Proc. Pak. Acad. Sci. 1965, Vol 2, No 1

External Male Genitalia of Fulgoroidea (Homoptera)

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(*Received November* 9, 1964.)

The study of male genitalia includes the representatives of ten important families of Fulgoroidea. This organ shows a great diversity in forms and structures and at least partially indicates the evolution of patterns, which can be compared with each other and may be reduced to small number of types much less in number than the number of families and sub-families of the super-family Fulgoroidea. The phalic complex and supporting structures were described and compared from functional and morphological points of view. As a result five types and one sub-type and genitalia were recognised. These are (1) Lophopid, Meenoplid cum Issid type including Ricanid cum Caliscelid sub-type (2) Cixiid type, (3) Fulgorid type, (4) Tropiduchid cum Flattid type and (5) Delphacid [redacted] type.

Introduction

The assemblage of insect groups included in the super-family Fulgoroidea (Homoptera) exhibits a wide variety of structures including carnium, wings, legs and other external structures. This has led to the creation of a very large number of families by Stål (1864-66), Muir (1923) and Chȋna and Fennah (1952). The number of families has gone up to twenty and is likely to grow if a similar point of view continues in regard to external structures other than the genitalia. The present author (1963) has shown the existence of some definite types of ovipositors which, if investigated further, might lead to bringing together these families into five or a few more groups or families and relegate the rest to the status of sub-families. It may also lead to the better understanding of relationship of these, families and sub-families. The present study of male genitalia has pointed out the existence of several types of external male genital structures which have much broader and more fundamental morphological differences than those which could be related to the level of a species or genus. The dearth of material, more so, of type material, has surely affected the value of this work; but the following description will give a better understanding of such broad differences, and the author has not only aimed at pointing out morphological differences but also at a fundamental interpretation of various structures comprising the external male genitalia of Fulgoroidea.

Snodgrass (1957) has given account of external male genitalia of Homoptera including those of the families of *Fulgoridae* and *Delphacidae*. His studies, however, do neither reveal broader morphological differences nor do they take into account any appreciation of fundamental nature of various structures included in the male genitalia except that of parameres.

Before dealing with different types of the pairing structures of the male a brief description of these may be made with reference to a generalised *Cicadidae*

type of Homopterous genitalia which probably exists in *Cicadidae* or as in *Cercopidae* (Fig.1) which is also studied by Metcalfe (1932). Broadly speaking, these structures are derived from two main sources *viz.*; (1) Phallus and the genital cavity, and (2) The ninth sternum. The rudiments of phallus arise from

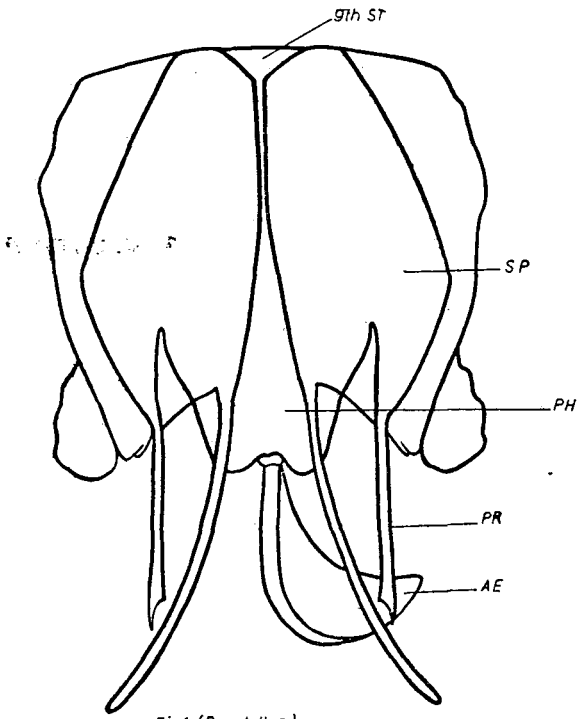
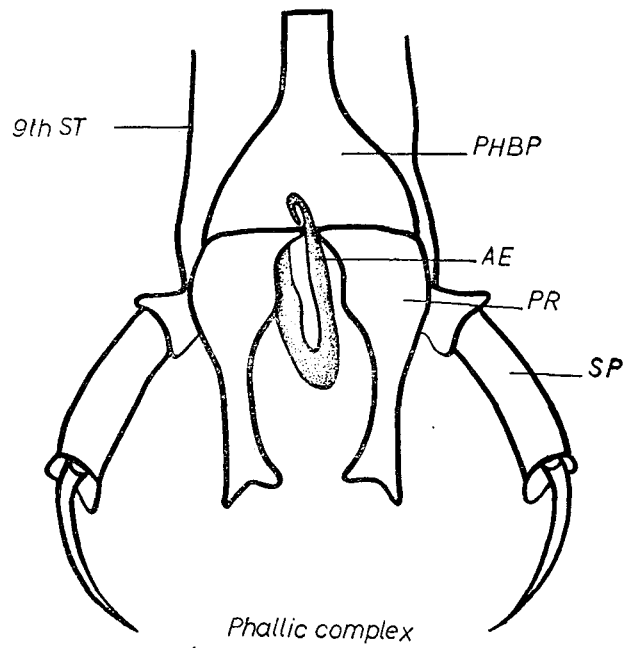


Fig 1 (Poophilus)
Phallic complex

an invaginated cavity behind the ninth sternum in the form of a pair of buds (Fig. 2). These phallic buds and the walls of the genital cavity give rise to a number of structures known as phallus, phallobase, phallic lobes, aedeagus, aedeagal hooks, basal plate and parameres.

