

# PHYLOGENETIC STUDY OF AUCHENORRHYNCHA

By

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## INTRODUCTION :

The classification of Auchenorrhyncha has been a matter of dispute and doubt since the days of Latreille. Latreille proposed the name of the suborder as Cicadariae or Zikaden. The later word is still used by German and other European authors (Weber-1955). The suborder was subsequently divided into three major groups or super-families viz., Super Family, 1. Fulgoroellae Lat., including the modern Fulgoroidea Steph., Super Family -2. Stridulantes Lat., including the modern Cicadoidea West Wood and super family 3- Jassoidea VanDuzee including Jassids and Membracids. The classification proposed by Weber, however is very different. He proposed a suborder Cicadina for including all the so called Auchenorrhyncha including Family 1- Cixidae, Family 2- Fulgoridae, Family 3- Delphacidae, Family 4- Cicadidae, Family 5- Cercopidae, Family 6- Membracidae and Family 7- Jassidae. Chester Bradley translating and adopting Lamere's classification has divided existing Auchenorrhyncha (Cicadaria) into two super families viz., Super family 1. Fulgoroidea and Super family 2. Cicadoidea. The same was adopted by Imms (1925) in his General Text Book of Entomology, Evans (1945) who first proposed three major categories viz., Fulgoroidea, 2. Cicadoidea and the third Cercopoidea plus Cicadelloidea, later (1963) reverted to two groups namely a Fulgorid group and the other group including the rest viz., Cicadoidea, Cercopoidea and Cicadelloidea. (Jassids and Membracids). A similar phylogenetic picture was proposed earlier by Z. P. Metcalfe (1951).

The principles governing phylogenetic relation have so far been firstly an assessment of morphological structures and secondly a comparative study of the recent and the fossil forms. In case of Homoptera a worthwhile picture of fossil Homoptera is not so far available. Heslop Harrison and Evans have commented on this aspect and derived two conclusions, namely (1) Homoptera and Heteroptera were derived from common ancestors prior to the commencement of Permian era and (2) that the Fulgoridomorph must presumably have become differentiated as such before Procercopoidea. Heslop Harrison also held that primitive Cercopids existed which linked two major natural groups, 1. Cicadidomorpha and 2. Jassidomorpha through a common ancestral plexus. Evans (1963) however, holds that "Cicadids cannot possibly be related to leafhoppers by way of Cercopids as both the two former groups (Cicadas and Jassids) retain different combination of characters which are absent from the Cercopoidea". It is therefore evident that the paleontological studies do not go far to depict any acceptable relationship either between Fulgoroids and the rest of Auchenorrhyncha or between the Cercopoids, the Cicadoids and the Jassoids. The relationship between Cicadomorpha and Jassidomorpha is equally obscure as held by Heslop Harrison.

The other means of seeking phylogenetic relations are based on structural characters. Hitherto the important characters chosen for this purpose are related to the areas of Head capsule or the wings. Metcalfe and Fennah attempted to group these forms on the basis of tarsal characters. In case of wing venation the chief stress was laid on peripheral vein and on nodal line in the wing base (Evans, 1963).

Quite recently Dr. Wagner of Hamberg has published an interesting study of dynamic taxonomy of Auchenorrhyncha. This study is related to different types of adaptations, in the limbs of leafhoppers belonging specially to Fulgoroidea, Jassoidea and seeks an explanation of these adaptation on fundamental morphological basis in order to relate the different groups of hoppers in a natural phylogenetic scheme. Much earlier than these studies Qadri (1951) in *Pyrilla*, Fulgoridae had described a special springing mechanism in the hind leg. This mechanism consists of an apodeme arising from trochanter and

going into limb base where it expands in the form<sup>y</sup> a disc. This disc<sub>f</sub> is provided with a thick bundle of muscles working (a) depressors of trochanter. Working in coordination with promotor muscles arising from metatergum and attached to trochanters, these muscles produce the characteristic jumping movement of the leafhoppers. It was therefore necessary that a more intensive and comparative study of limbs and limb bases be made for ascertaining taxonomical relations.

In addition to the structures in the head and thorax it was felt by the writer that a more detailed study of external genitalia was also called for. Hitherto much larger emphasis was being laid on external male genitalia especially on the pairing organs. In many cases the entire phallic complex has not been taken into consideration and very little effort has been made to understand such characters as basal plates, connectives and subgenital plates. The female genitalia or ovipositor have been completely neglected for their taxonomical value and such study has revealed a number of highly interesting facts helpful in discovering relationship of several important natural groups.

A comparative study of the external morphological groups of Auchenorrhyncha was undertaken in the following representative families:-

- |                         |  |
|-------------------------|--|
| Family: 1. Cicadidae    | <i>Seena</i> sp.                                 |
| Family: 2. Fulgoridae.  | 1. <i>Pyrops</i> sp. (Fulgorinae)                |
|                         | 2. <i>Pyrilla perpusilla</i> Walker (Lophopinae) |
|                         | 3. <i>Oliarus</i> spp. (Cixinae).                |
|                         | 4. <i>Paragomeda typica</i> Distant (Flattinae)  |
| Family: 3. Cercopidae.  | 1. <i>Poophilus Costalis</i> walker.             |
|                         | 2. <i>Calitettix Versicolor</i> Distant.         |
| Family: 4. Jassidae.    | 1. <i>Tettigoniella spectra</i> Distant.         |
|                         | 2. <i>Ledra</i> sp.                              |
|                         | 3. <i>Idiocerus niveosparsus</i> Leth :          |
| Family: 5. Membracidae. | <i>Centrotus Cornutus</i> Walker.                |

Family Cicadidae also regarded as Superfamily Cicadoidea includes the well known insects called Cicadas. The important and distinctive features as described by various authors specially by Snodgrass and Evans are as follows:-

The Head capsule has a highly developed Clypeal region demarcated into anteclypeus and post clypeus. The latter extends over the whole of the face and farther, behind the compound eyes. The post-clypeus has been mistaken as frons by some authors. The latter is however a small triangular plate on the top of the head and has 3 ocelli located on it. The antennae are thread like with 7 joints or more. In the thorax the front femora are expanded especially in the nymphs and each of the wings has peripheral vein. Tegulae are absent and the pretarsi have neither pulvillus nor arolium nor empodium. In the abdomen the most characteristic organs are the stridulatory organs consisting of a timbal, a mirror and folded membrane located in a cavity at the base of the abdomen and generally covered by plates or opercula.

