

**MORPHOLOGY AND MUSCULATURE OF THE HEAD CAPSULE  
AND MOUTHPARTS OF LIBURNIA PALLESCENS (DISTANT)  
AND DELPHACODES PROPINQUA (FIEBER)**

(Homoptera, Fulgoroidea, Araeopidae)

A. N. T. JOSEPH

*Zoological Survey of India, Calcutta, India*

**T**HE morphology of head capsule and mouthparts of an araeopid, *Peregrinus maidis* (Ashmead), was studied in detail for the first time by Mathur and Joseph (1961), but little is known about the cephalic musculature of araeopids. Hence an attempt has been made to study the cephalic musculature of two species of Araeopidae. In morphological descriptions the concept commonly followed by the great majority of workers like Yuasa (1920), Crampton (1921 *et. seq.*) and Snodgrass (1928 *et. seq.*) are followed here. Side by side with this, the system advanced by Ferris (1942 *et. seq.*), considering that majority of head sutures are parts of primary segmental lines, is also discussed.

MATERIAL AND TECHNIQUE

Specimens were collected from Agra, by sweeping grasses, during the monsoon of 1962. For study of sclerites, they were treated with concentrated potassium hydroxide solution, at room temperature, for about 6 to 8 hours and stained with 1% solution of picro-indigo-carmin. The musculature was studied by dissections as well as by cutting microtome sections.

OBSERVATIONS

**The head capsule**

In both the species, the head capsule is subtriangular in outlines. It is opisthognathous and mouthparts extend beyond the fore coxae. The anterior region of head capsule apposes the thorax, which is moved forwards at the time of feeding. The head capsule is narrower than thorax in *Liburnia pallescens*, whereas it is as broad as the thorax in *Delphacodes propinqua*. It is decorated with keels or carinae. The clypeus is tricarinate, one median and two lateral, the lateral ones pass along the lateral boundaries. The frons is five carinate, one median, two lateral and two outer,

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the latter delimit the outer boundary of frons and stop a little short of the antennal sockets. The median carina is bifurcated at its base and join the lateral carinae at the anterior region of vertex, while the remaining part of vertex is entire. The lateral carinae run anteriorly, apposing the inner side of the compound eyes and continue to the vertex.

*Labrum:* The labrum is lobe-like, tapers distally, strongly convex dorsally, concave ventrally with a mediolongitudinal groove, extending upto the middle of the third labial segment. It is closely adpressed at its distal end with the labium, lying beneath, and thus keeping the mandibular and maxillary stylets in position. The clypeo-labral suture is absent, but the labrum is marked off from the clypeus by two lateral constrictions present at the junction of the two. The labrum is devoid of musculature.

*Clypeus:* The clypeus is triangular, strongly convex dorsally, separated anteriorly from the labrum by the lateral constrictions at the junction between the two and posteriorly by the clypeofrontal or epistomal suture. The clypeofrontal suture is arched posteriorly and internally it bears a well developed epistomal ridge. Laterally it is delimited by the lateral carinae, as is evident from the origin of clypeal muscles, which are always restricted to this area. The lateral sutures, separating the lateral margins of mandibular plates, are obliterated. The clypeus can be divided into an anterior small anteclypeus and a large posterior postclypeus, the separation being marked off by two lateral constrictions. The muscles take their origin from postclypeus.

*Frons and parietals:* The area in between the epistomal and occipital sutures represent the frons and parietals. The former bears ocelli and the latter antennae and compound eyes. The epicranial suture is absent in both the species, so that the exact boundary between the frons and vertex cannot be demarked. Snodgrass (1947) advocated a study of facial muscles for the determination of the exact boundary between frons and vertex, but in the absence of labral muscles, this is not also possible. Mathur and Joseph (1961) mistook some muscles of this region for labral muscles in *Peregrinus maidis* and hence the area of vertex was marked. A detailed study of these two species and the re-examination of *Peregrinus maidis* has shown that the labrum is devoid of muscles in araeopids.

The vertex is longer than broad in *Liburnia pallescens*, but as wide as long in *Delphacodes propinqua*. The lateral regions below the com-

ound eyes are called genae. The fronto-genal area basally is broader in *Delphacodes propinqua* and narrower in *Liburnia pallescens*.