The ninth sternum in some cases, as in *Cicadellidae* (Pruthi, 1925 a and b; Qadri, 1949; and Snodgrass, *op. cit.*) and in *Cercopidae, e.g., Callitettix versichlor* Dist. (Fig. 2.), may be differentiated into a sternal base and two arms, movable or immovable known as the subgenital plates which in some cases carry hooks or processes at their apices. In addition to these fundamental sturctures the roof of the genital cavity may give rise to hooks or arms which are of secondary nature and are helpful in pairing.

In Fulgoroidea the author has come across the structures which could be derived either from the phallic lobes or from the genital cavity. Snodgrass (*op. cit.*), while reviewing the interpretations of Qadri(1949)in regard to parameres has probably correctly pointed out that they do not correspond to the harpagones of orthoptera. He has insisted that the parameres show a variable origin. In certain cases the parameres appear to arise directly from the phallic lobes while in other cases, *e.g.*, *Pyrilla* (*Lophopidae*), they arise independently of the phallic lobes from the wall of the genital cavity.



Phallic complex
Fig 2.(Calittetix versichlor)

In addition to the study of the phallus and parameres it is also very important to study the connecting and basal structures of these genitalia and determine their function in relation to the muscles arising from different regions of the genital segments. Such a study will not only lead to distinguishing the function of each structure but will also help in ascertaining its nature and homologies.

The author is grateful to Miss Kulsum Fatima Khokhar for preparing the illustrations of this paper. The author is also grateful to the Agricultural Research Council of Pakistan for financial support for the study of Fulgoroidea in the Department of Zoology, University of Karachi.

DESCRIPTION OF EXTERNAL MALE GENITALIA OF FULGOROIDEA

1. FAMILY *Lophopidae.*

The Lophopid type of male genitalia was already described in case of *Pyrilla perpusilla* Walker, by Qadri (1949). These genitalia are fairly comple and consist of numbe· of complicated phallic structures and a pair of large an laterally placed plate called parameres. The phallic complex (Fig. 3A) consis of a membranous sheath which encloses a bilobed phallus and a bifurcated aedeagu each arm of which carries on its apex a strongly curved hook. The valves of th

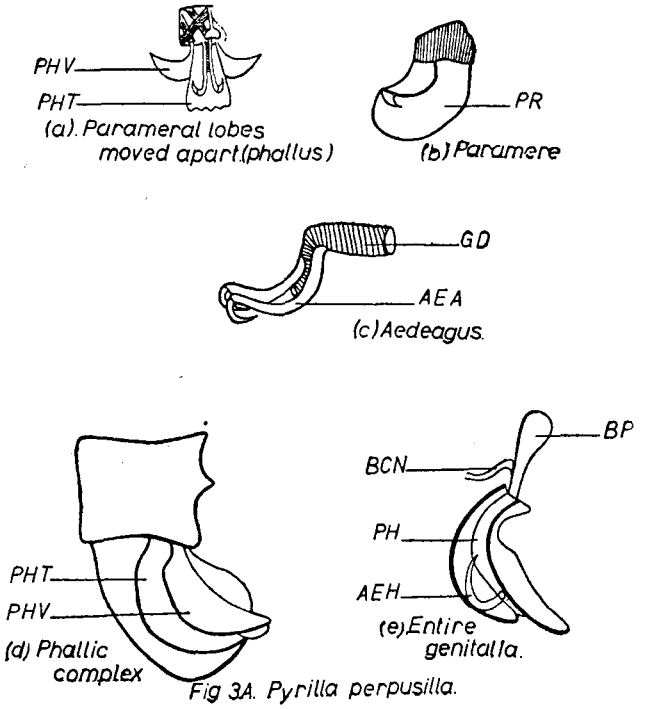


Fig 3A. *Pyrilla perpusilla.*

phallus are supported and contained in a phallic theca which may correspond t the phallobase of other insects as described by Snodgrass (*op. cit.*). The phalli valves and the phallobase are provided with separate muscles and can mov independently as well as in unision. The aedeagus is continued basally witl the ejaculatory duct. It is connected with the phallobase at its proxima end. The phallobase is a large oblong plate and is also connected with the base of the parameres, by a thread-like cuticular filament or the basal filament. Th lateral parameres are broad plates and are provided with their own muscles origi nating, far apart from those of the phallic muscles, from the ninth segment.

The morphological nature of the above mentioned complex, consisting of phallic valve, phallic theca, phallic base, aedeagus, basal filament and particularly of the parameres, needs further careful study, firstly, because these structures play an important part in pairing, and secondly, because they are diversely modified in different families of the super-family Fulgoroidea.

