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REPRODUCTIVE ORGANS OF LIBURNIA PALLESCENS (DISTANT) AND DELPHACODES PROPINQUA (FIEBER) (HOMOPTERA, FULGOROIDEA, ARAEOPIDAE)

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THE morphology of the external male genitalia of Araeopidae has been studied by several investigators (Giffard, 1921; Kershaw and Muir, 1922; Pruthi, 1925, Muir, 1925, 1926; Fennah, 1945 and Hassan, 1948). But there is very little work on the external genitalia of the female as well as the internal genitalia of both the sexes. The present paper attempts to study the genitalia of araeopids in detail and two species—*Liburnia pallescens* and *Delphacodes propinqua*—have been selected. Araeopids exhibit sexual dimorphism in that the males are always darker than the females.

MATERIAL AND METHODS

Liburnia pallescens and *Delphacodes propinqua* are two species of common Indian araeopids They were caught from Ajmer (Rajasthan) and Agra (Uttar Pradesh) in the months of July, August and September by sweeping the grassy grounds. For dissections, the insects were preserved either in 70% alcohol or formalin-acetic acid-alcohol solution. For microtomy, they were fixed in Bouin's fluid for six hours. After the usual treatment, their body was punctured by a fine needle before embedding in histowax (56-58°C). Sections were cut at 8-10μ, and were stained with Delafield's haemotoxylin and eosin.

OBSERVATIONS

Internal Genitalia

Female: In both the species under observation (Figs. 1-6) there is a pair of well developed ovaries filling the dorsal part of the abdomen and extending from the middle of the thorax upto the middle of the ninth abdominal segment. They are comparatively larger in *Delphacodes propinqua* than in *Liburnia pallescens*. In the former due to the lateral expansion of the ovaries the rest of the genital organs are hidden beneath them. In *Liburnia pallescens* the ovaries are narrow and elongated and the spermatheca is visible posteriorly between them. In cases where the