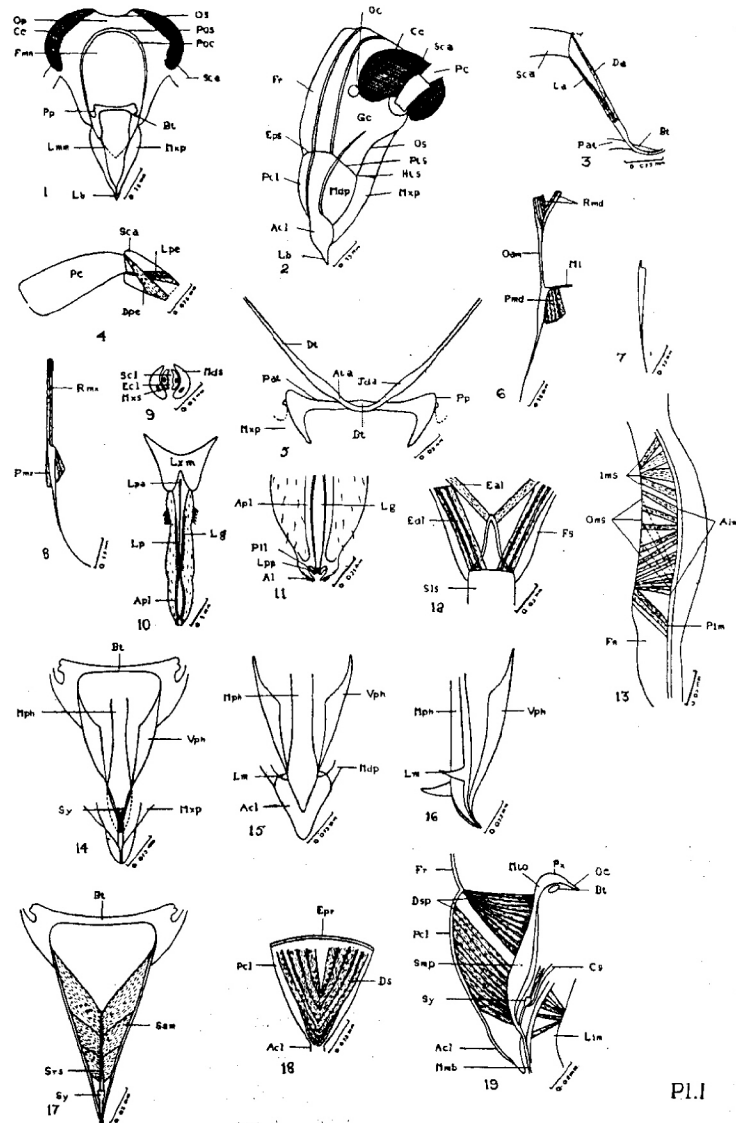
The occipital suture is incomplete; it starts from the caudal margin of the mandibular plate and extends dorsally to terminate at the side of the compound eye. It can be further traced medially as a transverse suture between the compound eyes. Internally, the median transverse part of the occipital suture gives a thin ridge.

The compound eyes are well developed, reniform, and occupy considerable area on the dorsolateral regions of the head capsule. The ocular suture is obsolete; the ocular sclerites are restricted to the inner half of the compound eyes and take a 'U' course. It starts anteriorly just posterior to the antennal socket, extends anteriorly, then curves posteriorly and terminates near the base of the vertex. At the point of termination it projects somewhat into the compound eyes. A pair of lateral ocelli are situated in the frontal region in between the lateral carinae and compound eyes towards the anterior margin of the latter.

*Antennae:* The antennae are inserted in the antennal sockets. The antennal suture as well as the antennal sclerites are obsolete in both the species. The pedicel is longer than the scape in *Liburnia pallescens* and considerably longer in *Delphacodes propinqua*. The flagellum is longer than both the basal segments combined. The basal rim of the scape is heavily sclerotized at two places; one at the dorsolateral and the other diametrically opposite to it. The scape is clothed with scattered setae all over the surface. The pedicel fits into the distal part of the scape and has two lateral sclerotized places at the rim corresponding to those of scape, where the intrinsic muscles of the antennae are inserted. The antenna is provided with two types of sensoria, minute hair-like, scattered all over the surface, and plate-like, located only on the pedicel, concentrated more towards its distal part. A small oval projection, the ring-joint, fits into the anterior depression of pedicel which continues anteriorly as flagellum.

*Antennal muscles:* The antennae are provided with both extrinsic and intrinsic muscles. The former include the levator and depressor of antenna, while the latter, the levator and depressor of pedicel.

*Levator of antenna:* (Plate I, Fig. 3; Plate II, Figs. 3, 4, La). In *Liburnia pallescens* it is a large muscle, composed of two closely applied bundles, having common origin near the swelling seen at the fused anterior and dorsal arms of the tentorium, apposing the dorsal arm for some dist-

PLATE I *Liburnia pallescens*

P.I.

ance, and inserted on the dorsolateral sclerotization at the base of scape. This common origin shows that they belong to the same muscle and they conjointly elevate the antenna. The levator in *Delphacodes propinqua* is similar, except for the basal branching of the inner bundle and is thus composed of three bundles.

*Depressor of antenna:* (Plate I, Fig. 3, Plate II, Figs. 3, 4; Da). It is similar in both the species and consists of a single bundle originating near the levator. It extends for the greater part of its length apposing the dorsal arm of the tentorium and is inserted on the ventrolateral sclerotization present at the base of the pedicel. It is broad at base and gradually narrows anteriorly. It is antagonistic to the levator of antenna.

*Levator of pedicel:* (Plate I, Fig. 4, Plate II, Fig. 5, Lpe). It is a short, stout muscle, originating from the base of the ventrolateral margin of the scape and extending obliquely to join the basal sclerotization present at the pedicel. It is composed of two thick bundles of muscle fibers.

*Depressor of pedicel:* (Plate I, Fig. 4, Plate II, Fig. 5, Dpc). It is a little longer than the levator and arises from the base of the scape at its dorsolateral margin. It extends obliquely to attach at the base of the pedicel at the sclerotization situated at the ventrolateral margin. It is composed of a single bundle.