A more critical study of the Cicadid has revealed the following additional facts of significance. They are as under:-

1. The antennae are non aristate and in the nymphs they are clearly jointed and filamentous-the joints being sub-equal.
2. The hind legs are not provided with a jumping apparatus provided in the rest of the four groups and their pretarsi have no pulvillus nor empodium which help in a take off for jumping.
3. The ovipositor is different in the form and function. The dorsal or lateral valves do not participate in oviposition and are palp like out growths of the ninth coxites.
4. In case of male genitalia the aedeagus is absent and the intromittant organ is a phallic tube provided with hooks. The parameres are located far off from the base of the

phallus and are not connected with the phallobase by means of any defined sclerite or connective. (fig. 1)

**Fulgoridae-** The Fulgorids have a number of distinctive feature recognised long before. Some of these are listed below:-

1. The head capsule has a reduced clypeus and the face is mainly occupied by Frons which often has lateral carinae separating it from genae.
2. The antennae, as a rule are located below the eyes and the second segment has special sensory organs.
3. The Pronotum is a narrow collar like structure.
4. The wings have no peripheral veins and the tegulae are well developed.
5. The middle coxae are elongated and their bases are far off from each other.
6. Hind coxae are immobile and basally approximate.

The author has also discovered the following additional features of phylogenetic significance:-

1. The lorae of Fulgorid are inflected internally and are not well defined on the external surface.
2. The meso coxae are located in soft sternal cavities so that lateral movements are possible. The Fulgorids unlike others can directly move to the sides.
3. The Hind trochanters are short, conical and immobile. (See figs. 8 A, 8 B, 10.)
4. The abdomen in a large number of fulgorids is provided with wax secreting glands.
5. In female the ovipositor is highly variable and as a rule the first pair of valves are externally dentate. (See figs. 3A, 3B.)

6. The male genitalia are also highly variable but have a few common features. The aedeagus is produced at its base into a phallobase and is connected by a sclerotised bar with the parameres or claspers. A well marked basal selerite is not distinct. (See figs. 6 & 7)

Cercopidac: The Cercopid morphology is rather inadequately known. The chief features of taxonomical significance are :

1. The post clypeus is highly developed and expanded. It extends beyond the base of the eyes.
2. The antennal flagellum is composed of a subpyriform base and a very slender seta.
3. Posterior coxae are short and conical, not laterally dilated.
4. Empodia are large.
5. Hind tibiae are cylindrical.
6. Scutellum may be enlarged to form a spine like process. Many authors regard Cercopids closely related to Cicadids.

The following additional characters have been worked out by the writer :-

1. Middle coxae are short and basally approximate.
2. Tegulae are absent.
3. Peripheral vein is absent from eitherwing.
4. Hind coxae are soft, conical and movable. (See figs. 9A, 9B )
5. Hind trochanters are mobile, hinge like and provided with the jumping apodeme as in Fulgorids.
6. Ovipositor is valvular, all the three pairs of valves are functional. The inner valves are dentate.

7. Male genitalia consist of a phallus and aedeagus, and have no basal plates. (See fig. 5)

A pair of well defined partially mobile sub genital plates is present.

**Jassidae.** The morphology of Jassids or Cicadellids is much better known than in other Auchenorrhyncha. The significant features of fundamental importance are mentioned below :-

1. The Clypeus is highly developed and forms with genae a laterally inflated face.
2. Pronotum is well developed, mobile and is never prolonged backward.
3. Tegulae are present.
4. Peripheral vein may be present especially in the hind wings.
5. Hind coxae are laterally dilated, sclerotised and immovably ankylosed with metapleura.
6. Hind tibiae have four angles and a double row of setae. (See fig. 10B)
7. Ovipositor is adapted for piercing the tissue. (See fig. 2)
8. The male genitalia consist of an aedeagus with two basal plates and a pair of claspers. subgenital plates are present. (See fig. 4)

The following additional features were observed by the author :-

1. Frons is not carinate on the sides.
2. Mesocoxae are short and not movable laterally.
3. The Hind legs have similar jumping apparatus as in Fulgoridae and Cercopidae. (See figs. 9 & 10)

4. Wax glands are never present in the abdomen.
5. The Inner Valves and not the first or anterior valves are provided with dentate margin.
6. No part of phallus or phallobase is present.

Membracids are closely related to Jassids and in fact Evans has merged the superfamily Membracoidea in the super family Cicadelloidea (Jassoidea).

The important characters of Membracids are given below:-

1. The clypeus is developed and forms with genae a single surface. The genae are however not much dilated.
2. The pronotum is highly developed, horned and extends behind.
3. The Hind tibia are angular in some case provided with a row of setae.

Evans on the basis of the head has proposed two hypothetic ancestral type (a) Fulgorid type and (b) Cicadid-Cercopid-Cicadellid type. According to him Fulgorids had independent origin from Protohemipterous stock probably before permian era. The other group, according to Evans may be grouped into two divisions : (1) Cicadoid group and (2) Cercopid Cicadellid group. He holds that Cicadoid cannot be related to Cicadelloid by way of Cercopoids. However he could not establish any phylogenetic relation between any four principal groups of Auchenorrhyncha namely Fulgoroidea, Cicadoidea Cercopoidea, and Cicadelloidea.

The writer on a closer study of Cicadids has failed to appreciate any near relationship between Cicadoidea and the rest of the three groups named above. The Cicadas have no jumping mechanism in the hind legs. Their pretarsi lack both the pulvilli and the empodium. Their anterior femora are dilated a character which is not shared by any homoptera and the antennae especially



in the nymph are jointed and non aristate. The presence of tympanal organs in the abdomen is also a unique feature. The wings lack tegulae also. But more important than the above are the characters in the genitalia of females as well as males. In the female the 3rd pair of valves or lateral valves do not participate in egg laying and are mere palp like processes. In case of the male the absence of aedeagus is a feature of great significance. In addition to this the claspers or parameres of Cicada have no basal connection with the phallus. The above cited fundamental difference along with the subterranean life of the immature Cicadas do not justify their inclusion in the Auchenorrhyncha at all. They may however be included in the order Homoptera because of the form of the forewings and they share the presence of peripheral vein with the Cicadelloids. The author will therefore suggest a separate sub-order Cicadina or Stridulantia for the Cicadids based on the characters cited above.

The rest of the three major groups viz., Fulgoroidea, Cercopodea and Cicadelloidea of Evans have several important features common to them. They are as stated below :—

1. The antennae are aristate.
2. Pulvilli and empodium are present in the pretarsi.
3. Hind legs are provided with a special apodeme on the trochanter provided with muscles in order to enable them to hop about.
4. In female the ovipositor is composed of three pairs of valves, the dorsal or lateral valve is a functional egg laying organ.
5. In the males an aedeagus is present.

It is therefore suggested that the suborder auchenorrhyncha may be retained to include the three above mentioned groups. In proposed reorganised suborder auchenorrhyncha the Fulgorids are

fundamentally different in their organisation. They have the following distinctive characters:—

1. Antennae are located below the eyes and their second joint has special sense organs.
2. Frons is highly developed and laterally carinate and adjacent to genae.
3. Clypeus is reduced and undivided.
4. Pronotum is very narrow and collar like.
5. Meso coxae are elongated, their bases are located far off from each other and they are capable of lateral movements.
6. Wax glands are present in the abdomen of a large number of forms.
7. In the vast majority the ventral or anterior ovipositor valves are externally dentate and the dorsal valves act as sheaths.
8. In the males the subgenital plates are totally lacking and the phallobase is connected with the claspers by sclerotised bar like connectives.

