Ocellus; *Occ.*, Occiput; *Occ. C.*, Occipital condyle; *O.F.*, Occipital Foramen; *Occ. S.*, Occipital suture; *Pb.*, Proboscis; *Pge.*, Post gena; *Poc. S.*, Post occipital sclerite; *Poc. S.*, Post occipital suture; *T.B.*, Tentorial Bar

Dorsal aspect (Fig. 3). The most prominent sclerites on the dorsal aspect of the head are the frons and the clypeus and are separated from each other by the median arm of the epistomal suture which FREEMAN (1947) wrongly described as the frontal suture. Hence the anterior limit of frons is the epistomal suture but its posterior end is not marked by a suture. The clypeal region is conical on the anterior side. The compound eyes which occupy almost the entire lateral sides of the head are surrounded by the ocular suture. The lateral ocelli are situated behind the antennal sockets and the occipital suture extending transversely between the two ocelli marks the anterior limit of the vertex, and the posterior limit of the occiput.

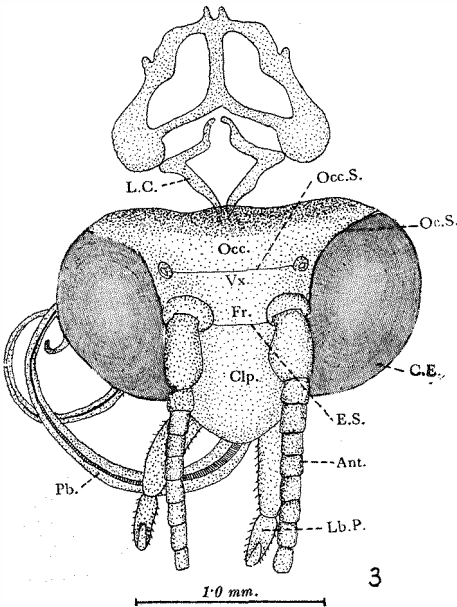


Fig. 3. Dorsal view of the head: *Ant.*, Antennae; *C.E.*, compound eye; *Clp.*, Clypeus; *E.S.*, Epistomal suture; *Fr.*, Frons; *Lb. P.*, Labial palp; *L.c.*, Lateral cervical sclerite; *Occ.*, Occiput; *Occ.S.*, Occipital suture; *Oc.S.*, Ocellar suture; *Pb.*, Proboscis; *Vx.*, Vertex

Ventral aspect (Fig. 4). On the ventral aspect of the head all the mouth-parts of the moth are attached. The lateral margins are occupied by the compound eyes which are separated by a ocular suture from the rest of the cranium. The conical or dome like convex projection of the clypeus is clearly seen from the ventral aspect of the head. A membranous band like labrum bearing pilifers on both the lateral ends is attached to the ventral margin. Behind each pilifer and slightly covered by the latter are small conical structures, the mandibles. A little posterior to the mandibles are a pair of prominent sclerites — the stipes, each of which bears a chitinised cardo posteriorly and a four jointed maxillary palp and the proboscis anteriorly. The rest of the area is occupied by the labium and major part of which is membranous. A pair of 3-jointed labial palpi are very prominent.

Compound eyes (Fig. 1–4). As stated above the compound eyes are conspicuous and extensively developed — the greatest development being on the ventro-posterior direction where they project beyond the head capsule. They are surrounded all round by a ocular suture and extend nearly upto the anterior margin of the vertex. In KOH treated specimen the hexagonal facets are seen very clearly.

Ocelli (Figs. 2 and 3). A pair of ocelli can be clearly observed on the vertex in KOH treated preparations. They are situated on the dorsal side of the head between the compound eyes and a little dorsal to the antennal sockets on the region of the vertex. The lateral margins of the ocelli are only a little removed from the ocular suture of the compound eyes. The ocelli are thickly covered over by hairs and scales. This feature suggests that they may be non-functional and are present only as vestigial organs.