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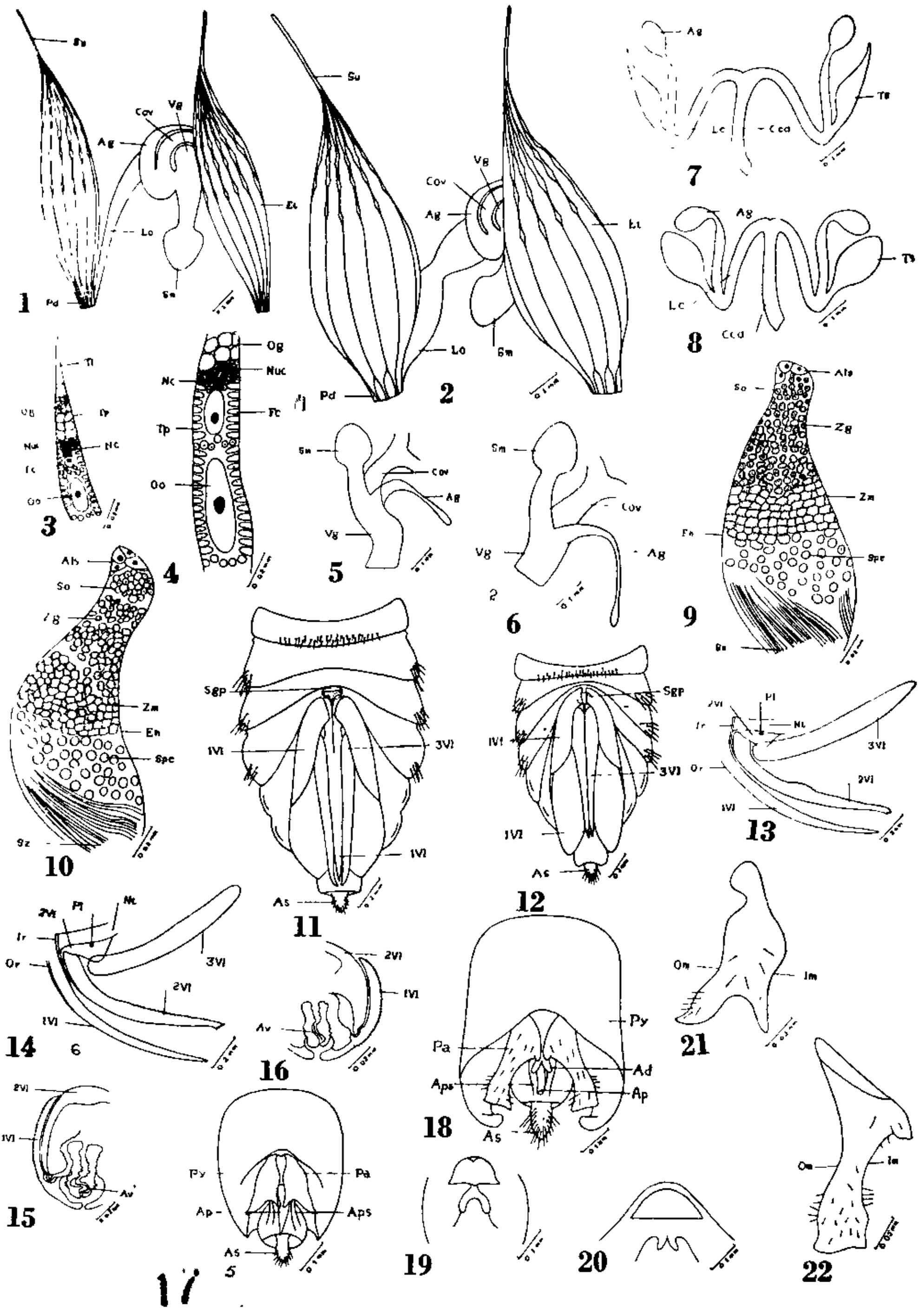
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ovarioles contain mature oocytes and especially those situated at the inner side, they enlarge to such an extent as to cover the spermatheca completely.

Each ovary is composed of twelve to sixteen distally tapering ovarioles, which have a thin structureless membranous tunica propria. Three regions, *viz.*, a terminal thread-like filament, a median egg tube and a basal stalk or pedicel are clearly discernible. The filaments of each side are intertwined in the thoracic region and form a suspensory apparatus for the ovary, which runs through the tracheoles along the lateral sides of the alimentary canal. The rest of the ovariole is suspended in the fat bodies. Inner to the tunica propria, the egg tube has a regular row of follicular epithelium. In *Liburnia pallescens* and *Delphacodes propinqua* the nurse cells remain at the proximal region of the ovariole and the

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Fig. 1 Female internal reproductive system of *Liburnia pallescens* (the left ovary turned laterally to show the lateral oviduct.).

Fig. 2 Female internal reproductive system of *Delphacodes propinqua* (the left ovary turned laterally to show the lateral oviduct).

Fig. 3 L. S. of ovariole anterior region of *Liburnia pallescens.*

Fig. 4 L. S. of ovariole anterior region of *Delphacodes propinqua.*

Fig. 5 Distal region of the female internal reproductive system of *Liburnia pallescens* straightened to show the openings of the spermatheca and accessory glands into the vagina

Fig. 6 Distal region of the female internal reproductive system of *Delphacodes propinqua* straightened to show the openings of spermatheca and accessory glands into the vagina.

Fig. 7 Male internal reproductive system of *Liburnia pallescens.*

Fig. 8 Male internal reproductive system of *Delphacodes propinqua.*

Fig. 9 L. S. of sperm tube of *Liburnia pallescens.*

Fig. 10 L. S. of sperm tube of *Delphacodes propinqua.*

Fig. 11 Ventral view of female abdomen of *Liburnia pallescens* showing the external genitalia.

Fig. 12 Ventral view of female abdomen of *Delphacodes propinqua* showing the external genitalia.