It is therefore asserted that Fulgoroidea should constitute a separate series or division of the auchenorrhyncha namely Fulgoraria or Hypocerata.

The remaining two major groups namely Cercopoidea and the Cicadelloidea share the following common characters:—

1. The clypeus is highly developed and divided into a post clypeus and antclypeus.
2. Frons is reduced and pushed back to near the forehead and the antennae are located between the compound eyes.

The second antennal joint has no sensory organs.

3. The pronotum is well developed and not inflected on the sides like a collar.

4. The meso coxae are short, conical and basally approximate.
5. The abdomen has no wax glands.
6. The ovipositor is basically similar.
7. In the males the subgenital plates are present.

It is therefore desirable to include Cercopids and Cicadelloids in a common series or Division-Endocerata or Clypeata.

Coming to Cercopoids they have a number of features different from Cicadelloids.

1. The antennal flagellum is composed of a subpyriform base and a long slender seta.
2. The Pronotum is closely ankylosed with the mesonotum and is not capable of independent movement.
3. Tegulae are absent.
4. The meso scutellum may be elongated to form a spine like posteriorly directed process.
5. Hind wings have no peripheral vein.
6. Hind coxae are as a rule conical, not sclerotised at the base and can move freely.
7. Hind tibiae are rounded.

It is therefore proposed to regard them as a separate superfamily named as Cercopoidea.

In so far as Cicadelloids are concerned the author is agreeable to the inclusion of Jassids and membracids in a single superfamily Cicadelloidea as proposed by Evans.

#### Summary :

1. The author has undertaken an intensive study of the morphology including that of the external genitalia of the major groups Cicadoidea, Fulgoroidea, Cercopoidea and Cicadelloidea-the latter including Jassids as well as Membracids.

2. The above studies point out that the Cicadids have fundamentally different organisation from the rest. They have no jumping mechanism and their ovipositor and male genitalia are also basically different from the rest of three above mentioned major groups. They also possess distinctive tympanal organs in the abdomen. The Cicadids are therefore proposed to be placed in a separate S. O. Cicadina or stridulantia.

3. The suborder Auchenorrhyncha be retained in order to include Forligoroids, Cercopoids and Cicadelloids because of (1) Their common jumping mechanism, (2) aristate antennae and a complete ovipositor in which all the three pairs of valves are incorporated.

4. The Auchenorrhyncha are proposed to be divided into two series, (1) Fulgoraria or Hypocerata chiefly based on location of antennae, reduction of clypeus, elongated and laterally mobile mesocoxae, possession of wax glands in the abdomen and the absence of subgenital plates in the males. Series two has been proposed as Endocerata or Clypeata in order to include Cercopoids and Cicadelloids. Its chief characters are as follows :—

1. Antennae are located in between the compound eyes.
2. Clypeus is highly developed and divided into anticlypeus and post clypeus.
3. The meso coxae are short and conical and are basally approximated.
4. In the male genitalia the subgenital plates are present.

The series Endocerata is divided into two following superfamilies :—

1. Super family Cercopoidea having Hind coxae conical and mobile and hind tibiae rounded.
2. Super family Cicadelloidea having Hind coxae laterally expanded and the hind tibiae angular. The second superfamily includes Jassids as well as Membracids.

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N.B. A more detailed list of references is given by Evans (1963).

## LIST OF ABBREVIATIONS

<b>Acd</b>	...	Aedeagus.
<b>Acd H</b>	...	Aedeagal hook.
<b>BC</b>	...	Basal Connective.
<b>BP</b>	...	Basal Plate.
<b>Cl</b>	...	Claw.
<b>DVV</b>	...	Dorsal Valve.
<b>EMP</b>	...	Empodium.
<b>IVV</b>	...	Inner valve.
<b>JM</b>	...	Jumping mechanism.
<b>MSC</b>	...	Meso Coxa.
<b>MSCG</b>	...	Meso Coxal Cavity.
<b>MTC</b>	...	Meta Coxa.
<b>PFR</b>	...	Pygofer.
<b>PH</b>	...	Phallus.
<b>PM</b>	...	Paramere.
<b>PV</b>	...	Pulvillus.
<b>SgP</b>	...	Sub genital plate.
<b>ST</b>	...	Sternum.
<b>Tb</b>	...	Tibia.
<b>TR</b>	...	Trochanter.
<b>Vfr</b>	...	Valvifer.
<b>UTR</b>	...	Unguitractor.

## LIST OF ILLUSTRATIONS

- Fig. 1. Male and Female genitalia of *Sena quaerula* (Cicadidae).
- Fig. 2. Female genitalia of *Tettigoniella Spectra* (Jassidae).
- Fig. 3. Female genitalia of *Pyrops* sp. Fulgoridae.
- Fig. 4. Male genitalia of Jassidae.
- Fig. 5. Male genitalia of *Calittetix Versicolor* Cercopidae.
- Fig. 6. Male genitalia of *Paragomeda typica* Flgattidae (Fulgoridae).
- Fig. 7. Aedeagus and basal connectives of *Pyrops* sp. (Fulgoridae).
- Fig. 8. Hind leg and springing mechanism of *Pyrilla Lophopidae* (Fulgoroidea).
- Fig. 9. A. Hind pretartus. B. Hind coxa of <sup>Aphrophora sp</sup> ~~Poo-~~ *phitus*, ~~Coctalis~~, (Cercopidae).
- Fig. 10. A. Meso and meta coxal cavities of *Cixius-Cixiidae* Fulgoridae and  
B. *Allygus*/Jassidae.