The post-embryonic rudiments of the male genitalia of *Pyrilla perpusilla* (Figs.3B and 3C) originate in a genital pouch formed by the invagination of the membranous venter of the tenth segment consisting of sternum and coxites.

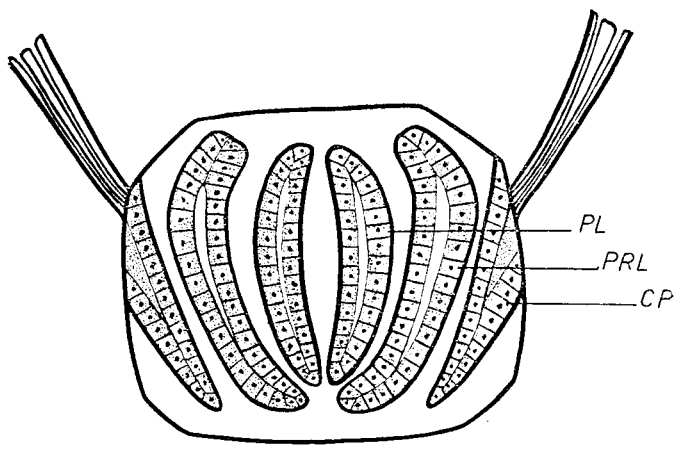


Fig 3B (Pyrilla perpusilla)
T.S. of an older nymph

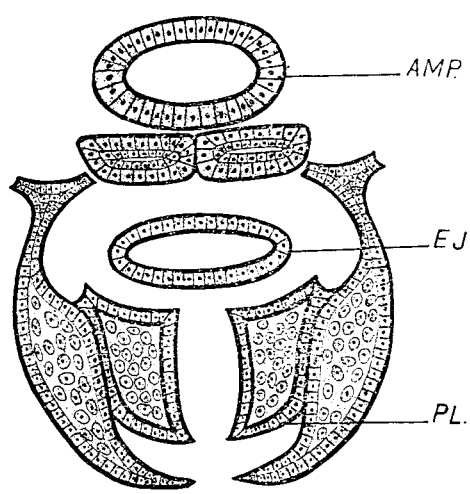
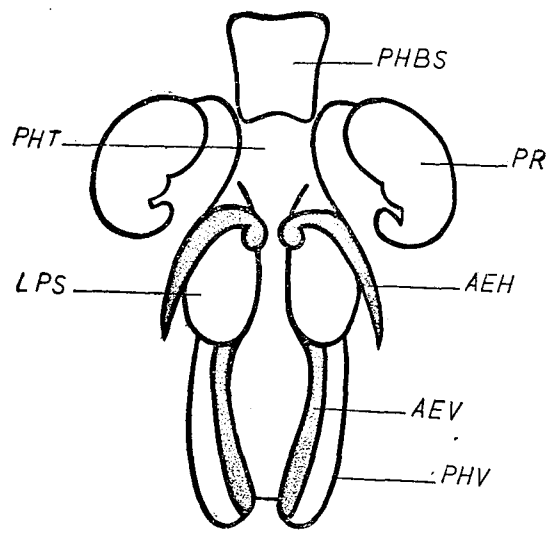


Fig 3C. (Pyrilla perpusilla)
T.S. of an older nymph.
passing through hind abd: regior

This invaginated genital pouch develops a pair of phallic lobes which give rise to the phallic and aedeagal structures by subsequent differentiation. The pharameres, however, appear to arise independently from the genital cavity. They are, indeed, connected at their bases with the phallic lobes.

(2) FAMILY *Issidae*

The family *Issidae* is represented in the present study by (1) *Ziartissus artimesiae* Qadri (*Issinae*) and (2) *Caliscelis eximia* Stal. (*Caliscelinae*). In the case of *Z. artimesiae* (Fig. 4), the phallic structures are strikingly similar to those



Phallic complex
Fig 4 (Ziartissus artimesiae)

of Lophopid type. The paired phallic valves are well-developed plates and are connected to each other at their bases by the basic filament. The parameres are much smaller than those of *Pyrilla perpusilla* but they are quite independent of phallic structures.

The external male genitalia in *Caliscelis eximia* (Fig.5) are better differentiated than in the previous cases. The phallic complex consists of bilobed distal part inside which aedeagus is contained. The aedeagus at its tip carries recurved hooks. The phallobase is strengthened by a pair of lateral sclerites and a proximal and investing hard phallobase. The phallobase is a well-developed plate and is connected with a bar at its base ventrally which may be called basal filament.