Fig. 13 Female external genitalia of *Liburnia pallescens* dissected.

Fig. 14 Female external genitalia of *Delphacodes propinqua* dissected.

Fig. 15 T. S. of ovipositor of *Liburnia pallescens* showing the union of first and second valvifers.

Fig. 16 T. S. of ovipositor of *Delphacodes propinqua* showing the union of first and second valvifers.

Fig. 17 Ventral view of pygofer of *Liburnia pallescens.*

Fig. 18 Ventral view of pygofer of *Delphacodes propinqua.*

Fig. 19 Armature of diaphragm of *Liburnia pallescens.*

Fig. 20 Armature of diaphragm of *Delphacodes propinqua.*

Fig. 21 Ventral view of paramere of *Liburnia pallescens.*

Fig. 22 Ventral view of paramere of *Delphacode spropinqua* developing oocytes are connected to the nurse cells by protoplasmic strands, the nursing cord. So the ovariole in these insects is acrotrophic as generally met with in the Hemiptera (Snodgrass, 1935). The growth of the oocytes produces a number of egg chambers of varying dimensions giving the ovariole a gradually enlarging beaded appearance. The ovariole is continued posteriorly as the stalk, which is a short, narrow tube, directed inwards to join the oviductus lateralis.

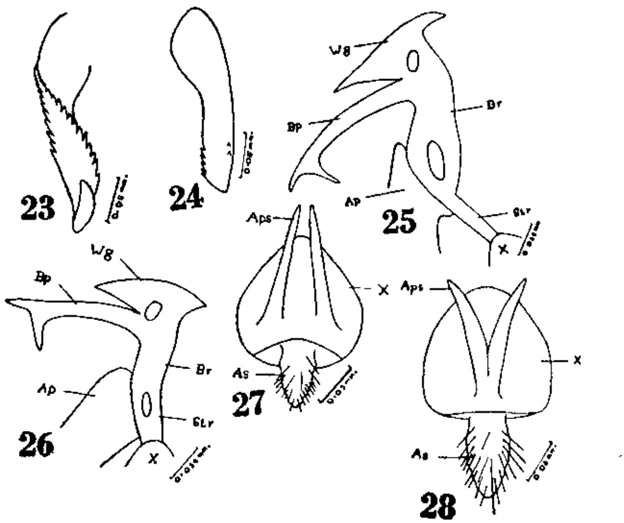

Fig. 23 Aedeagus periandrum of *Liburnia pallescens.*
Fig. 24 Aedeagus periandrum of *Delphacodes propinqua.*
Fig. 25 Basal plate bridge, basal plate prolongation and aedeagus basal strut of *Liburnia pallescens.*
Fig. 26 Basal plate bridge, basal plate prolongation and aedeagus basal strut of *Delphacodes propinqua.*
Fig. 27 Ventral view of tenth and eleventh male abdominal segments of *Liburnia pallescens.*
Fig. 28 Ventral view of tenth and eleventh male abdominal segments of *Delphacodes propinqua.*

Ad. armature of diaphragm; Ag. accessory gland; Als. apical cells; Ap. aedeagus periandrum; Aps. anal process; As. anal style; Av. apposition of first valvulae; Bp. basal plate prolongation; Br. Basal plate bridge; Ced. ejaculatory duct; Cov. common oviduct Eh. epithelial sheath; Et. egg tube; Fc. follicular cell; Im. inner margin of paramere; Ir. inner ramus of first valvula; Le. vas deferens; Lo. lateral oviduct; Nc. nursing cord; Nt. ninth tergum; Nuc. nurse cell; Og. oogonia; Om. outer margin of paramere; Oo. oocyte; Or. outer margin of first valvula; Pa. paramere; Pd. stalk; Pl. position of condyle; Py. pygofer; Sgp. subgenital plate; Sm. spermatheca; So. spermatogonia; Spe. spermatids; Str. aedeagus basal strut; Su. suspensory apparatus; Sz. spermatozoa; Tf. terminal filament; Tp. tunica propria; Ts. testis; 1Vf. first valvifer; 2Vf. second valvifer; Vg. vagina; 1Vl. first valvula; 2Vl. second valvula; 3Vl. third valvula; Wg. wing; Zg. zone of growth; Zm. zone of maturation; X. tenth abdominal segment.