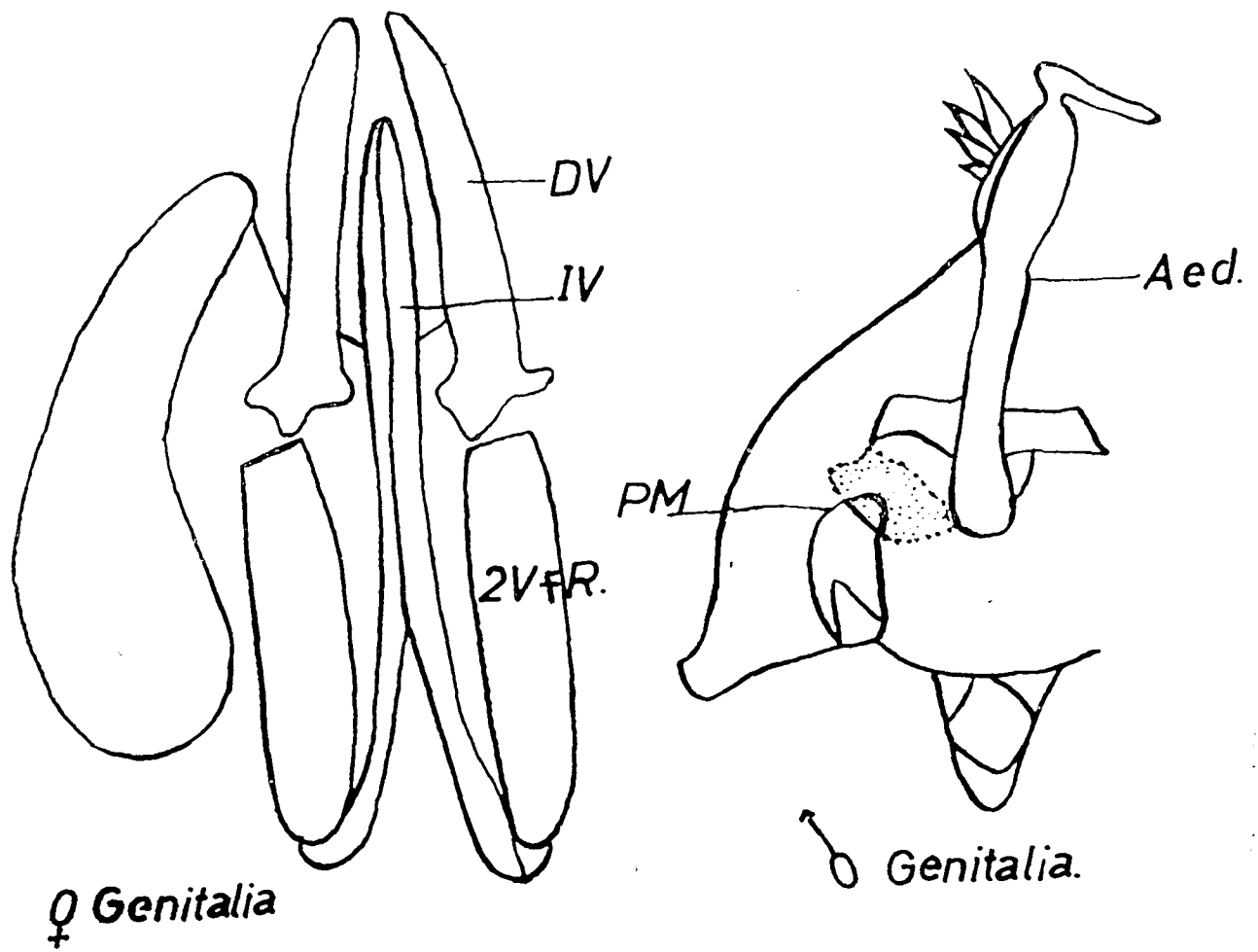


Fig.1- *Sena quaerula*. (Cicadidae).

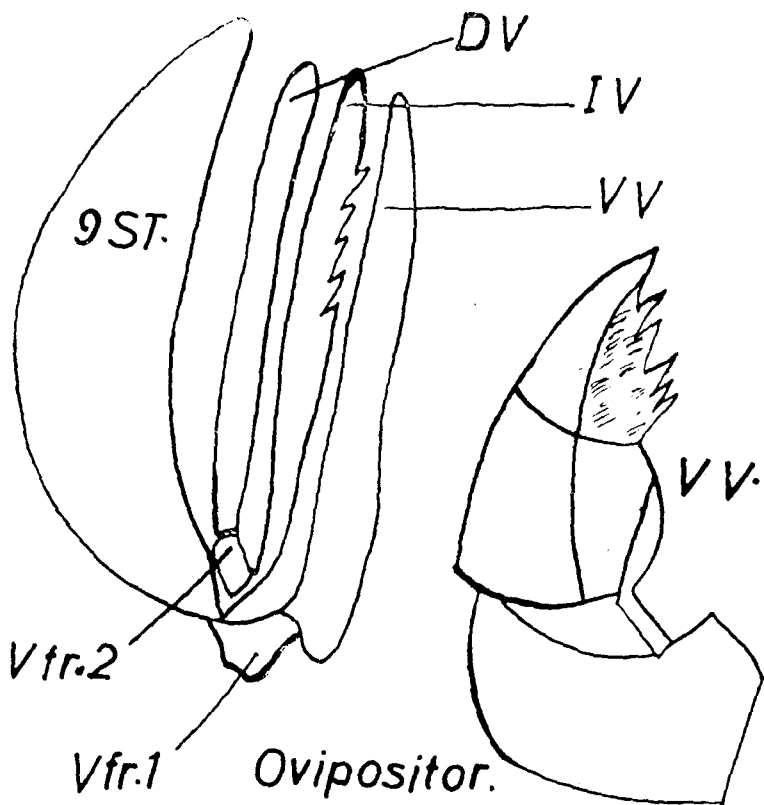
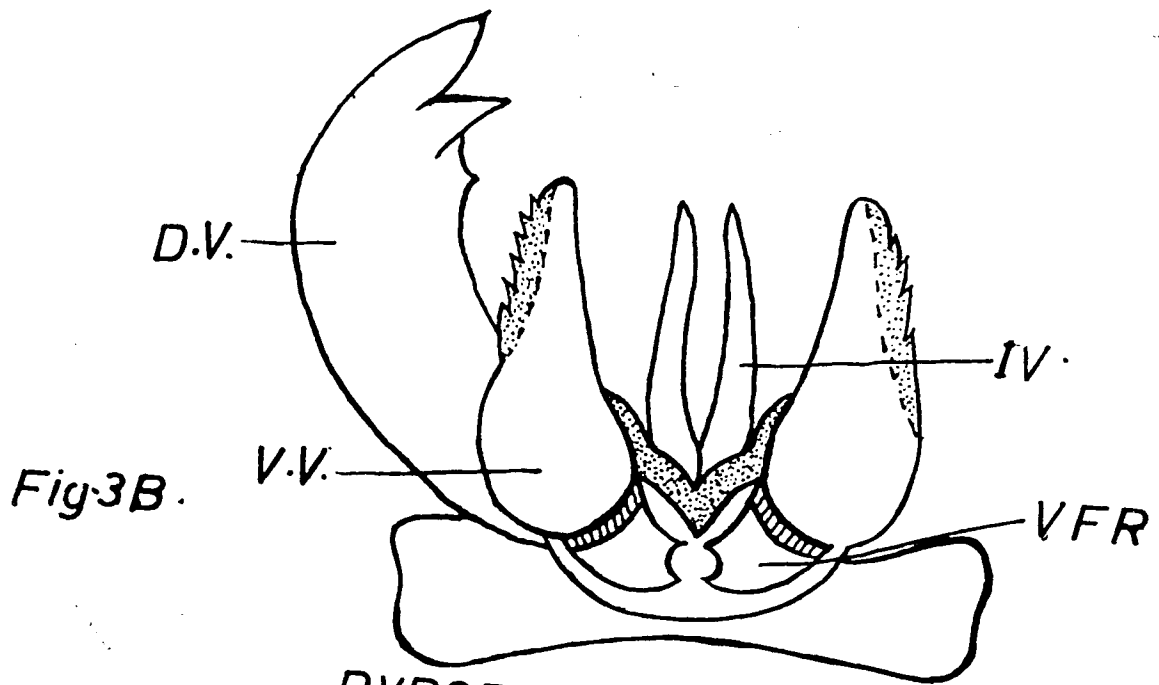


Fig.2. *Tettigoniella spectra*. Fig. 3A  
 (*Jassidae*).