1. Caudal view of head capsule.
2. Dorsolateral view of head capsule.
3. Diagrammatic view of antennal muscles to show their origin and insertion.
4. Lateral view of scape dissected to show the origin and insertion of muscles of pedicel.
5. Cephalic view of tentorium.
6. Mandibular stylet with its musculature.
7. Maxillary stylet.
8. Maxillary stylet with its musculature.
9. T. S. of mandibular and maxillary stylets *in situ*.
10. Ectal view of labium.
11. Ectal view of the fourth labial segment enlarged.
12. Ectal view of the first and second segment of labium dissected to show the insertion of the extrinsic muscles of labium.
13. Lateral view of labium dissected to show the origin and insertion of intrinsic muscles of labium.
14. Caudal view of hypopharynx showing its connection with the tentorium.
15. Cephalic view of hypopharynx.
16. Lateral view of hypopharynx.
17. Caudal view of salivary syringe muscles showing their origin and insertion.
18. Ental view of postclypeus to show the origin of anterior dilator of sucking pump.
19. Diagrammatic view of the dissection of the head from the lateral side showing sucking pump with its muscles, the anterior region of stomodaeum and the position of salivary syringe.

The ring-joint and flagellum are devoid of muscles. The former is soldered to the pedicel. The movements of the ring-joint and flagellum are controlled by the levator and depressor of pedicel.

*Occiput:* The occiput is horse-shoe shaped and is highly reduced because of the greater development of compound eyes. The postoccipital suture towards the lower side of the head becomes marginal and near the termination it curves back to join the tentorial pits. It bears internally a feebly developed dorsomedian ridge.

*Mandibular plates:* (Plates I, II, Fig. 2, Mdp). They are rectangular and are situated between the clypeus and maxillary plates. Basally the mandibular plate is delimited by the pleurostomal suture and anteriorly fused with clypeus. Myers (1928), Hamilton (1931), Snodgrass (1938) and Butt (1943) call these plates as 'lora'. The suggestion by Quadri and Aziz (1950) and Akbar (1957) as mandibular plates and that the term 'lora' should be used for the paired laterodorsal processes of hypopharynx is followed here.

*Postocciput:* It is the narrow, lightly sclerotized marginal rim, surrounding the occipital foramen dorsally and laterally (Plate I, II, Fig. 1, POC.). The maxillary plates (Plate I, II, Figs. 1, 2, Mxp) are two small thick sclerites, extending from the hypostomal suture to the anterior end of the head. They are pointed anteriorly and lie caudad of the mandibular plates separated by vertical sutures. Caudally, they appose the labium.

Labial segment is obsolete, except for the submentum of labium (Ferris, 1942).

*Tentorium:* (Plate I, Figs. 1, 5; Plate II, Figs. 1, 6). There is a well developed transverse bar across the foramen magnum, representing the body of tentorium. The posterior pair of tentorial arms arise from the posterior tentorial pits, at the lower end of the postoccipital suture. They stretch transversely to join the body of the tentorium. Laterally each of them bears a knob-like projection. The posterior arm continues anteriorly as a small, triangular highly sclerotized plate, bracing the lateral margin of the occipital foramen, to impart a firm support to the tentorium. Posteriorly, at the outer margin it embraces the postoccipital suture. Anteriorly it is angular and rests on the maxillary plate. This plate was mistaken for clypeopharyngeal suspensorium by Mathur and Joseph (1961) in *Peregrinus maidis*. From the body of tentorium arise paired diverging processes, extending to the antennal bases. Each process is swollen (Plate

I, Fig. 5, Plate II, Fig. 6, Jda) a little beyond its origin. This swelling represents the place of union of the dorsal tentorial arm with the anterior tentorial arm. The part of the process, between the swelling and the antennal base, represents the dorsal tentorial arm, while the part between the swelling and the body of tentorium is the anterior tentorial arm. The part of the anterior tentorial arm between the union of dorsal and anterior arms, and the anterior pit is completely atrophied. It has been observed in another araeopid, *Purohita cervina*, that this part of the arm is represented in a reduced condition. The function of the anterior tentorial arm is to strengthen the facial region of insects, which is fulfilled in these insects by well developed, highly sclerotized epistomal ridges. Consequently, the anterior arms are either atrophied or occur in a reduced condition.

#### Mouthparts

*Mandibular stylets:* (Plate I, Fig. 6; Plate II, Fig. 7). Each mandibular stylet arises from the bristle pouch, situated one on either side of the head between inner wall of the maxillary plate and outer wall of the ventral process of hypopharynx. It is a long, slender, sclerotized needle-like structure. It is thickened basally and narrows gradually to a blunt apex. From the base it gives rise to two arms, an inner and an outer. The latter is a long, thin apodeme extending internally upto the frontoparietal region to which the retractor muscles are attached. The inner arm continues distally as lever but in the species under observation, there is no differentiation into inner arm and lever, reported in *Pyrilla perpusilla* and *Leptocorisa varicornis* by Quadri and Aziz (1950) and Akbar (1957) respectively. The inner arm is, therefore, referred to here as mandibular lever. It is small and joins the cranium at the lateral ends of the epistomal suture or rather at the junction between the pleurostomal ridge and epistomal suture. Hamilton (1931) in *Nepa cinerea* shows the attachment of the lever with the genal suture and Butt (1943) considers that it is always attached in front of antennal fossa. The mandibular bristles converge anteriorly and pass outside along the side of the hypopharynx. Their converging nature enables them to come closer and closer and distally beyond the tip of the hypopharynx the bristles enter into the labial groove apposing the maxillary stylets. Inner side of the mandibular stylets are concave and match against the convex sides of the maxillary stylets. Thus in the labium four bristles are closely assembled in a slender fascicle, the mandibular bristles occupying an outer position.