The pedicels of each ovariole meet the dilated distal region of the lateral oviduct namely the calyx. The lateral oviduct narrows to a short distance as it continues from the calyx and as it proceeds anterolaterally it gradually increases in dimension till it meets its fellow of the other side at the region of the seventh and eighth abdominal segments. These structures are hidden beneath the ovaries, on removing which the combined lateral oviducts give an arched appearance. The oviducts are laterally compressed and their walls are muscular. Each oviduct in *Delphacodes propinqua* has been observed at times to contain two mature oocytes in a row to be discharged into the oviductus communis or the common oviduct. It is remarkable that the common oviduct in these insects is not located in the median line but disposed off towards the left side. Hence the right lateral oviduct crosses over towards the left and joins its fellow of that side to open into the common oviduct.

The common oviduct is situated at the left half of the insect and it runs to the right to join the terminal part of the genitalia, the vagina. It is due to the deflection of vagina towards the left side that the region immediately anterior to it *i.e.*, the common oviduct comes to occupy the left side. The common oviduct is a short, muscular, swollen tube situated between the eighth and basal part of the ninth segment. It curves and then runs along the vagina for some distance before opening into it. The female gonopore is concealed inside the vagina. In both the species of araeopids under observation the terminal part is not a chamber as is reported in *Magicicada septendecim* (Snodgrass, 1935) and *Pyrilla perpusilla* (Qadri and Aziz, 1950). In *Pyrilla,* though the terminal region forms a distinct genital chamber, Qadri and Aziz call it as vagina. The vagina in *Liburnia pallescens* and *Delphacodes propinqua* is situated between the eighth and the basal part of the ninth abdominal segment. It is short, muscular, somewhat wider posteriorly and curves towards the left side. This curving has produced corresponding changes in the position of the structures which open into it. The spermatheca has come to lie at the posterior end, the accessory gland and the common oviduct open at the lateral side. The vagina opens outside by vulva into the ovipositor at the hind margin of the eighth segment.

The spermatheca opens at the anterior region of the vagina. It extends posteriorly upto the ninth segment and stops short of the hind margin of the ovaries. It has distal muscular, globular sac and a short, wide duct connecting to the vagina. The duct is curved slightly to the left side.

A little posterior to or almost at the same level of the spermathecal opening, the accessory gland opens into the vagina. It is directed from the left to the right side, runs around the vagina outer to the common oviduct and distally it is projected posteriorly. It is wider basally, narrow medially and distally terminates in a narrow sac. At times it has been observed that the sac is swollen. In *Liburnia pallescens* the accessory gland extends upto the middle of the spermatheca. In *Delphacodes propinqua* it is longer and extends upto the hind margin of the spermatheca. The middle region of accessory gland in this species is much narrower and filament-like.

Male: The male internal genitalia (Figs. 7-10) is similar in both the species. It is located in the posterior half of the abdomen, extending from the distal part of the sixth to the posterior margin of the ninth abdominal segment and is covered by fat bodies. Medially it apposes the alimentary canal.

The testis in *Liburnia pallescens* is a small, flask-shaped structure extending from the distal part of the seventh to the base of the ninth segment. In *Delphacodes propinqua* it is almost oval, shorter than the former, and extends from the distal part of the eighth to the basal part of the ninth segment. Each testis is composed of two small sperm tubes, which are bundled up together by peritonial sheath. The sperm tube is connected to the vas deferens by a narrow, short, vas efferens and is covered externally by an epithelial sheath. In longitudinal sections of the sperm tube, the usual four regions, *viz.*, the germarium, zone of growth, zone of maturation and zone of transformation, are clearly discernible. In insects generally only one apical cell is observed (Snodgrass, 1935), but in araeopids under observation there are a number of large and distinct apical cells. Qadri and Aziz (1950) also report a number of apical cells in *Pyrilla perpusilla*. Carson (1945) has shown the presence of more than one apical cell in many cases and has described the nature of the various kinds of such cells in insects.

