STUDIES ON INDIAN DELPHACIDAE (HOMOPTERA)

by

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CERTIFICATE

This is to certify that the thesis entitled "Studies on Indian Delphacidae (Homoptera)" submitted by Sri K.V. Mammen, in partial fulfilment of the requirements for the award of the Degree of Doctor of Philosophy in Entomology of the Post-Graduate School, Indian Agricultural Research Institute, New Delhi, embodies the results of the bonafide research work carried out by him under my direct supervision and guidance. No part of this thesis has been submitted for any other Degree or Diploma.

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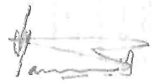

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INTRODUCTION

Delphacids, popularly known as leafhoppers or plant hoppers, belong to the family Delphacidae under the superfamily Fulgoroidea in Homoptera. This family has been considered till recently by some workers as a subfamily of the larger group Fulgoridae. The distinctiveness of delphacids from all other fulgorids seems to favour its segregation under a distinct family.

The name Delphacidae is derived from the generic name Delphax given by Fabricius (1798) to one of its constituent genera. Metcalf (1938) renamed this as Araeopidae selecting Spinola's genus Araeopus (1839) as the type for the family. Which of the two should be the valid name of the family is still under controversy among taxonomists. The older name Delphacidae is more popular in entomological literature for this group of insects and further it is based upon the oldest generic group name still current. Hence the present author prefers to use the name Delphacidae until the International Commission on Zoological Nomenclature makes a definite decision.

The delphacids are the largest of all the fulgorid families which are widely distributed all over the world, excepting the extreme Arctic and Antarctic regions. Metcalf (1943) in his 'Catalogue on Araeopidae' has listed 1,114 species under 137 genera. From the limits of the Indian Republic, however, only 30 species falling under 19 genera have so far been recorded. From the fact that 38 species

have been recorded under 18 genera from the neighbouring island of Ceylon, with its very limited geographical boundaries and climatic limits, the vast richness of the delphacid fauna of our extensive subcontinent is easily conceivable. No further evidence is necessary to show that this group has remained one of the most neglected groups of insects in our country.

It is also noteworthy to recall here that Distant (1916) while monographing the species of this group from the Indian region remarked "although the present contribution is a considerable advance in number of genera and species to any previously given as found in British India, it is absolutely certain that it only refers to a fraction of the Delphacinae found in this region. The number of species from Ceylon collected by Mr. E.E. Green conclusively proves what can be done by other workers in our Indian Empire". The fact that during the last two and a half years, the present author could procure from just one locality in Delhi alone, viz., the campus of the Indian Agricultural Research Institute, as many as 27 different species proves the validity of Distant's statement and the very rich fauna awaiting discovery from our country.

Delphacids bear a superficial resemblence to jassids in general form, habits and habitats and are also called as 'leaf hoppers' or 'plant hoppers' because of their habit of hopping about on the leaves of green vegetation when disturbed, not readily taking to flight. However, the members of this

family are easily recognised by the presence of a large mobile spur (calcar) borne on the inner side of the apex of the hind tibia. They are very small insects never measuring over a centimetre in length to the tip of the forewings and many small forms measure even less than 2 mm. They are all phytophagous in nature, found associated with all kinds of vegetation excluding only the very lowest plants. They are usually attracted to light in large numbers except some genera.

The delphacids are economically a very important group of insects. Not only are many of them found serious pests of cultivated crop plants and forest trees, but a large number of them have been found serious vectors of a number of virus diseases of plants. In nature, they are controlled by a number of enemies like predaceous and parasitic insects, parasitic mites, nematodes and fungi and also by frogs, lizards and spiders.

Since Linnaean days there had been a steady increase in the number of workers engaged in faunistic surveys of the delphacids from different parts of the world. A very large amount of information is by now available on the delphacid fauna of the Palaearctic and Nearctic regions. However, most of the other parts of the world have remained rather badly neglected.

Our knowledge on the Indian delphacids is very meagre compared to even the less explored areas of the world. Lefroy (1909) has affirmed that no family would so well repay

study from every point of view. Despite this statement collections made from our country have been very few, though Lefroy, Annandale, Campbell, Fletcher, Mann, Mackenzee, Misra and others procured a few specimens which Distant (1906-1917) and Muir (1921-1934) subsequently listed. Distant (1906,1916) in his volumes on the "Fauna of British India" listed as many as 51 species from the present day political India, Pakistan, Burma and Ceylon. Out of these only 16 species have been recorded from the Indian Union and these too have been from only a few scattered localities within the domain. A comparison of the fauna that have been brought to light from the more explored regions of the world, would indicate the possible vastness of the Indian delphacids as well. After Distant's work there has been very little addition to our knowledge of the delphacids of our country.