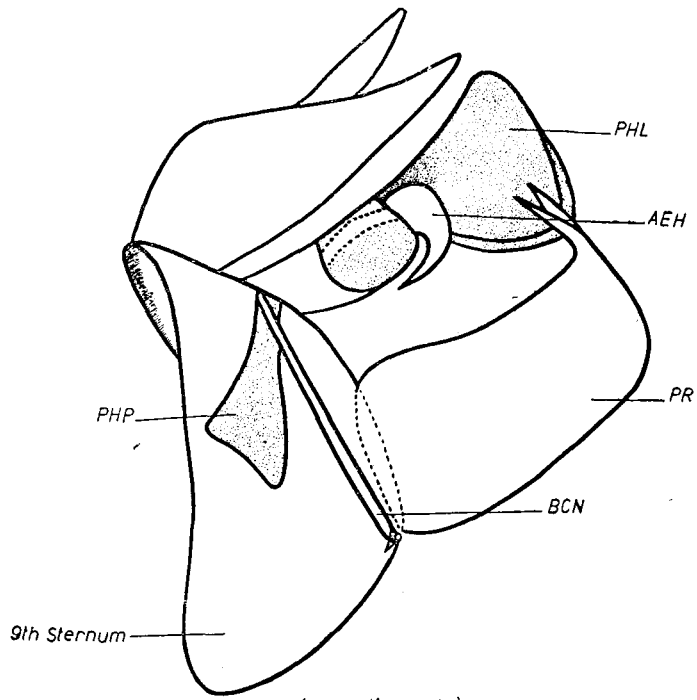


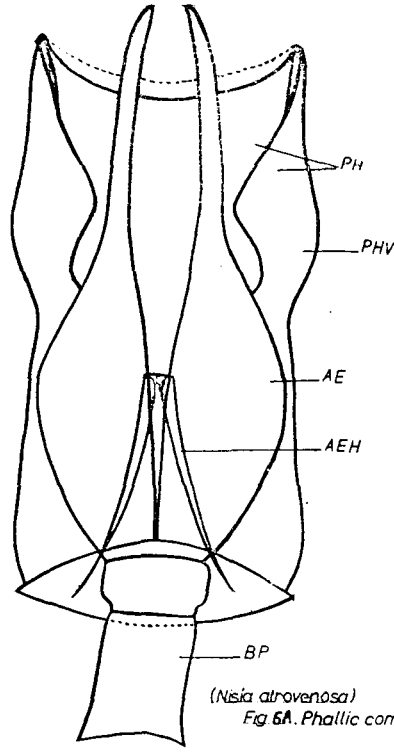
Fig5 (Caliscelis eximia)
Phallic complex

The basal filament rests on and is connected at its ventral end with a small membrane forming the base of the male genital cavity. The basal membrane in its turn is intimately connected with the parameres. The parameres are strong and well-formed plates and are provided with hooked apices.

(3) FAMILY *Meenoplidae*

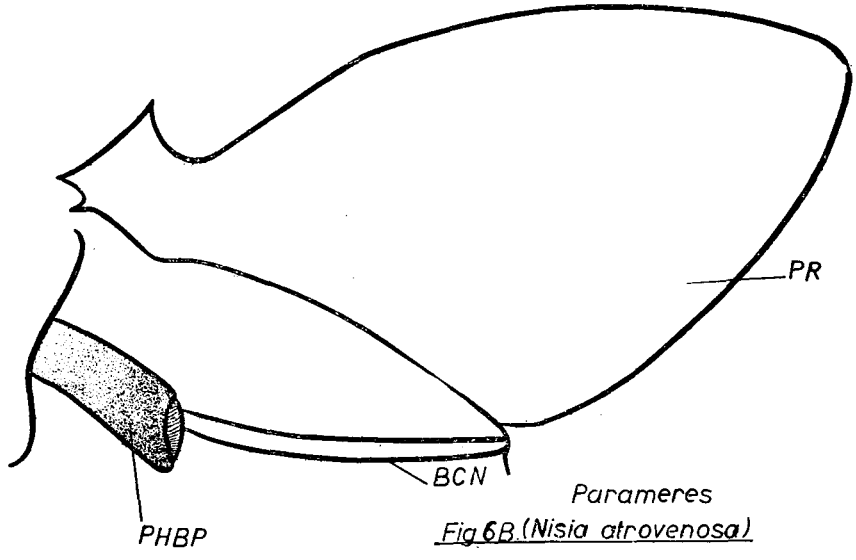
A different form of external male genitalia is found in *Nisia atrovenosa* which again has a well-developed phallic complex. The phallus (Fig. 6-A) is a membranous theca with evident sclerotised lateral lobes. The base of the phallic complex is sclerotised and is connected with a pair of elongated valve-like sclerites, the aedeagal arms, which enclose the membranous penis. These valves, like sclerites, represent a part of the aedeagus and each one carries an anteriorly

directed elongated hook. The phallobase is produced into a broad plate which is connected with a well-developed sclerotised connective joining a small tough



(Nisia atrovenosa)
Fig 6A. Phallic complex

membrane supporting the bases of the parameres. The parameres (Fig. 6B) are well-developed and are conical at their apices.