The vas deferens receives the vasa efferentia anteriorly and after running for some distance opens into the ejaculatory duct posteriorly. No distinct seminal vesicle could be discerned in both the species under study. The vas deferens is a little shorter than the ejaculatory duct and in many cases it has been observed that its basal region is orange coloured. The ejaculatory duct runs in the middle to open posteriorly by the male gonopore situated at the posterior end of the aedeagus.

The accessory gland is a small, oval, muscular, whitish structure situated at the lateral side of the seventh segment towards the ventral side. It opens into the lateral ejaculatory duct along with the vas deferens by a short duct whose basal region is constricted.

The External Genitalia

Female: The ovipositor (Figs. 11-16) is well developed and represents the typical homopterous type. In araeopids it extends upto the hind region of abdomen or projects even beyond that. In *Delphacodes propinqua* it extends upto the base of the tenth abdominal segment while in *Liburnia pallescens* it reaches upto the distal region of the tenth segment. The ovipositor is composed of a basal apparatus, a shaft and a pair of accessory lobes. The basal apparatus consists of two pairs of small plates, the first and second valvifers, which bear ventrally the ovipositor shaft. The first pair of valvifers is composed of elongated plates implanted in the membranous ventrolateral parts of the eighth segment and extending a considerable distance over the ninth tergum to articulate with it. It is large in *Liburnia pallescens* whereas in the other is of medium size. The second valvifers comprise small plates concealed within the projecting lower parts of the tergum Each plate of the second valvifer is articulated at a point near the posterior side of its dorsal margin with a condyle on the ventral margin of the ninth tergum. The shaft consists of a pair of medially apposing or articulating elongated plates, the first valvulae, over a second grooved plate, the second valvulae. They are connected to each other by a ridge-and-groove-method, the second valvulae bearing the ridges at the lateral margins which fit into the corresponding groove present at the inner side of the first valvulae, forming a canal for the passage of eggs. The first valvulae extend laterally over the second for a considerable distance beyond the grooves thus strengthening the articulation between the two. Medially they are articulated to each other by a ridge-and-groove-method, one valvula developing a ridge and its mate forming a corresponding groove. The base of each valvula is produced into two rami the outer one is joined to the first valvifer and the inner one fused with the ninth tergum. The outer surface of each valvula is coarse from the region where the first and second valvulae articulate to the distal end. The second valvulae are formed by the fusion of a pair of elongated structures during ontogeny. It is highly sclerotised and narrows down posteriorly with a slight projection towards the distal end. Anteriorly it is continuous with the base of second valvifers. Dorsally it bears serrations extending more than half of its length which facilitates to pierce the plant tissue for the deposition of eggs. The accessory lobes or third valvulae are paired, sclerotised, flattened blade-like structures articulated anteriorly to the second valvifers towards the middle just ventral to the condyle. They extend distally a little beyond the first valvulae and project the ovipositor between their inner concave surfaces. In many of the araeopids it has been observed that the seventh sternite bears a small subgenital plate roofing over the base of the ovipositor which is poorly developed in both the species under study.