Muscles of mandibular stylets comprise the protractor and retractor muscles.

*Protractor of mandibular stylet:* (Plate I, Fig. 6; Plate II, Fig. 7, Pmd). It is well developed in *Liburnia pallescens* and consists of five or six bundles, originating from the inner face of the mandibular plate. They stretch posteriorly in a row and are inserted to the mandibular lever, but the proximal bundle is attached to the base of the mandible. Contraction of this muscle ejects the bristle. The musculature in *Delphacodes propinqua* is similar, except for the number of bundles which are seven. This muscle resembles the protractor of mandibular stylet, described by Myers (1928) in *Cicada*, Qadri and Aziz (1950) in *Pyrilla* and Akbar (1957) in *Leptocorisa*.

*Retractor of mandibular stylet:* (Plate I, Fig. 6; Plate II, Fig. 7, Rmd). It is well developed in *Liburnia pallescens* and consists of two groups of muscles, originating from the basal margin of vertex and adjacent to the compound eyes. One group arises caudally and consists of four or five bundles, just inner to the other. The next group consists of two bundles and is a little longer than the first, since it attaches more cephalad than the first. Anteriorly they are attached to the posterior end of the outer arm of the mandible. In *Delphacodes propinqua* the large group is composed of four bundles and the other similar to *Liburnia pallescens*. Often one of these bundles of the small group appears to be divided in *Delphacodes propinqua* and it appears that this group is composed of three bundles instead of two. These muscles are antagonistic to the protractor muscles. This corresponds to the retractor of *Pyrilla perpusilla* recorded by Qadri and Aziz (1950). It resembles in its division into two groups to *Leptocorisa varicornis* described by Akbar (1957) but differs from its place of origin.

*Maxillary stylets and their musculature:* (Plate I, Figs. 7, 8; Plate II, Figs. 8, 9). Each maxillary stylet arises from the bristle pouch outer to the mandibular stylet. It is somewhat thinner and longer than the mandibular stylet and rests along the inner aspect of the maxillary plate. Basally it is swollen and distally it narrows to a bristle. From its base a small apodeme, to which the retractor muscles are attached, is directed anteriorly. There is, however, no maxillary lever attached to the maxillary stylet and the retractor muscles are directly attached to the base of the stylet. In a paper in collaboration with Mathur (1961), I mistook the apodeme at

the base of the maxillary stylet for the lever. The maxillary bristles converge anteriorly and project out of the bristle pouches along the hypopharynx. Beyond this they appose each other and enter into the groove of the labium surrounded by the mandibular stylets. Inside the head, the maxillary stylets are external to the mandibular stylets and they cross over the latter to occupy an inner position in the labium. Thus they converge more than the maxillary stylets. The inner surface of each maxillary stylet is provided with two furrows, separated by a ridge along as much of its length as it apposes its mate of the opposite side. These furrows in union with the corresponding furrows of the other stylet form two canals (Plate I, Fig. 9; Plate II, Fig. 10, Scl and Ecl), an anterior and a posterior canal popularly known as food canal or suction canal and salivary canal or ejection canal, respectively. Wherever the bristles diverge to enter into the pouches, the anterior canal joins to the mouth channel. Into the other canal opens the salivary meatus. The canals are dissimilar in calibre, the suction canal being larger than the ejection canal.

The motor equipment of maxillary seta is similar to that of mandibular stylet and consists of a protractor and retractor muscle. The musculature is similar in both the species under consideration.

*Protractor of maxillary stylet:* (Plate I, Fig. 8; Plate II, Fig. 9, Pmx). It is a stout muscle of four compactly packed bundles, which originate from the anterior margin of the maxillary plate and gradually decrease in length from one end to the other. Unlike that of the mandibles, they are directly inserted at the base of the maxillae, since the maxillary levers are absent. The protractor of the maxilla is similar in origin and attachment to that of *Pyrilla perpusilla* (Qadri and Aziz, 1950). In *Notonecta* (Butt, 1943) and *Leptocorisa* (Akbar, 1957) the bundles of protractor muscle originate from different points.

*Retractor of maxillary stylet:* (Plate I, Fig. 8; Plate II, Fig. 9, Rmx). It consists of two bundles of uniformly stout muscles, originating from the vertex close to the mandibular retractor and external to it. It stretches externally parallel to the outer arm of the mandibular stylet. Proximally it lies parallel to the larger bundle of the mandible and is inserted on the basal apodeme of maxilla. Each bundle bifurcates basally. The muscle corresponds to the retractor of maxilla, described by Hamilton (1931), Qadri and Aziz (1950) and Akbar (1957) in *Nepa*, *Pyrilla* and *Leptocorisa* respectively.