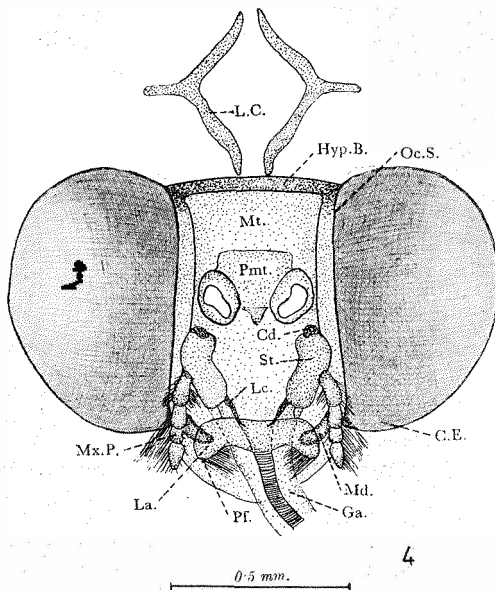


Fig. 4. Ventral view of the head: *Cd.*, Cardio; *C.E.*, Compound eye; *Ga.*, Galea; *Hyp. B.*, Hypostomal bridge; *La.*, Labrum; *Lc.*, Lacinia; *L.c.*, Lateral cervical sclerite; *Md.*, Mandible; *M.E.*, Mentum; *Mx.P.*, Maxillary palp; *Oc.S.*, Ocular suture; *Pf.*, Pilifer; *Pmt.*, Prementum; *St.*, Stipes

Antennal sockets (Figs. 1 and 3). Each antennal socket is a small membranous area bounded laterally by the compound eyes, dorsally by the vertex and ventrally by the clypeus. The rim of the socket is strengthened by a narrow antennal sclerite, which is produced laterally into a blunt antennafer or the basal segment of the antenna.

Antennae (Figs. 1—3). Each antenna consists of fifty three segments in both the sexes and is of filiform type. The scape is the biggest segment and is somewhat globular. It is followed by the pedicel, which except being a bit longer, is much like other segments. The rest of the segments constitute the flagellum.

Frons and clypeus (Figs. 1 and 3). The region of the face on the dorsal side includes the frons and the clypeus. By the evidence derived on the basis of head musculature it appears that the median arm of the epistomal suture which runs between the two antennal sockets forming a strong ridge on the inner surface, separates the clypeal area from the frontal area. The dilators of the cibarium consist of three groups of muscles which are inserted on the anterior and the dorsal walls of the sucking pump. The first two have their origin on the clypeus and the third on the epistomal ridge. The dilators of the pharynx which insert on the dorsal and the posterior walls of the sucking pump have their origin on the median arm of the epistomal ridge and the frons. Hence it is concluded that the median arm of the epistomal ridge marks the ventral limit of the frons and the dorsal limit of the clypeus. MADDEN (1944) and FREEMAN (1947) on the basis of the position of the frontal pits have erroneously described the clypeal area as the fronto-clypeus and the area beyond the epistomal suture as the vertex.

The cranial area between the two lateral arms of the epistomal suture of the adult has the form of an arch. The function of the well developed epistomal ridge is obviously to strengthen the dome like cranium by acting as the "abutments" of the arch. As a matter of fact all the cranial sutures (and ridges) act as stabilizers, against the buckling or distortion of the cranium.

Vertex (Fig. 3). The vertex is a large convex area and occupies the dorso-frontal position of the head capsule. The area of the vertex which applies to the top of the head dorsal to the frons is topographical and not anatomical, since there is no suture demarcating the boundaries of the frons and the vertex. There is no indication of the coronal stem on the region of the vertex as has been reported in tobacco horn worm by MADDEN (1944). FREEMAN (1947) observed in the spurce bud worm that the coronal stem is represented by a thin median area devoid of scale scars extending from the 'frontal suture' to the top of the head. But in the insect under study there is not the slightest evidence to indicate the presence of the coronal stem.

The mouth-parts (Figs. 4 and 5). As in other Lepidoptera the mouthparts are very much modified and are adopted to the special mode of feeding. They consist of a labrum, a pair of mandibles, maxillae and labium.

The labrum (Fig. 4). It is an unpaired narrow, transverse band-like membranous structure. Because of being hidden by the convexity of the clypeus it is

not clearly visible from the dorsal side. On both of its lateral margins the labrum bears prominent lancet-shaped processes — the pilifers which project downwards and bear numerous bristles on their inner faces. The edges of the membranous labrum are highly chitinised and in unstained preparations the outer margins can be clearly seen because of being darker than the inner membranous region. The median lobe of the labrum is probably a remnant of the epipharynx. The labrum in this insect appears to be immovable because of the absence of the knots at the base of the proboscis fitting against the pilifers. SCHMITT (1938) has rightly observed that in all those cases where labrum is movable, such knots are present in order to facilitate its movement.