Male: The ninth abdominal segment (Figs. 17-28) is well developed, highly sclerotised and ring-like without any trace of the segmental composition into tergum, pleura and sternum. It forms an armature around the genitalia and is generally referred to as the pygofer. However, Pruthi (1925) refers to the lateral part of the ninth segment as the 'pygofer'. The pygofer is narrow in *Liburnia pallescens* whereas it is broad in *Delphaccdes propinqua*. The hind margin of the pygofer is produced posteriorly into anal emargination and more or less surrounds the tenth abdominal segment. The corners of the anal emarginations, the anal angles, are angular and extend upto the hind margin of the tenth abdominal segment in *Liburnia pallescens* ; they are well developed, rather rounded and extend beyond the tenth abdominal segment in *Delphacodes propinqua*. The opening of pygofer is longer than broad in the former and broader than long in the latter. In *Liburnia pallescens* the medio-ventral margin is produced ; in the other it is entire. The conjunctiva between the ninth and tenth abdominal segment is sclerotised and is called diaphragm, whose dorsal margin is V-shaped. It divides the pygofer into an inner and an outer chamber and carries in the middle its armature. The armature of the diaphragm is comparatively well developed and U-shaped in *Liburnia pallescens* whereas it is well developed and projects as two highly sclerotised outgrowths in *Delphacodes propinqua*. Ventro-lateral mărgins of the diaphragm is pierced by a pair of sclerites called the genital styles, parameres or harpogones It is twice constricted in *Liburnia pallescens ;* its basal region is circular in outline and the distal region is asymmetrically divided into two, the inner one narrow and straight and the outer one large and directed laterally. In *Delphacodes propinqua* the paramere is diverging distally, swollen for two thirds of its length from the base and medially constricted. The basal angle or the basal region of it is produced posteriorly; distally the lateral margin bears long hairs, usually the outer margin with five hair and the inner with four.

The phallus comprises a basal phallobase and a distal tubular aedeagus. The phallobase is poorly developed in both the species and according to Fennah (1945) it is represented by " the median sclerotised suspensorial arm passing upward to the tergum" and the 'diaphragm'. The aedeagus rests on the armature of the diaphragm. It is composed of a sclerotised tubular structure, the aedeagus periandrum, enclosing the distal part of the ejaculatory duct which is called 'sheath' by Pruthi (1925). The aedeagus in *Liburnia pallescens* is subtubular, much swollen basally, and curved medially with two rows of anteriorly directed teeth gradually decreasing in size from the distal to the proximal region. Of these two rows, one starts from the external opening of aedeagus periandrum and the other well behind and both of them meet basally. In *Delphacodes propinqua* the aedeagus is short, pistol-shaped, basally swollen and distally bears two rows of anteriorly directed teeth, one row at the distal side with five to six spines and the other a little lateral to the dorsomedian line in the opposite direction of the former row with two to three spines. The aedeagus periandrum opens internally by the basal foramen through which the ejaculatory duct enters into it. In araeopids, the basal foramen of the periandrum is thickened at its rim; which is thicker in *Liburnia* pallescens than in *Delphacodes propinqua.* As the ejaculatory duct comes out of the basal foramen of the periandrum it is slightly enlarged, this region being called as 'chamber' by Muir (1926). The 'chamber' expands basally to form a small sclerite, the basal plate bridge, bearing its wing distally. The basal plate bridge is connected to the paramere by another small sclerite, the basal plate prolongation. The combined basal plate bridge and the basal plate prolongation forms the 'basal plates' of Pruthi (1925). The ejaculatory duct opens externally by the gonopore and that region represents the endophallus. The base of the aedeagus is produced towards the tenth segment as a small sclerite, the aedeagus basal strut, which connects the aedeagus to the tenth segment. The aedeagus basal strut is short in *Delphacodes propinqua* whereas it is narrow in *Liburnia pallescens.*

The tenth segment in males bears a pair of anteriorly directed processes, the anal processes, arising from the ventral side towards its posterior margin. In *Liburnia pallescens* the processes are almost straight and basally well apart; in *Delphacodes propinqua* they are divergingly curved distally and appose each other basally.