PYROPS SP (Fulgoridae).  
Fig3B. Ovipositor.

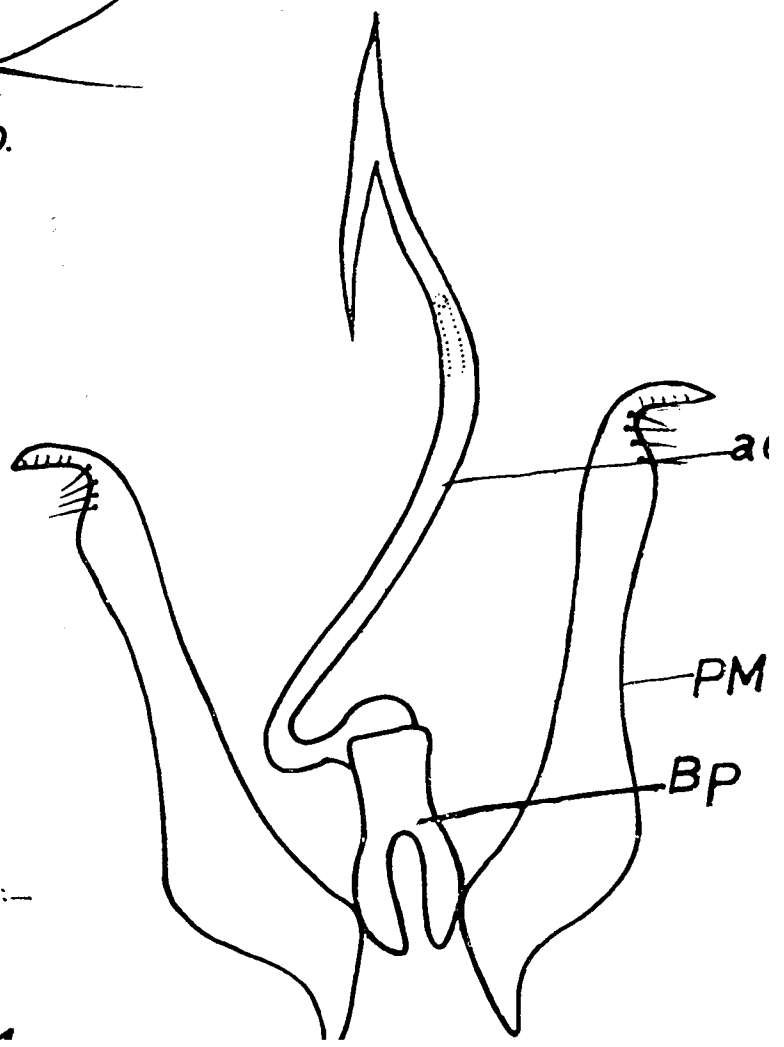
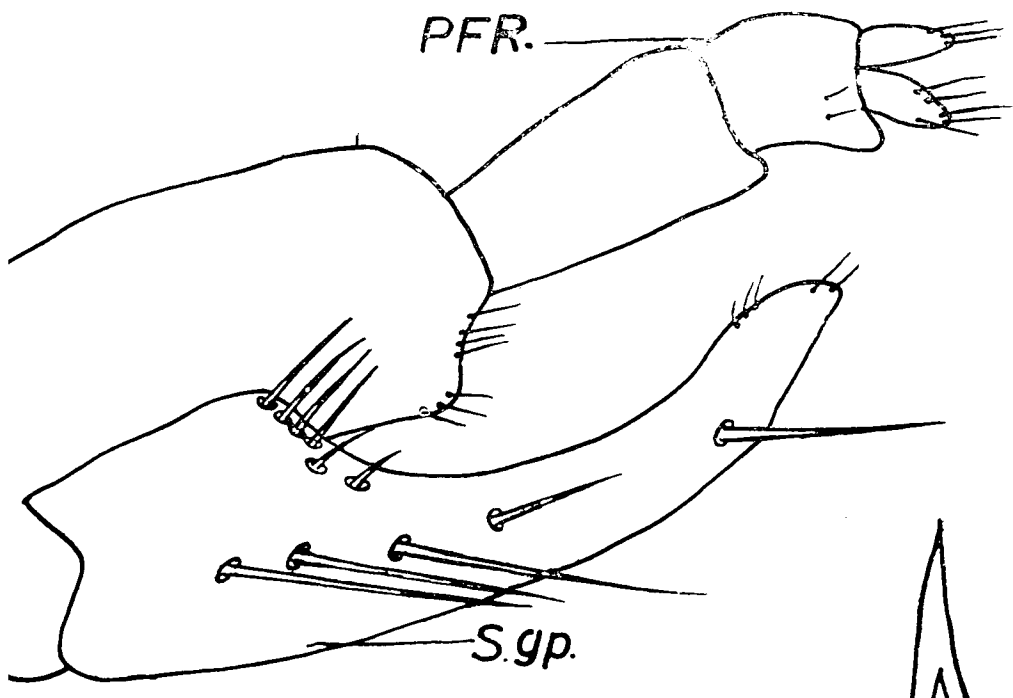
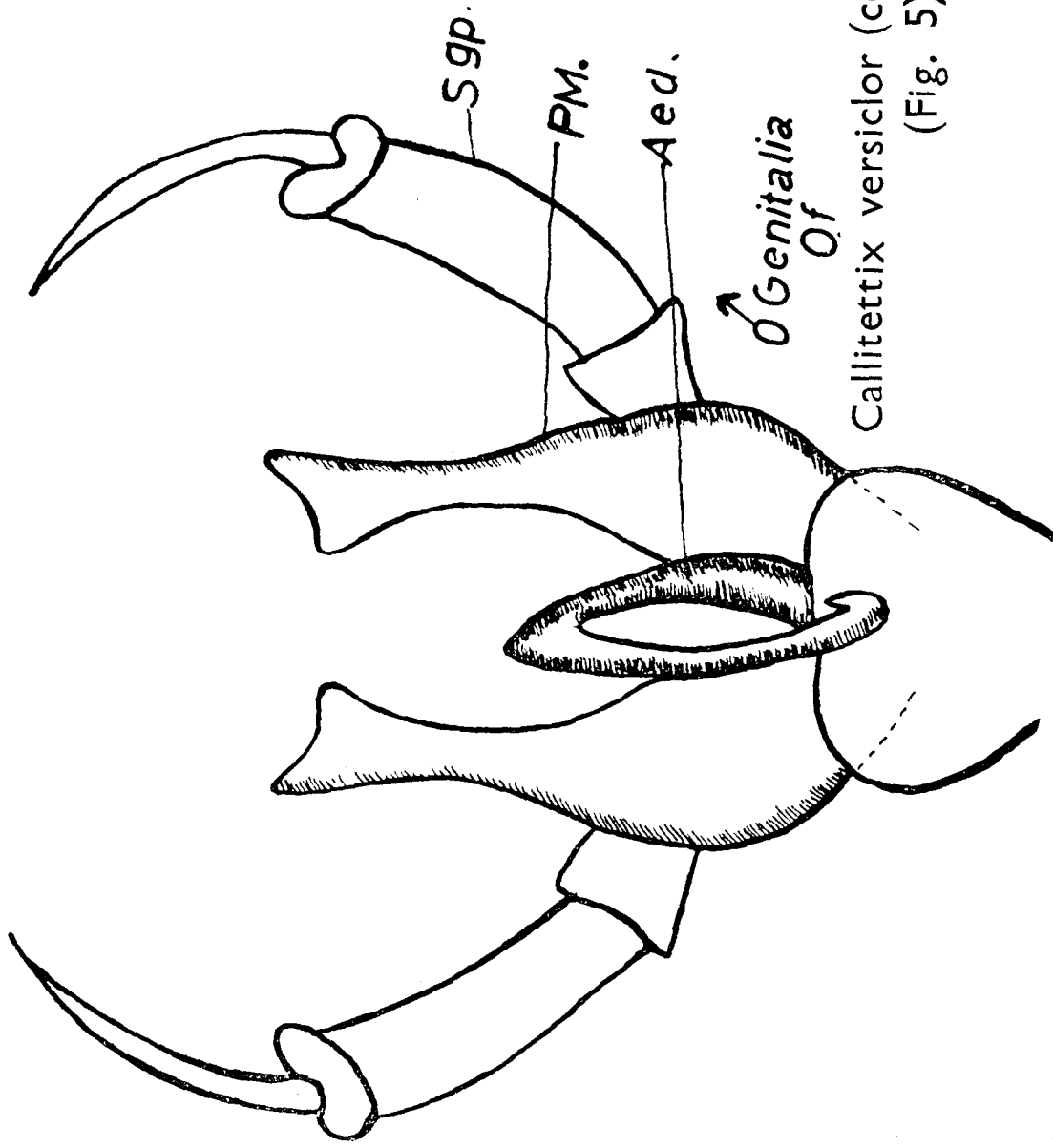