The mandibles (Fig. 4). Each mandible is situated behind the pilifer of its side and is slightly covered over by the latter. They are cylindrical in structure and any trace of a suture demarcating the point of articulation of the mandibles with the head capsule is totally wanting in this Pyraustid. Feeble condylar thickenings on the inner ends of the mandibles which have been observed by PRADHAN & AREN (1941) in *Scripophaga nivella* are also not visible in *Leucinodes orbonalis*. The mandibles are feebly chitinised except at their outer margins. The feeble chitination and the absence of any articulation line or suture of the mandibles indicates that they can hardly be of any effective use for the moth.

The maxillae (Fig. 4). The maxillae are highly specialised although they have not lost the fundamental structure and the various components can be easily distinguished.

The stipes constitute the most prominent sclerites on the ventral side of the head. Each articulates laterally with the head capsule and is placed posterior to the mandibles. Its apex is directed backwards and upwards and its cavity opens into the head capsule. On the proximal end of the stipes is a small chitinised structure which represents the cardo. The cardo and the stipes together are lodged into a shallow concavity of the head capsule. The distal end of each stipes bears one half of the proboscis which is formed by the galea of both the maxillae and are loosely held together. The nature of insertion and the position of the two halves of the proboscis strongly support the interpretation that the lepidopteran proboscis is formed by the extreme modification of the galea. There is a small highly chitinised structure at the base of the proboscis which strongly resembles the typical lacinia in shape and position. Although the lacinia is almost completely incorporated in the base of the proboscis, its tip remains separate and indicates its identity, thus giving support to the view that the chitinous structure is lacinia of the typical maxillae and nothing else.

Each stipes bears a four segmented maxillary palp which is ventro-external to the base of the galea in position. Its entire surface is covered with a large number of bristles of varying length, the scales being specially numerous and large towards the external side. In the living imago the palpi remain permanently bent upwards and serve as a pair of brushes on either side of the proboscis. On the inner side of the first segment of the maxillary palp there is a bundle of large bristles. The second segment is the largest of all and the long un-even sized

bristles are situated towards its posterior end. The third segment is oval in structure and the bristles cover the whole of the external margin of this segment. The last segment is dome-shaped and bears long bristles on the external margin.

The proboscis (Fig. 4). It is formed of two halves which, as already stated, represent the galea of the maxillae. Each half or unit of the proboscis is, therefore, a tube the lumen of which is continuous with the body cavity through the stipes. The two halves of the proboscis are rather loosely held together and a slight treatment with KOH easily separates them. When not in use it remains coiled vertically. Each half of the proboscis is a hollow double-walled chitinous gutter wider at the base and narrower towards the tip. The gutter which functions as the food channel is lined internally with chitinous rings or bands. It appears that it is because of these chitinous bands on the inner wall of the food channel that the shape of the proboscis is maintained. The very interesting and peculiar feature of the proboscis of *Leucinodes orbonalis* is the presence of chitinous bands only on the inner wall of the entire gutter and not on the outer wall as is generally met within other Lepidoptera. The outer wall of the food channel is formed by a continuously chitinated membrane and separate chitinous bands are not present.

The labium (Fig. 5). The labium is much less chitinated and the sclerotised areas are limited around the base of the labial palpi. Except for varying degree of sclerotisation, the distinction between the various regions of the labium is imperceptible.

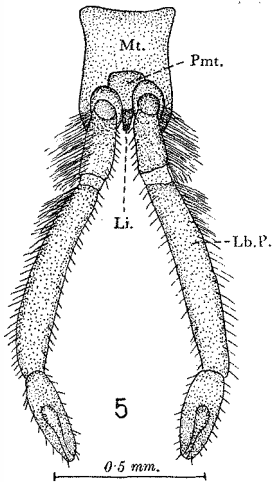


Fig. 5. Ventral view of the labium: *Li*, Ligula; *Lb.P.*, Labial palp; *Mt.*, Mentum; *Pmt.*, Prementum

The labial palpi are very prominent and well developed and each one is composed of three segments. The first segment is thick and slightly clavate. It is curved forwards and upwards in such a way that each labial palp is directed upwards and is closely applied to the anterior surface of the imaginal head. The second segment is the largest and is also slightly curved upwards. The third or the terminal segment is small and oblong and at its apex bears a ventral pit which is lined with short setae which are probably sensory in nature.