*Labium and its musculature:* (Plate I, Figs. 10, 11; Plate II, Figs. 11, 12). The labium is kept abreast with the ventral surface of head and thorax and extends posteriorly upto the posterior margin of metathorax. It is suspended by a membrane, which can be called as the labiomaxillary membrane because of its position. It is not a part of the labium since it does not exhibit the modification undergone by the other segments. It represents the membranized hypostomal bridge. The labiomaxillary membrane is well developed in *Liburnia pallescens*, whereas it is reduced in *Delphacodes propinqua*. In both the species it is indistinguishably fused with the base of labium. The labium is four segmented and the segments are of unequal length. The basal segment is lightly sclerotized and membranous except for the labial groove, while the remaining parts are well sclerotized. The distal part of the labial groove of the first segment has a basal sclerotized plate, the labial plate, which continues posteriorly into the following segments. It enlarges basally to form an apodeme, the labial plate apodeme (Myers, 1928). Akbar (1957) reports that in *Leptocoris varicornis* the labial plate apodeme is confined to the first segment alone. The lateral margins of the first segment are heavily sclerotized. The second and third segments are similar to the first, but for the distal labial plate apodeme. The penultimate segment is the longest. In the last segment the lateral walls are provided with two apodemes. The lateral walls of the labial groove has a ridge and groove arrangement starting from the distal part of the second segment; but these are more pronounced in the last segment. When the underlying muscles of the labial apodeme act, the lateral walls of this segment come together to form a tube, which helps to keep the bristles in position during piercing. The ridge and groove method enables to make it a complete tube, especially distally, during contraction.

Earlier workers have paid little attention to the apex of the fourth segment. Qadri and Aziz (1950) and Akbar (1957) have studied in detail the labial apex of *Pyrilla perpusilla* and *Leptocoris varicornis*. In the species studied by me it (Plate I, Fig. 11, Plate II, Fig. 12) is deeply emarginated, with the sides developing into apical lobes (A1). A short process is borne on the inner side of each lobe (P11), which continues posteriorly with the apodeme at the lateral margin of the labial groove. The labial plate extends beyond the labial groove and bifurcates distally to form two sclerotized processes (Lpp). These combine with the processes of the labial apical lobe to form a temporary ring around the stylets

when the intrinsic muscles of the labium contract. The bifurcated labial plate occupies a mesoventral position to form the lower part of the ring, while its upper part is completed by the processes of the labial apical lobes, when the muscles contract. Naturally, the lateral sides are protected by the apical lobes of the labium.

Chaetotaxy of the labium follows a similar pattern in both the species. In the second segment there are six setae in a row at the ventrolateral margins. It begins a little away from the base and extends upto the hind end. On either side of the lateral margins of the labial groove, there is a row of chaetae at regular intervals, starting from the distal part of the second segment onward upto the hind end of the third segment. The surface of the second, third and fourth segments is clothed with scattered chaetae, which are longer than the ones at the lateral margins of the labial groove, but shorter than those occurring at the lateral margins of the second segment. The apical region of the apical lobe of the labium bears a profuse growth of setae, which are in clusters and sensory.

*Muscles of the labium:* They comprise the extrinsic and intrinsic muscles.

*Extrinsic abductor of labium:* (Plate I, Fig. 12; Plate II, Fig. 13, Ed1). In *Liburnia pallescens* it is a short tendinous muscle and the combined muscles of both sides look like a 'V'. It originates from the inner wall of the hypopharyngeal process and is inserted at the base of the labial plate. Contraction of this muscle brings the labium from a horizontal to a ventral position. The muscle is similar in *Delphacodes propinqua*, but is more divergent basally. This resembles the protractor of labium of *Pyrilla perpusilla* described by Qadri and Aziz (1950).

*Extrinsic adductor of labium:* (Plate I, Fig. 12; Plate II, Fig. 13, Ed1). It consists of three bundles of fibers in *Liburnia pallescens* having a common origin and attachment. It originates from the inner wall of the ventral hypopharyngeal process near the abductor, a little posterior to it and is attached to the base of the second segment. Basally it extends inner to the abductor. In *Delphacodes propinqua* it consists of five bundles of fibers, occasionally the fifth may not be distinct. The extrinsic adductor resembles the retractor of labium of *Pyrilla perpusilla* recorded by Qadri and Aziz (1950). It is antagonistic to the abductor.

*Intrinsic muscles of labium:* (Plate I, Fig. 13; Plate II, Fig. 14). They are quite different in distribution from *Pyrilla perpusilla*, described

by Qadri and Aziz (1950). The second and third segments are practically filled with muscles. They originate from the inner wall of the labium and are inserted to the labial plate. The last segment is devoid of muscles except for the insertion of some bundles from the preceding segment with the labial plate. The second segment has four pairs of muscles (Ims) diverging from their origin to the insertion. In the third segment, there are three groups of muscles, one transverse and two oblique. The former consists of a number of pairs, generally thirteen, of transverse muscles (Aim) diverging from their origin to attachment. The basal oblique muscle (Oms) consists of three pairs of bundles originating from the base of third segment. In *Delphacodes propinqua* occasionally a fourth bundle is also noticeable. They are inserted a little posterior to the middle of the third segment. The other group (Pim) is also composed of three bundles having their origin near the distal margin of the segment. Of the three bundles, the distal or sometimes all the three bundles encroach upon the basal region of third segment.

*Hypopharynx*: (Plate I, Figs. 14 to 16; Plate II, Figs. 15 to 17).