Parameres
Fig 6B (Nisia atrovenosa)

(4) FAMILY *Ricaniidae*

The external male genitalia of *Ricania zebra* Distant (Fig. 7) show some resemblance to those of the above mentioned types. The phallus is mainly membranous and its apical part is divided into two valves. On each side of the phallus there is an elongated sclerotised plate. The phallus is supported by a thetical

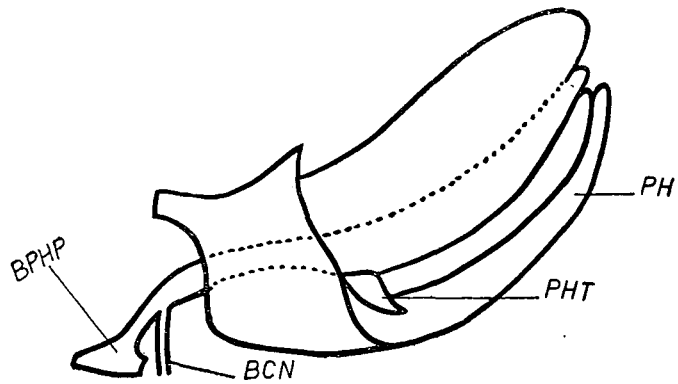


Fig 7. (Ricania zebra)
Phallic complex

plate. The phallobase is produced anteriorly and it gives rise to the basal filament which runs downwards towards the ventrum of the ninth segment and meets the membrane supporting the bases of the paramères. The parameres are well-developed.

(5) FAMILY *Cixiidae*

A different type of external male genitalia is found in *Oliarus hodgarti* (Walker), (Figs. 8A and 8B). The phallic complex consists mainly of sclerotised

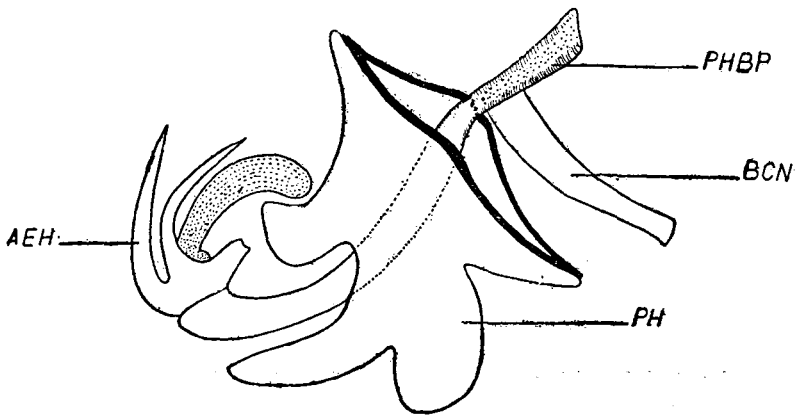


Fig 8A (Oliarus hoagarti)
Phallic complex

structures. The phallus is bilobed at the apex. Each phallic lobe is completely sclerotised, and is branched at its apex into three arms. The aedeagus is also branched at its apex. Each apical arm of the aedeagus has the shape of a hook. Between the arms of aedeagus the membranous apical portion of ejaculatory duct is produced in the form of a membranous penial lobe. The base of the phallus

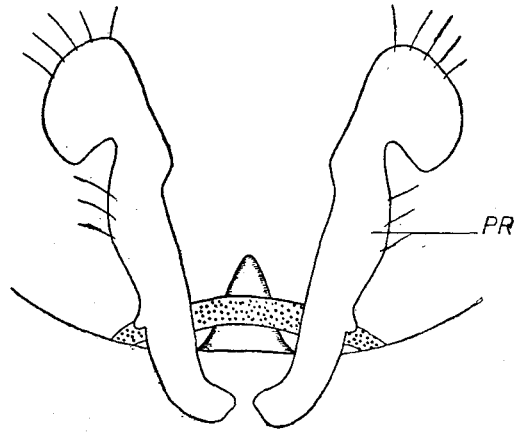


Fig 8B. (Oliarus hodgarti)
Parameres

is connected anteriorly with an elongated sclerite. This basal sclerite in its turn is connected with a broad basal filament of connective which joins the membrane supporting the parameres. The parameres are elongated plates overlying the base of the phallic complex.

(6) FAMILY *Fulgoridae*

The external male genitalia of *Fulgoridae* are represented in the present study by those of *Pyrops* sp. They show (Fig. 9) a more simpler phallic complex than those of the forms mentioned above. The phallus is mainly membranous but supported by a pair of sclerites in its proximal region. The distal region of the phallus is bilobed. The phallobase consists of a small sclerite from which the

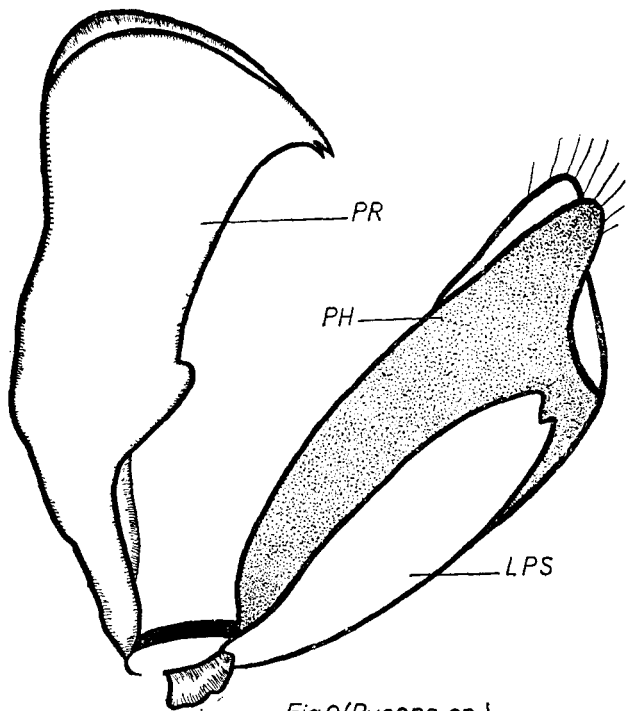


Fig 9.(Pyrops sp.)
Phallic complex

basal filaments run downwards to meet a small membranous sheet supporting the bases of the well-developed parameres. The closer placement of the parameres with each other and the short basal filament indicate a closer functional co-ordination between the parameres and the phallus.