Discussion

Only a few workers have studied the external morphology of the imago in detail and they differ greatly among themselves regarding the identification of various sclerites and sutures.

Frons, clypeus and head sutures

SNODGRASS (1928, 1935, 1947) claims that the frontal and the clypeal areas of the insect head can be recognised soundly only by the criteria furnished by the head musculature. However, his idea did not find support with DU PORTE (1946) who felt that instead of muscular attachment the various sclerotic lines on the face of insects should be used for the identification of the regions of the head. Thus, according to him, a 'transfrontal sulcus' extending across the face between the mesal edges of the two antennal sockets separates the 'vertex' situated dorsally and the 'antefrons' situated ventrally. He regarded that the 'frontoclypeal sulcus' running between the anterior tentorial invaginations cuts off the clypeus bearing the pilifers from the 'antefrons'. The suture extending between the antennal socket and the anterior tentorial invagination was termed by him as 'frontogenal sulcus'. For reasons given in the Part I of this paper SNODGRASS' criteria and terminology have been followed for the identification of various sclerites in this account. Unfortunately, in Lepidoptera the accounts of external morphology are very few and incomplete. MADDEN (1944) in *Protoparce* (Sphingidae) and FREEMAN (1947) in *Archips* (Tortricidae) basing their identification on the position of the frontal pits, described that an indistinct 'frontal suture' running between the antennal sockets separates the frons from the vertex and that the ventral margin of the frons is limited by an 'obscure' suture between the two frontal pits. Obviously they could not exactly identify this suture, hence they refrained from giving any name to it. However, they regarded that this suture separates the frons from clypeus. Although they did not mention the criteria and the terminology they followed in their accounts, but for reasons more than one it appears that they based their description on SNODGRASS' works (1928, 1935). However, SNODGRASS (1928) states "Ventrally frons is limited, and separated from the clypeus, by the epistomal suture, except when the suture is lacking". Evidently, therefore, this suture running between the two sclerites which they described as frons and the clypeus should have been termed by them as the epistomal suture and the one, running between the antennal sockets as the remaining 'frontal arms' of the epicranial suture. We have, however, shown that the so-called 'epicranial suture' is nothing more than the dorsal ecdysial cleavage line which is absent in the adult Lepidoptera. Besides, the study of muscle attachments shows that the entire suture running between the two antennal sockets and between the antennal sockets and the anterior tentorial pits is the epistomal suture; hence its former part has been termed as the median arm and the latter as the lateral arms of the epistomal suture. The area dorsal to the median arm of the epistomal suture which provides attachment to the pharyngeal muscles is, therefore, to be regarded as the frons while the area

ventrad to the median arm of the epistomal suture and bordered laterally by the lateral arms of the same which gives origin to the cibarial muscles is the true clypeus.

It may also be noted here, that DU PORTE's (1946) observation that the pilifers are attached to the ventro-lateral edges of the clypeus, is certainly erroneous. It has been shown in this account that the pilifers actually arise from the ventral edges of the labrum and not the clypeus. This fact at once becomes clear if the ventral aspect of the head of the imago is carefully examined.

The mouth parts

Mandibles: KELLOGG (1893) was the first to criticise the older view that the pilifers are the modified mandibles of the adult Lepidoptera and clearly demonstrated that both the pilifers and the mandibles existed together in *Protoparce*. SHARP (1936) reported that the mandibles are absent in the majority of Lepidoptera and wherever present they are in the form of obtuse projections without any trace of articulation. TILLYARD (1923) found that in *Sabatinca* the mandibles are denticulate and functional. IMMS (1948) reported that in *Eriocranis* the mandibles are not dentated and in *Mnemonica* they are unchitinized. In *Sabatinca nivella* (PRADHAN & AREN, 1941) the mandibles are feebly sclerotized and bear a slight condylar thickenings on their inner edge but are non-functional and vestigial in nature. In *Leucinodes orbonalis*, however, it has been found that they are feebly chitinized and any trace of the suture demarkating the point of articulation with the head capsule is totally wanting which indicates that they can hardly be of any effective use.