It is a sclerotized pad-like structure with a cylindrical central mass tapering anteriorly. The salivary syringe is fused ventrally with the central mass

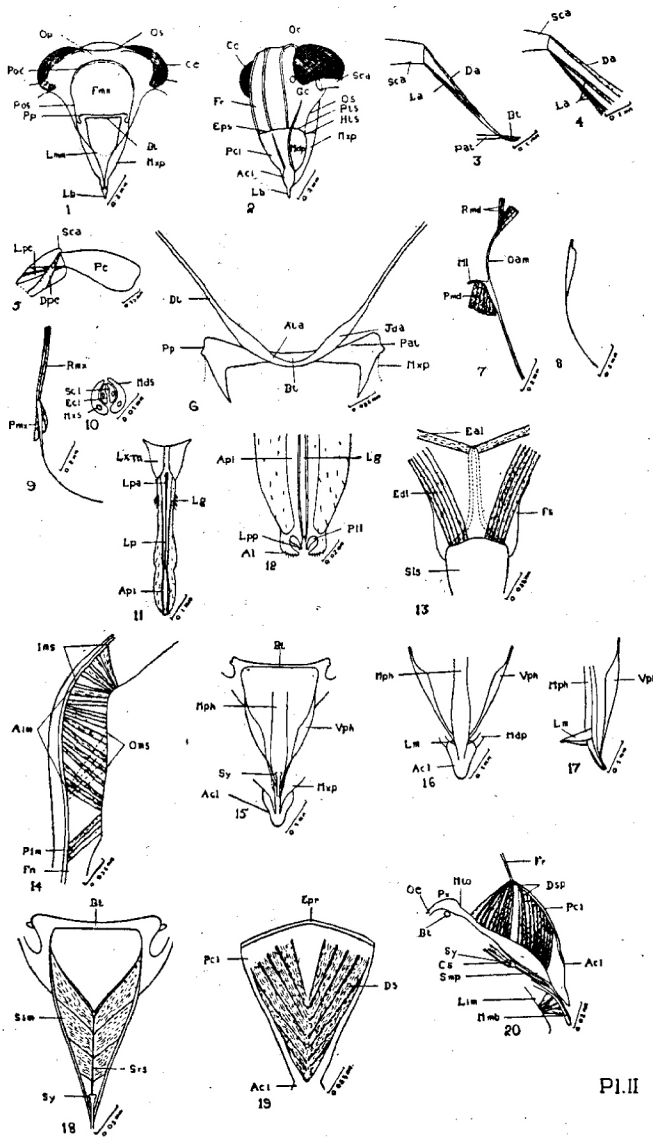


PLATE II *Delphacodes propinqua*.

1. Caudal view of head capsule.
2. Dorsolateral view of head capsule.
3. Diagrammatic view of antennal muscles to show their origin and insertion.
4. Antennal muscles separated from the tentorium to show the branching of levator.
5. Lateral view of scape dissected to show the origin and insertion of muscles of pedicel.
6. Cephalic view of tentorium.
7. Mandibular stylet with its musculature.
8. Maxillary stylet.
9. Maxillary stylet with its musculature.
10. T. S. of mandibular and maxillary stylets *in situ*.
11. Ectal view of labium.
12. Ectal view of the fourth labial segment enlarged.
13. Ectal view of the first and second segments of labium dissected to show the insertion of the extrinsic muscles of labium.
14. Lateral view of labium dissected to show the origin and insertion of intrinsic muscles of labium.
15. Caudal view of hypopharynx showing its connection with the tentorium.
16. Cephalic view of hypopharynx.
17. Lateral view of hypopharynx.
18. Caudal view of salivary syringe muscles showing their origin and insertion.
19. Ental view of postclypeus to show the origin of anterior dilator of sucking pump.
20. Diagrammatic view of the dissection of the head from the lateral side showing sucking pump with its muscles, the anterior region of stomodaeum and the position of salivary syringe.

at its posterior side. The hypopharynx carries paired laterodorsal and ventral processes and an unpaired median dorsal process. The paired laterodorsal processes (Lm) are small, flat, conical plates arising from the dorsal surface of the central mass of the hypopharynx. They stretch dorsolaterally to join the dorsal area of the respective mandibular plates at the junction between the ante- and postclypeus. These plates, called lora, are quite independent of the mandibular plates. Their independent nature has been demonstrated by Qadri and Aziz (1950) and Akbar (1957) in *Pyrilla perpusilla* and *Leptocoris varicornis*, respectively. The paired ventral processes (Vph) are flat, plate-like and arise ventrally from the central mass of hypopharynx. The expansion of the ventral process strengthens the hypopharynx for a powerful muscular action. It is narrower at its origin and gradually enlarges from the anterior to the posterior region. Distally for one-fourth the distance, the ventral process again narrows gradually and are attached to the posterior arm of the tentorium. The ventral process forms the inner wall of a pouch at the lateral side of head capsule, the bristle pouch, whose outer wall is formed by the maxillary plate. The mandibular and maxillary bristles arise from the bristle pouch. To the ventral processes are attached the muscles of the salivary syringe. The median hypopharyngeal process (Mph) continues posteriorly as the median dorsal process. It extends towards the occipital foramen as a sclerotized trough. It is medially constricted and is comparatively broad at both ends. This supports the buccal cavity of the alimentary canal.