(7) FAMILY *Tropiduchidae*

A totally different form of external male genitalia is found in *Tropiduchidae* represented in this study by that of *Antabhoga* sp. In this case (Fig. 10) the phallic complex is much simplified and fused into a single structure without any evident and distinct aedeagus. The whole phallus is a sclerotised stalk which at

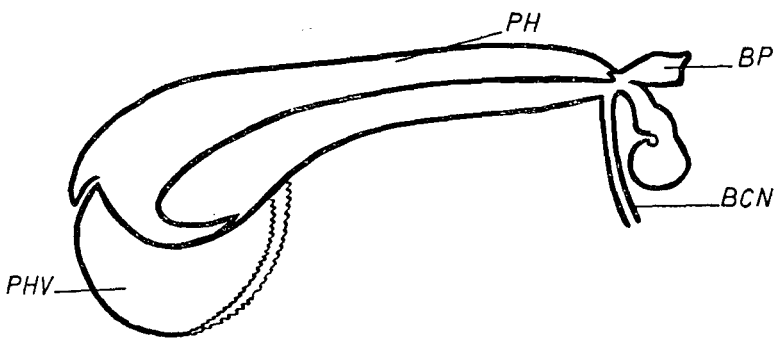


Fig 10.(Antabhoga.)
Phallic complex

its apex is expanded into two spatulate lobes. Along the base of each of these spatulate lobes there runs a hard spinous ridge with a small but hard project spine. At the base of the phallus there is a small basal sclerite with a basal rod-like connective meeting the bases of the paramerse.

(8) FAMILY *Flattidae*

The external male genitalia of *Paragomeda typica* Distant (Fig. 11) show a fundamental resemblance with those of *Antabhoga* sp. (*Tropiduchidae*). The phallic complex of *P. typica* is fused to form an elongated thick stem. This stem at its tip carries a pair of processes or corni which are provided with elongated flagellar hooks on their distal ends. The base of the phallus has a small plate which

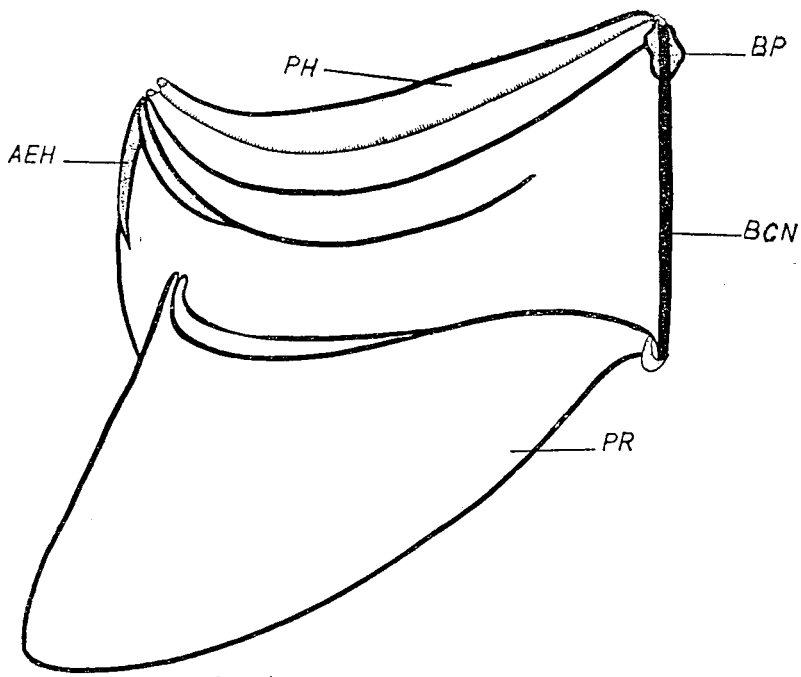


Fig 11(Paragomeda typica)
Phallic complex

is connected by a bar-like basal connective to the closely approximated bases of the parameres. The bases of the parameres narrow down and lie closely approximated to each other and the basal connective. The parameres and the basal rod are held together by a small ligament.