Fig 4:-



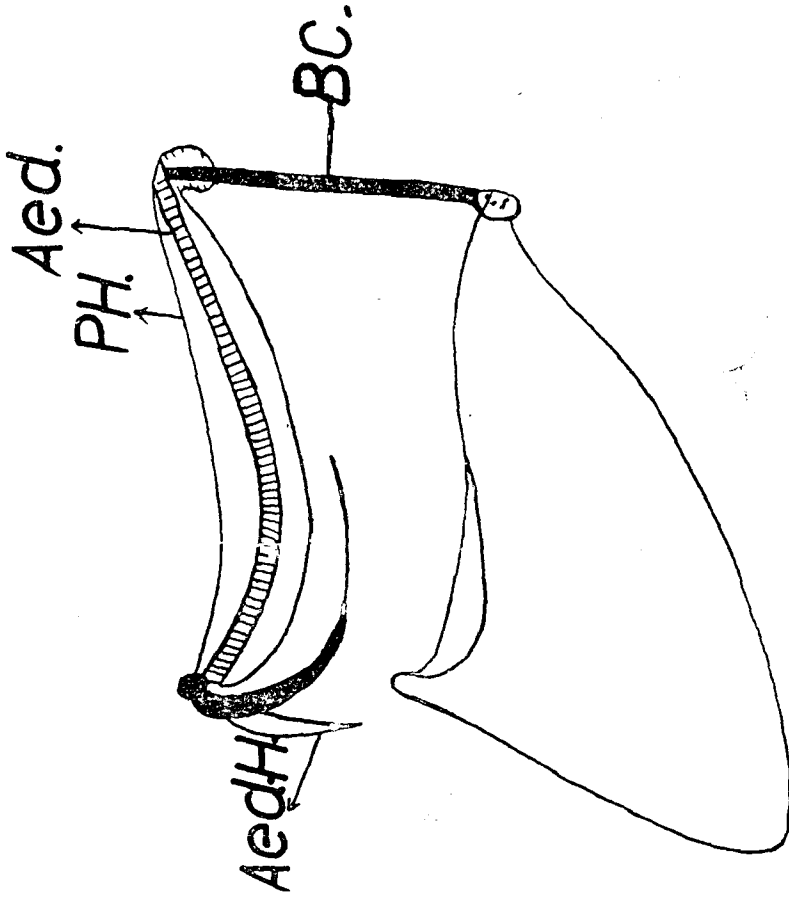


Fig.6. *Paragomeda typica*. ♂.  
(Fulgoroidea).

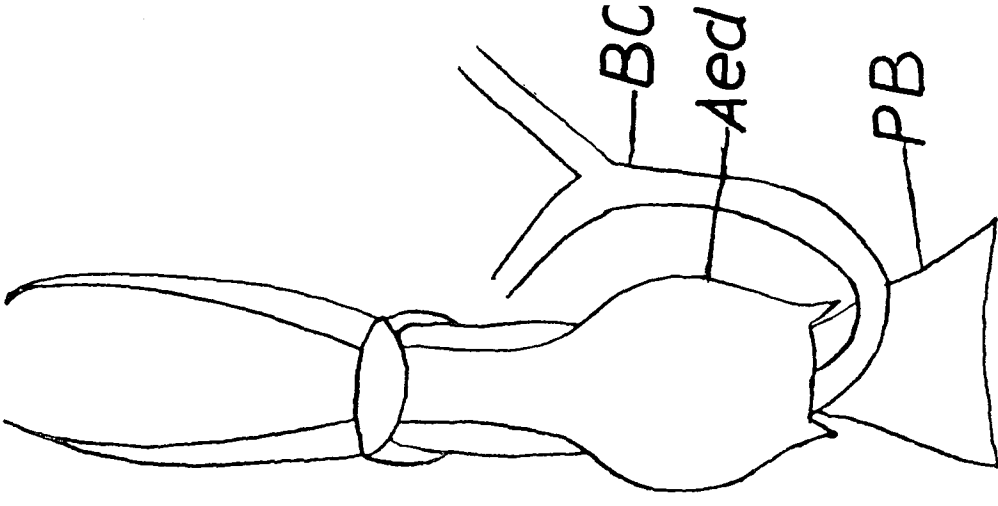


Fig.7 *Pyrops* ♂.  
(Fulgoroidea)