DISCUSSI ON

Ovipositor: Hassan (1948) studied the morphology of external female genitalia of araeopids for the first time in connection with their systematics. However, he did not study these important structures in detail and consequently reported only two valvulae instead of three as is found generally in insects. He appears to have ignored the closely articulating contact between the first and second valvulae and possibly mistook these two pairs as one, *i.e.*, first pair, and consequently the third pair as the second, as is evident from his remarks, "The first valvula possesses a canal through which the egg passes, when deposited, into the puncture which it does by its serrated dorsal surface. The second valvula forms a sheath around the first one." The first and second pair of valvulae are articulated by means of a groove in the first and a ridge in the second. A light pull could easily separate them to prove the independent nature of these, which also become evident by tracing the basal connection to their valvifers. The present study in this respect, agrees perfectly with the general condition met within other homopterans.

'Subgenital plates' of the male: Kershaw and Muir (1922) and Muir (1925) homologised the 'subgenital plates' of male auchenorrhynchous Homoptera to the first valvulae of the hemipterous ovipositor. According to them, the posterior area of eighth sternite in male, on which they believe the subgenital appendages (gonophyses) develop, move to a position below the ninth tergum and fuse with it to form a pygofer. Muir's (1926) belief is based on the claim that the ninth abdominal sternite has not been reported in any homopterous male. This is no more valid as Fennah (1945) has reported the presence of ninth abdominal sternite in *Peregrinus maidis*—an araeopid—throughout the development. Further, he has denied the posterior drifting of the posterior part of the eight sternite.

Pruthi (1924) believes that the 'subgenital plates' are homologous to the third valvulae of the female genitalia. In *Peregrinus maidis* as has been demonstrated by Fennah (1945) the buds arising at the corresponding positions of the male develop into the parameres.

The present author believes that the plate in question, in araeopids, is represented by the posterior outgrowth of the ventral margin of the pygofer as suported by anatomy, since there are no muscles connected to it at any stage. Ontogeny (Fennah, 1945) also supports it.

Aedeagus : Divergent views have been expressed regarding the morphology of aedeagus in araeopids. Pruthi (1925) states that the ejaculatory duct passes through the basal plate bridge, 'chamber' and 'sheath' till it opens by the gonopore. On the contrary Muir, (1926) believes that the 'sheath' is the thick, sclerotised region of the ejaculatory duct which continues posteriorly and expands to form the 'chamber'. The basal plate bridge with its wing is formed by the union of an expansion of the basal plate prolongation and the expansion and sclerotisation of the ejaculatory duct. The author has been unable to trace the ejaculatory duct through the 'chamber' and 'sheath' in *Liburnia pallescens* and *Delphacodes propinqua* and consequently he agrees with Muir (1926) that the 'sheath', 'chamber' and part of the basal plate bridge are the variously modified regions of the ejaculatory duct.

SUMMARY

The morphology of the reproductive organs of Araeopidae is studied in detail for the first time. The observations are based on *Liburnia pallescens* and *Delphacodes propinqua*. The following features are noteworthy:

1. Each ovary is composed of twelve to sixteen acrotrophic ovarioles. The vagina takes a peculiar course in that it is deflected towards the left side and consequently its preceding region has also changed its usual course. The spermatheca and the accessory gland open almost at the same level to the vagina.

2. Each testis is composed of two sperm tubes which bear a number of apical cells. The vas deferens is devoid of a distinct seminal vesicle. The accessory gland opens into the vas deferens at its basal region. The 'sheath', 'chamber' and part of the basal plate bridge are variously modified regions of the ejaculatory duct.

3. The ovipositor is well developed and is of the typical homopterous type. The first valvulae themselves and these and the second valvulae are articulated by a ridge-and-groove-method. The second valvulae are serrated dorsally.

4. The pygofer is ring-shaped and without any distinction into tergum, sternum and pleura. The length and breadth of the opening of pygofer, the outgrowth of the ventral margin, the anal angles and the

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development of the diaphragm etc. vary with the species. The phallobase is poorly developed. The aedeagus periandrum and the parameres are of different shapes and sizes in different species.

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