(9) FAMILY *Delphacidae*

A different, and probably the most specialised of all types of external male genitalia discussed in this paper, is found in *Delphacidae*. The Delphacid genitalia is described from a number of species of the genus *Sogata* Distant (Fig.12)

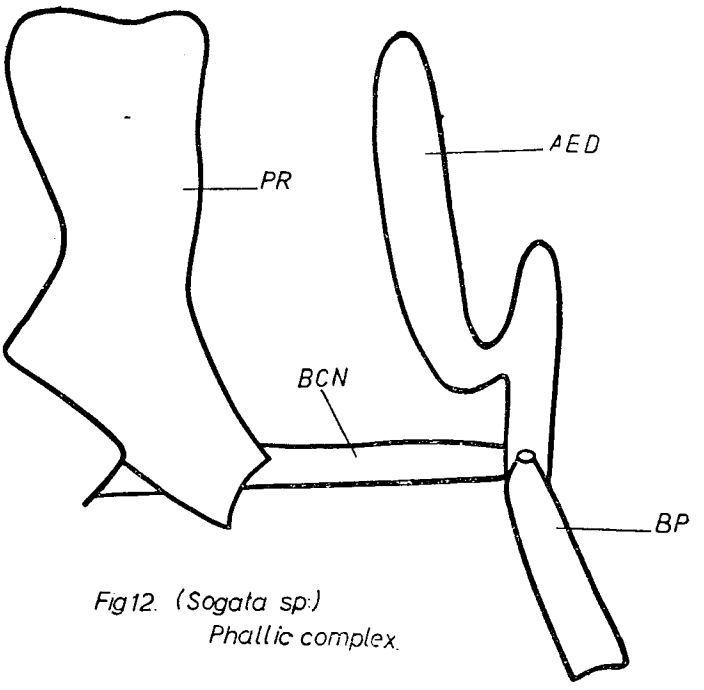


Fig 12. (Sogata sp.)
Phallic complex.

and from *Eoeurysa flavocapitata* Muir (Fig. 13). The Delphacid phallic structures consist mainly of an aedeagus which is elongated and sclerotised and may be

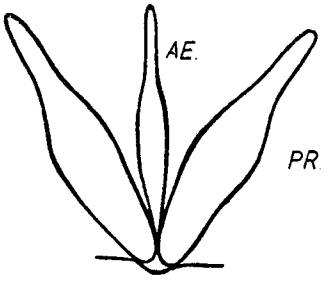


Fig 13.(Eoeurysa flavocapitata)
Parameres, Aedeagus

armed with spines. The aedeagus is connected at its base with a basal plate which corresponds to the basal phallic plates of the previous types. It clearly shows that the above designated basal plates are probably parts of the aedeagus. Down

from the basal plate runs the basal connective which is a fairly long sclerotised and well-developed sclerite and is joined to the bases of parameres by a small tough ligament. The parameres of *Sogata* and *E. flavocapitata* are well-sclerotised functional structures and are variously modified in shape in different forms.

Discussion

The above analysis bears out the fact that there are several types of external male genitalia in Fulgoroidea. The most complex and completed type of external male genitalia is found, according to the foregoing study, in the following forms :

1.	*Pyrilla perpusilla*	*Family*	*Lophopidae*	*S. family*	*Lophopinae*
2.	*Ziartissus artimesiae*	,,	*Issidae*	,,	*Issinae*
3.	*Nisia atrovenosa*	,,	*Meenoplidae*	,,	*Meenoplinae*
4.	*Ricania zebra*	,,	*Ricaniidae*	,,	*Ricaniinae*

In these forms the phallic complex consists of a membranous and bivalved phallus which is supported at its base by a sclerotised phallic theca. In *Z. artimesiae* the phallic theca is provided with a pair of lateroventral sclerite on the ventral aspect of the phallus. At the posterior end of the phallic theca a pair of aedeagal hooks emerge probably from near the sides of the male gonopore. These hooks play an important role in guiding forward the eversible ejaculatory duct.

The aedeagus in these forms consists of well-developed and sclerotised arms, which meet together basally and eventually get fused with the phallobase. The phallobase is continued anteriorly in the form of a broad basal plate. From the posterior end of this basal plate a basal filament arises which goes downwards to get itself connected with a membranous sheet supporting the bases of the parameres. This basal filament is thread-like in *P. perpusilla,* but shorter and broader in the remaining two forms, *i.e., Z. artimesiae and N. atrovenosa.* Nearly similar type of phallic complex is found in *Caliscelis eximia,* and *Ricania zebra.* In these cases the phallus is also membranous and bilobed or bivalved. It is similarly provided with a phallic theca at the base. The chief difference, however, lies in aedeagal structures. Whereas the aedeagal hooks probably correspond to those found in *P. perpusilla* there are no aedeagal arms or valves as are found in the first mentioned three forms.

The second type of phallic complex is found in *Oliarus hodgarti* (*Cixiidae*). In this case the phallus is totally sclerotised and the aedeagus has an enlongated median stem which is bifurcated at its apex and carries an eversible penial papilla.

The third type of phallic complex is found in *Pyrops sp.* (*Fulgoridae*). It has an entirely membranous phallus which is bilobed at the apex. The phallus is however invested by a pair of latero-ventral sclerites.

The fourth type of phallic complex is represented by those of *Paragomeda typica* (*Flattidae*) and *Antabhoga sp.* (*Tropiduchidae*). In *P. typica* the aedeagal and the phallic structures are fused to form a single four-sided elongated stem which at its apex supports a pair of sclerites carrying flagellar hooks on them. In the case of *Antabhoga* the fused aedeago-phallic stem has a pair of spatulate lobes at the apex and carries a pair of hooks on the sides.