*Salivary syringe and its musculature:* (Plate I, Figs. 14, 17, 19; Plate II, Figs. 15, 18, 20). The salivary syringe is a small, sclerotized cavity, along the ventral surface of the median lobe of the hypopharynx. The ventral processes of the hypopharynx arise laterally and the median process anteriorly. The common duct of the salivary glands (Cs) opens at its posterior side and anteriorly the syringe opens exteriorly by a narrow tube, the salivary meatus. The latter passes anteriorly through the median lobe to join the ejection canal, situated inside the maxillary stylets. The inner end of the syringe supports a small, sclerotized rod which gradually enlarges proximally. This rod exhibits a restricted movement during the pumping of saliva. Although the rod does not manifest a clear-cut distinction between a basal piston and a distal handle, as reported in *Leptocoris varicornis* by Akbar (1957), its basal portion may, however, be referred to as piston and the remaining part as handle.

The muscles of the salivary syringe (Plate I, Fig. 17; Plate II, Fig. 18, Ssm) consists of flat, thick bundles originating from the inner side of the ventral process of hypopharynx and occupying major portion of its inner wall. Each group is composed of four bundles extending laterally to attach with the handle of the salivary syringe. They converge towards the point of attachment, resembling the condition in *Pyrilla perpusilla* (Qadri and Aziz, 1950), but differing from that of *Leptocoris varicornis*, in which Akbar (1957) reports that a few bundles originate from the ventral portion of the rim of the foramen magnum also. The contraction of this muscle lifts the invaginated wall of the cavity, which is immediately filled by the inflow of the salivary liquid from the common duct of the salivary gland, and the relaxation of the muscle forces out the liquid through the ejection canal.

*Sucking pump muscles:* (Plate I, Fig. 19; Plate II, Fig. 20; Dsp). There are two sets of dilator muscles for the sucking pump (divaricator muscles of Willis, 1948), arising from the inner wall of the clypeus. Like in the majority of homopterans, these muscles are confined to the clypeal area.

*Anterior dilator of the sucking pump:* (Plate I, Fig. 18; Plate II, Fig. 19; Ds). It is a large muscle forming the great mass of muscle fibers that fill the space between the postclypeus and sucking pump. Its fibers originate in two oblique rows, starting a little anterior to the epistomal ridge and leaving some space in between for the origin of posterior dilator, inserted on the sucking pump posterad to the anterior dilator. Because of their oblique disposition, the muscle bundles gradually increase in length from the middle to the side. They are inserted on the cibarium near the anterior region of the postclypeus.

*Posterior dilator of the sucking pump:* It is smaller than the anterior dilator and originates from the area between the anterior dilator and the epistomal ridge in the posteromedian part of the postclypeus. It is inserted on the posterior part of the sucking pump. It is composed of a number of diverging bundles inserted on a larger area of the sucking pump than that of its origin on the postclypeus. The posterior dilator is prismoid in shape.

#### DISCUSSION

According to the system of Ferris (1942 *et seq.*) which can be followed with advantage, the labrum, clypeus, antennal-ocular, mandible,



maxilla and labium constitute the head segments. The intercalary segment is almost obliterated and is represented by the tentorium. The most important question that is yet to be decided is the number of segments that have entered into the formation of insect head, because it is the cornerstone on which Ferris builds up the whole concept of his morphology.

Normally the ocular lobes are separated from the mandibular segment by the pre-mandibular suture, but in these two insects under observation the ocular lobes have directly come in contact with the mandibular segment, which is an extremely interesting feature. Such a condition is the result of a certain tendency in the frons and vertex region to shift forwards owing to the opisthognathous condition. Since the most useful position for the compound eyes is to be situated dorsolaterally, they maintained their position but covered greater area. On the contrary, the other sclerites mentioned above shifted forward, with the result that the region immediately posterior to them, *viz.* the mandibular segment also shifted anteriorly. They have come to lie along with the ocular lobes, but the median part of the mandibular segment is still separated from the antennal-ocular segment by the pre-mandibular suture.

The homology of the mandibular plates has been a subject of much controversy and from time to time various attempts have been made to explain it in different ways. Earlier workers like Muir and Kershaw (1911) and Davidson (1914) regarded them as lateral developments of clypeus. Evans (1938) and Spooner (1938) considered them as lateral expansions of postclypeus. Snodgrass (1938) and Butt (1943) took them to be expansions of hypopharynx. Ferris (1943) derives the mandibular plate from the antennal segment and calls it as paraclypeal lobe and the suture separating its lateral boundary as tentorial suture. The view that these plates are derived from clypeus is no more valid as demonstrated by Snodgrass (1938), and he believes them to have originated from hypopharynx, because of their continuity with the mandibular plates through the laterodorsal processes of hypopharynx. He does not, however, account for the sutures, met with between these processes and mandibular plates, in many bugs. The laterodorsal processes seem to have joined to the anterolateral margins of mandibular plates to strengthen the hypopharynx, this junction of union is marked off by a suture in many hemipterans. Ferris' (1943) view that the mandibular plate belongs to the antennal segment seems untenable, because the protractor of mandible

takes its origin from the mandibular plate. It seems thus justifiable to believe that the plate in question belongs to the mandibular segment. Qadri and Aziz (1950) and Akbar (1957) were apparently correct in their view that the mandibular plates represent the highly developed pleurostomal regions of generalized insect head. Ferris (1942) erred by neglecting the importance of subgenal areas; they go a long way in the formation of the generalized insect cranium.