Maxillae: It has been shown that in *Leucinodes orbonalis* there is a small highly chitinized structure at the base of each half of the proboscis which is a remanent of the lacinia of a typical insect. While describing the mechanism of coiling and uncoiling of the proboscis in *Sabatinca nivella*, PRADHAN & AREN (1941) suggested that the chitinous area at its base may represent the rudimentary lacinia. In *Leucinodes orbonalis*, the authors have described that while the lacinia is more or less completely incorporated in the base of the proboscis, its tip is separate. This clearly reveals the position of the lacinia of the typical maxilla in Lepidoptera which is situated at the base of the galea and is usually so completely fused with it that its separate identity is lost. The presence of rudimentary lacinia is of special significance because in *Leucinodes orbonalis* the lacinia is seen in the actual process of being incorporated in the base of galea as was suspected by BERLESE (1910).

Proboscis: In most of the lepidopterons both the outer and the inner walls of the gutter or the food channel are lined with numerous small chitinous rings in a spiral fashion (SCHMITT 1938). Burgess (1880), however, described an exceptional case in *Danaida* in which the chitinous rings extend all round the proboscis but do not extend into the groove i.e., the chitinous bands form the outer wall while the inner wall is free of them. The proboscis of *Leucinodes orbonalis*

presents a condition which is different from both the generalized type of SCHMITT (1938) and the exceptional type of BURGESS (1880). In this moth the chitinous bands are confined to the inner wall of the gutter while the outer wall consists of a continuously chitinized membrane with no separate chitinous bands.

It has been shown that contrary to the general belief the larval maxilla bears a prominent galea, besides the palp.

Summary

A complete description of the head sclerites and the mouth parts is given. It has been established that like the larval head also the clypeus of the adult is bounded dorsally and laterally by the median and the lateral arms of the epistomal suture. The median part of the epistomal suture extends between the two antennal sockets and each of its lateral arms between the antennal socket and the anterior tentorial invagination of its side. The ventral limit of the frons is formed by the median part of the epistomal suture while its dorsal end is unlimited. The proboscis of *Leucinodes orbonalis* is peculiar in so far as the chitinous bands are confined to the inner wall, while the outer wall is formed by a uniformly chitinized membrane without separate bands. Besides the lacinia, regarded as absent in Lepidoptera except the Micropterygidae, is distinguishable in this Pyraustid which thus presents an intermediate stage in the incorporation of the lacinia with the base of the galea.

Zusammenfassung

Es wird eine vollständige Beschreibung der Kopfsklerite und der Mundteile gegeben. Dabei wird festgestellt, daß wie der Larvenkopf auch der Kopfschild des reifen Stadiums dorsal und lateral von den mittleren und seitlichen Zweigen der Epistomanah begrenzt wird. Der mittlere Teil der Epistomanah erstreckt sich zwischen zwei Fühleransätzen und jeder der seitlichen Zweige zwischen dem Fühleransatz und der vorderen tentorialen Invagination seiner Seite. Die ventrale Grenze der Stirn wird vom mittleren Teil der Epistomanah gebildet, während sie dorsal nicht begrenzt ist. Der Rüssel von *Leucinodes orbonalis* ist insofern eigentümlich, als die Chitinbänder auf die Innenwand beschränkt sind, während die Außenwand von einer einheitlich chitinierten Membrane ohne getrennte Bänder gebildet wird. Außerdem ist die Lacinia, von der man annahm, daß sie bei den Lepidoptera außer den Micropterygidae fehle, bei diesem Pyraustid klar zu unterscheiden, der damit eine Zwischenstufe in der Vereinigung der Lacinia mit der Basis der Galea darstellt.

Резюме

Даётся полное описание головных склеритов и ротовых частей. При этом отмечается, что и голова личинки и клюпеус взрослого ограничивается дорсально и латерально средними и боковыми ветками эпистомного шва. Средняя часть эпистомного шва лежит между началами усиков и каждой из боковых веток между этими началами и передней тенториальной инвагинацией его стороны. Вентральная граница лба образуется средней частью шва, дорсально он не ограничен. Хоботок у *Leucinodes orbonalis* строен по-другому, так как хитиновые ленты находятся только на внутренней стене, и наружная стена образуется одной хитинизированной мембраной без отдельных лент. Кроме этого лациния, которая, по мнению всех, не имеется у всех шешуекрылых кроме у Micropterygidae, у этой Pyraustidae чётко отличается, этим она показывает промежуточную степень соединения лацинии с основой галеи.

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Autor(en)/Author(s): Srivastava B.K., Yadava C.P.

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