JM  
TR

TERGAL PROMOTOR MUSCLE

TROCHANTERAL  
DEPRESSOR  
MUSCLES

SPRINGING APODEME

COXA

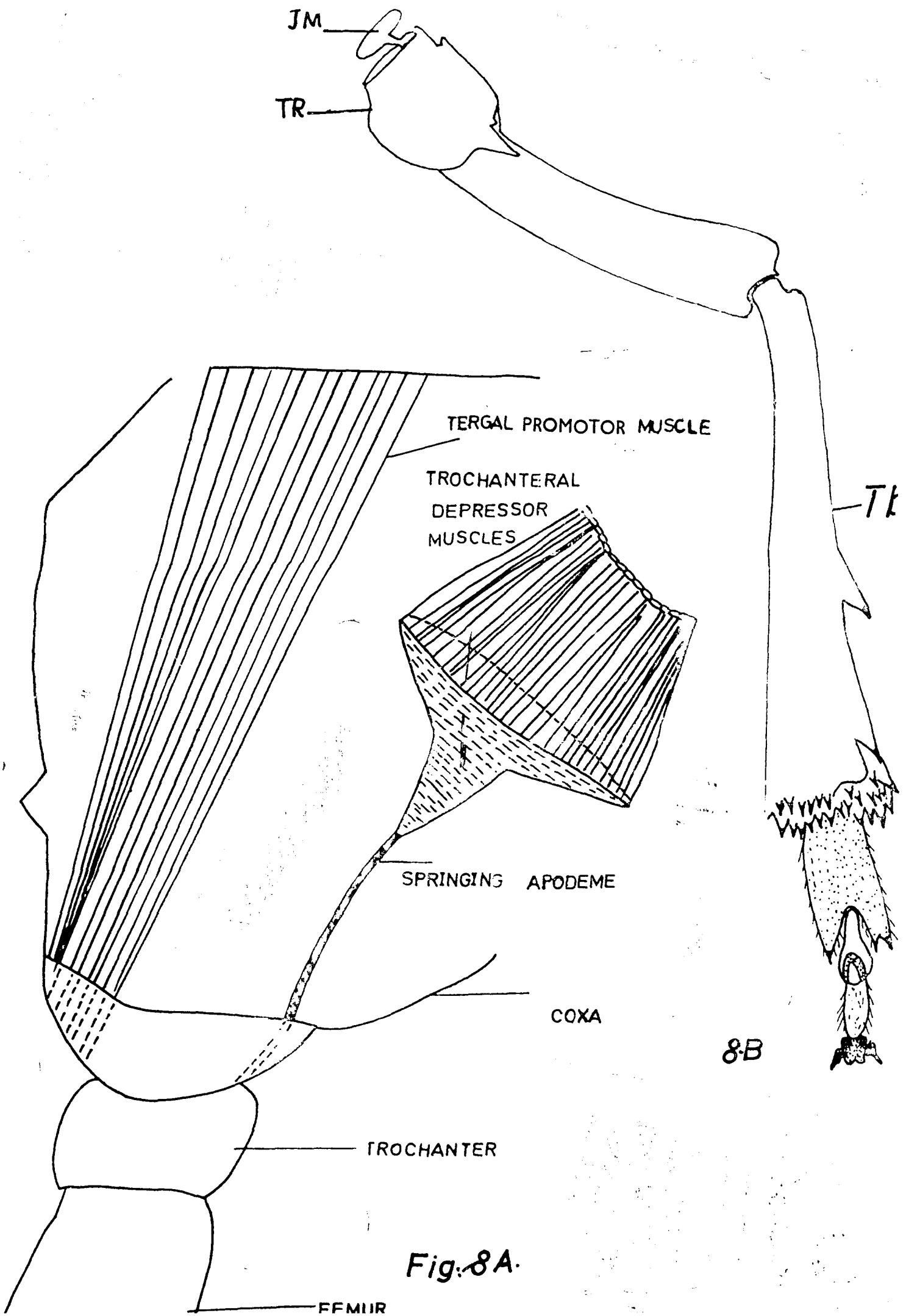
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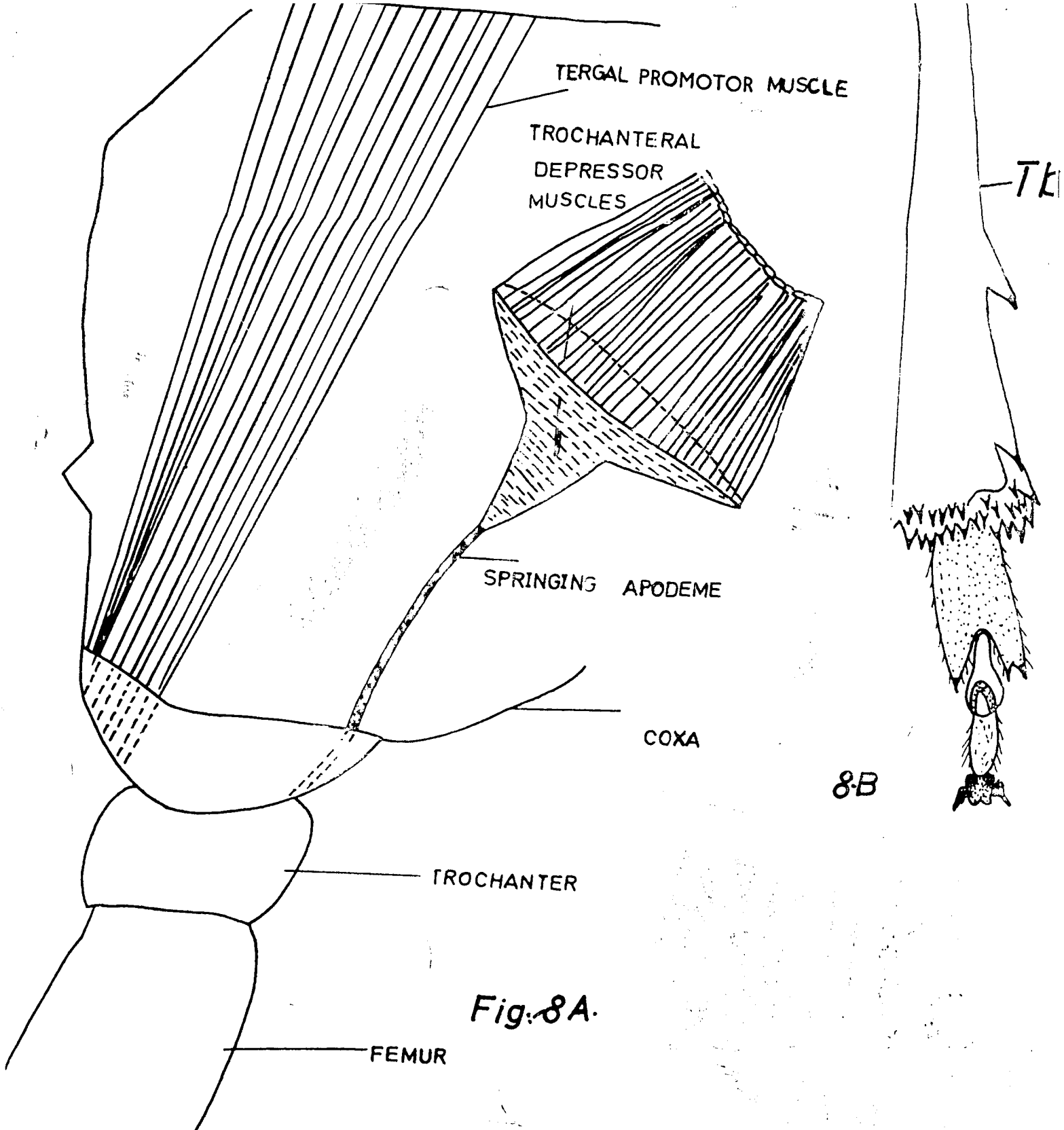
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8-B

Fig. 8A.