The reduction in the anterior tentorial arms in *Peregrinus maidis* attracted the attention of Mathur and Joseph (1961) earlier. It was observed that there is a pair of well developed dorsal arms, but at the same time the anterior arms are reduced and have no independent existence. As a matter of fact, the dorsal arms arise from the anterior arms in insects, but in the two species under discussion as well as in *Peregrinus maidis*, in spite of their origin as usual, it is interesting to note that the parent body, *i.e.*, the anterior arms get reduced. The anterior arms upto the origin of the dorsal arms are retained while the remaining portion is atrophied. The suggestion then put forth was that the role of strengthening of facial region—the normal function of the anterior arms—is secondarily taken up by the highly sclerotized epistomal ridge and consequently the anterior arms have lost their importance. In the evolutionary stages involved in the reduction of the anterior arms, *Pyrilla perpusilla* (Qadri and Aziz, 1950), represents an intermediate stage, wherein the anterior arms are present in a reduced condition and the epistomal ridge is well developed. The occurrence of a reduced pair of anterior arms in *Purohita cervina* confirms the idea put forth earlier. Further study on this subject is likely to bring out a complete evolutionary series, in which the reduction of arms in the same family has taken place.

The labiomaxillary membrane may be either homologized to gula or hypostoma. Gula as defined by Snodgrass (1935) is the "median ventral plate of the head in some prognathous insects formed by a sclerotization of the neck region proximal to the posterior tentorial pits, continuous with the postmentum or submentum." In both the species under consideration, the region connecting the labium with the maxillary plates does not extend upto the posterior tentorial pits, hence this region (labiomaxillary membrane of the author) can hardly be considered as gula. Its position almost agrees with Muir and Kershaw's views (1911) on the gular region of Homoptera, *viz.*, the "gular region is reduced to

a minimum in many cases being but a thin membrane connecting the labium with the foramen magnum." Similarly, Qadri (1949) has observed in *Idiocerus* (Jassidae) a structure, which he believes to be homologous with the gula (Snodgrass), irrespective of the position of the tentorial pits, and according to him the gula is a "basal sclerite which articulates it (labium) with the head."

In Heteroptera, a structure named hypostoma is located in exactly a similar situation as in the insects under study. We should, therefore, consider it as homologous with the hypostomal bridge of heteropterans. It is rather remarkable that the homopterans seem to have evolved by reduction of the gula of heteropterans. Owing to its membranous condition and its location, we should prefer to call it the labiomaxillary membrane.

#### SUMMARY

Morphology and musculature of the head capsule and mouthparts of two species of araeopids are described in detail. The concept of morphology of insect cranium, advanced by Ferris, is discussed side by side with the general concept.

The fate of ocular lobes, the homology of mandibular plates, the reduction to atrophy of anterior tentorial arms and the homology of the membrane suspending the labium, called here as labiomaxillary membrane, have been discussed in detail. It is shown that the mandibular plates represent the highly developed pleurostomal regions of generalized insect head.

#### Abbreviations

Acl—anteclypeus, Aim—transverse intrinsic muscles of third labial segment, Al—apical lobe of labium, Apl—apodeme at the lateral margin of the fourth labial segment, Ata—anterior tentorial arm, Bt—body of tentorium, Ce—compound eye, Cs—common salivary duct, Da—depressor of antenna, Dpe—depressor of pedicel, Ds—anterior dilator of sucking pump, Dsp—dilator of sucking pump, Dt—dorsal tentorial arm, Eal—extrinsic abductor of labium, Ecl—ejection canal, Edl—extrinsic adductor of labium, Epr—epistomal ridge, Eps—epistomal suture, Fmn—foramen magnum, Fn—fourth labial segment, Fr—frons, Fs—first labial segment, Ge—gena, Hts—hypostomal suture, Ims—intrinsic muscles of second labial segment, Jda—junction of the union of dorsal tentorial arm with anterior arm, La—levator of antenna, Lb—labrum, Lg—labial groove, Lim—labium, Lm—lorum, Lmm—position of labiomaxillary membrane, Lp—labial plate, Lpa—labial plate apodeme, Lpe—levator of pedicel, Lpp—labial plate process, Lxm—labiomaxillary membrane, Mdp—mandibular plate, Mds—mandibular stylet, Ml—mandibular lever, Mmb—mandibular and maxillary stylets in cluster, Mph—median process

of hypopharynx, Mto—mouth, Mxp—maxillary plate, Mxs—maxillary stylet, Oam—outer arm of mandibular stylet, Oc—ocellus, Oe—oesophagus, Oms—oblique basal intrinsic muscles of third labial segment, Op—occiput, Os—occipital suture, Pat—posterior tentorial arm, Pcl—postclypeus, Pe—pedicel, Pim—oblique distal intrinsic muscles of third labial segment, Pll—process of labial apical lobe, Pmd—protractor of mandibular stylet, Pmx—protractor of maxillary stylet, Poc—postocciput, Pos—postoccipital suture, Pp—posterior tentorial pit, Pts—pleurostomal suture, Px—pharynx, Rmd—retractor of mandibular stylet, Rmx—retractor of maxillary stylet, Sca—scape, Scl—sucking canal, Sls—second labial segment, Smp—sucking pump, Srs—sclerotized rod to which the salivary syringe muscles are inserted, Ssm—salivary syringe muscles, Sy—salivary syringe, Vph—ventral process of hypopharynx.

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