The fifth type of external male genitalia, is found in *Sogata sp.* and *Eoeurysa sp.* (*Delphacidae*), [redacted]. In these families the phallus is entirely absent and the external male genitalia consists of a simple tubular aedeagus, a basal plate, a basal connective and a pair of parameres connected to the basal connective with the help of a ligament.

Conclusion

The five types and one sub-type of external male genitalia found in the ten families studied, do not, of course, provide a complete assessment of fundamental organisation in different families or sub-families comprising the super-family Fulgoroidea, which may have as many as twenty families (Imm, 1959). The present study, however, reveals that certain fundamentally different types could be recognised in the architecture of external male genitalia. A similar basic difference exists in the female terminalia of different families of Fulgoroidea as shown elsewhere by the present writer (Qadri and Mirza, 1963). Pending a more extensive study of external male as well as female genitalia in all the families and sub-families, the following tentative conclusions could be arrived at on the basis of the present study :

1. The male genitalia of *Lophopidae*, *Meenoplidae* and of *Issinae* of the family *Issidae* belong to one fundamental type.
2. The external male genitalia of *Ricaniidae* and *Caliscelinae* of the family *Issidae* closely resemble each other and may represent a sub-type of the first type (Lophopid type).
3. The external male genitalia in *Cixiidae* are totally different and peculiar to this family. The female terminalia of *Cixiidae* are also peculiar to this family. This family, therefore, must be regarded as a distinct one.
4. The external male genitalia of *Fulgoridae* is totally different and peculiar to this family. The female ovipositor of *Fulgoridae* is also distinctive, hence the family is a distinct one.
5. The external male genitalia of *Tropiduchidae* and *Flattidae* are different from the above mentioned types. But though basically similar, they, nevertheless show significant differences between themselves. So, *Tropiduchidae* and *Flattidae* may be regarded as distinct families, but closely related to each other.

6. The external male genitalia of *Delphacidae* [redacted] present the most specialised form of genitalia in the super-family Fulgoroidea.

SUMMARY

The external male genitalia of the following forms were studied :

1. *Pyrilla perpusilla* (*Lophopinae, Lophopidae*)
2. *Nisia atrovenosa.* (*Meenoplinae, Meenoplidae*).
3. *Ziartissus artimesiae.* (*Issinae, Issidae*).
4. *Ricania zebra.* (*Ricaniinae, Ricaniidae*).
5. *Caliscelis eximia* (*Caliscelinae, Issidae*).
6. *Oliarus hodgarti.* (*Cixiinae, Cixiidae*)
7. *Pyrops sp.* (*Fulgorinae, Fulgoridae*).
8. *Antabhoga sp.* (*Tropiduchinae, Tropiduchidae*).
9. *Paragomeda typica.* (*Flattinae, Flattidae*).
10. *Sogata sp.* (*Delphacinae, Delphacidae*).
11. *Eoeurysa sp.* (*Delphacinae, Delphacidae*).

[redacted]

The phallic complex consisting of phallic, aedeagal and connecting and supporting structures were described and compared from functional and morhological points of view. The following five types and one sub-type of external male genitalia are distinguished.

TYPE :— 1. Lophopid, Meenoplid *cum* Issid type, including Ricanid *cum* Caliscelid sub-type.
2. Cixiid type.
3. Fulgorid type.
4. Tropiduchid *cum* Flattid type.
5. Delphacid [redacted] type.

These types have been used as pointers in ascertaining the relationships of the families and subfamilies included in the present paper.

ABBREVIATIONS USED ON TEXT FIGURES

AE. ... Aedeagus
AEA. ... Aedeagal arm.
AED. ... Aedeagal duct.
AEH. ... Aedeagal hook.
AEV. ... Aedeagal valve.
AMP. ... Ampulla of the vas-deferens.
BCN. ... Basal connective.
BP. ... Basal plate.
BPHP. ... Basal phallic plate.
CP. ... Connective plate.

EJ. ... Ejaculatory duct.
GD. ... Genital duct.
LPS. ... Lateral phallic scler
PH. ... Phallus.
PHBP. ... Phallic basal plate.
PHBS. ... Phallic basal plate.
PHL. ... Phallic lobe.
PHP. ... Phallic plate.
PHT. ... Phallic theca.
PHV. ... Phallic valve.
PL. ... Parameral lobe.
PR. ... Paramere.
PRL. ... Parameral lobe.
SP. ... Sub Genital plate.

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2.— „ „ (*Calittetix versichlor*).
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3B.—T. S. of an older nymph (*Pyrilla perpusilla*).
3C.—T. S. passing through the hind abdominal region of a nymph.
4.—Phallic complex (*Ziartissus artimesiae*).
5.— „ „ (*Caliscelis eximia*).
6A.— „ „ (*Nisia atrovenosa*).
6B.—Parameres (*Nisia atrovenosa*).
7.—Phallic complex (*Ricania zebra*).
8A.— „ „ (*Oliarus hodgarti*).
8B.—Paramers (*Oliarus hodgarti*).
9.—Phallic complex (*Pyrops*).
10.— „ „ (*Antabhoga*).
11.— „ „ (*Paragomeda typica*).
12.—Phallic complex (*Sogata*).
13.— „ „ (*Eoeurysa flavocapitata*).

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