8-B

Fig. 8A.

Fig. 8. *Pyrilla* (Fulgoridae).



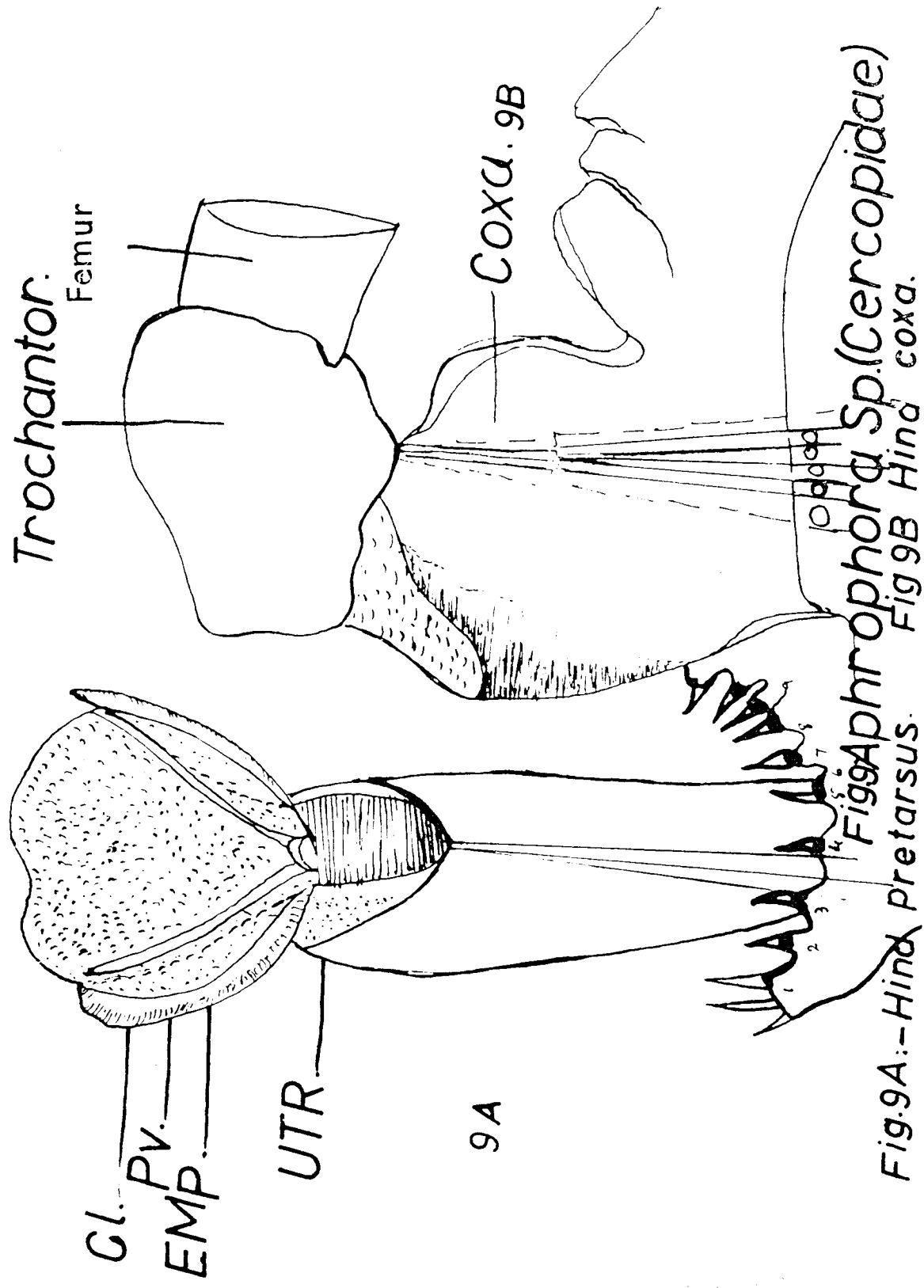


Fig 9A: - Hind Pretarsus.  
 Fig 9B: Hind coxa.  
 Fig 9Aphrophora Sp. (Cercopidae)

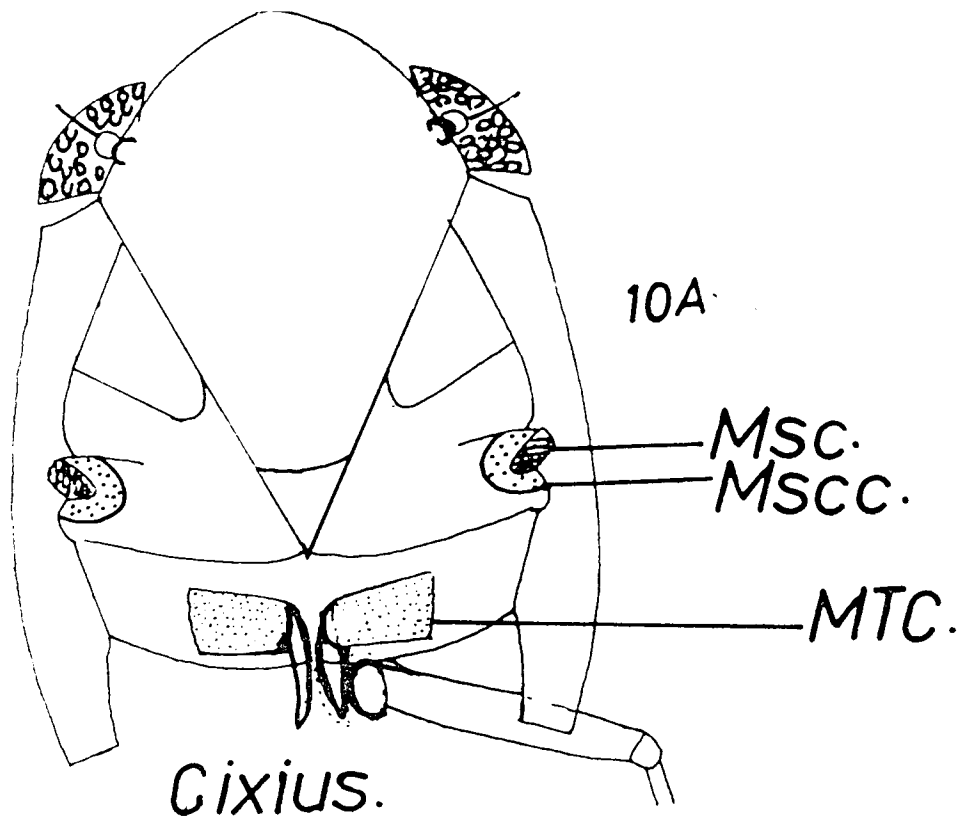


Fig.10A - *Cixius* (Fulgoroidea).  
B - *Allygus* (Jassidae).