Though 137 genera have been listed under this family upto 1943 and some more have since been added on to this number, the generic limitations have not yet been quite well established. The use of only superficial characters by most of the earlier workers has resulted in the multiplication of genera and species beyond reason, and confusion has crept in. Metcalf's (1938) statement that there are 120 genera in synonymy in this family gives an indication of the magnitude of the task facing those who work with delphacids. Hence, he has rightly pointed out that "the known genera need revision, with the characters of the male genetalia used to determine

their bounds and phylogenetic relationship". Any single dichotomous key for the separation of all the known genera as they are at present recognised too is also not available in literature, though such keys presented by Muir (1915), Muir and Giffard (1924), Caldwell (1950), Fennah (1956), Wagner (1962), Dantsig et al. (1964) and Vilbaste (1968) cover a good number of the known genera.

From preliminary studies conducted by the author, he felt convinced that the knowledge on this family covers but a fraction of the Indian fauna and there is plenty of scope for further work. Therefore, he undertook the present studies on the Indian Delphacidae with a two-fold purpose, namely to enhance our knowledge of the faunistics and zoogeography of this family and to probe into the soundness of the presently accepted classification with more efficient modern taxonomic tool of a study of the genetalia of these bugs. The results of the studies carried out by the author for just over a period of two and a half years are incorporated in this thesis.

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PART I

REVIEW OF LITERATURE

A. Taxonomical studies

1. Taxonomy of Delphacidae in general

Name of the family

The family Delphacidae, until quite recently, and in fact by some workers, have been considered as a subfamily of the family Fulgoridae.

Fabricius recognised this group by describing the genus Delphax in 1798, although the group was not given the family rank until 1815, when Leach recognised it so. The earliest name proposed for this group of insects appears to have been DELPHACIDA by Leach (1815). This has been followed by numerous names which include DELPHACOIDES Spinola (1839), DELPHACIDES Amyot et Serville (1843), DELPHACITES Blanchard (1845), LONGINAURES Amyot (1847), DELPHACIDAE Dohrn (1859), ASIRACIDES Motschulsky (1863), DELPHACINI Fieber (1866), DELPHACINA Stal (1870), DELPHACINAE Ashmead (1889), DELPHACINES Lameere (1900), ASIRACINAE Kirkaldy (1902), DELPHACINII Graeffe (1903), ASIRACIDAE Kirkaldy (1906), CRIOMORPHINI Kirkaldy (1910), PROTEROSYDNII Kirkaldy (1910), DELPHACINEN Holdhaus (1927) and ARAEOPIDAE Metcalf (1938).

Dohrn (1859) appears to have been the first to give the name DELPHACIDAE to this group of insects, which is derived from the generic name Delphax given by Fabricius (1798) to one of its constituent genera. Metcalf (1938) renamed this as ARAEOPIDAE selecting Spinola's genus

Araeopus (1839) as the type for the family. He considered Delphax of Fabricius (1798) to be preoccupied by the mammalian generic name Delphax of Walbaum (1792) (listed from Klein's work of 1744). However, as pointed by Fennah (1944), Opinion 21, handed down by the International Commission on Zoological Nomenclature was overlooked, for it states that the Delphax of Klein and Walbaum is not available under the rules. Opinion 21 reads as follows: "Shall the Genera of Klein, 1744, Reprinted by Walbaum, 1792, be Accepted? When Walbaum, 1792, reprinted in condensed form (but did not accept) the Genera of Klein, 1744 he did not thereby give Klein's genera any nomenclatorial status and Klein's genera do not therefore gain availability under the present Code by reason of being quoted by Walbaum". Thus Araeopidae of Metcalf becomes a synonym of the old and well known family name Delphacidae.

With regard to the choice of the proper name for this group of insects, the controversy is still continued; while the majority of workers have been calling this group Delphacidae, Metcalf and some Japanese workers call it Araeopidae. In the Zoological Records, published from 1954 onwards, the family name Delphacidae has been preferred over Araeopidae, though both the names are being indicated. Thus one who takes up a study of the family is confronted with the problem of which name to choose out of the two. The present author prefers to use the name Delphacidae on account of its wider and long-standing usage to avoid further nomenclatural confusion.

Workers on Delphacidae

Since the starting point for all modern animal taxonomy, according to the International Code on Zoological Nomenclature, is accepted as the first day of January, 1758, all publications on Delphacidae made by workers earlier to the publication of the tenth edition of 'Systema Naturae' by Linnaeus may be overlooked. Fabricius (1798) was the first to recognise this group of insects by erecting the genus Delphax, although the group was not given a family rank. Leach (1815) recognised this as a separate family of bugs, by giving the name Delphacida. The systematic entomologists of the first half of the nineteenth century described the more common forms. Notable contributions to the taxonomy of Delphacidae were made by Latreille, Burmeister, Boheman, Herrich-Schaffer, Germer, Say, Guerin-Meneville, Spinola, Amyot, Serville, Swartz, Costa, Puton, Breddin, Motschulsky, Curtis and Signoret. Fieber (1866) was the first to recognise the importance of male genetalia for specific determinations and his work gave real impetus to the studies of a group of entomologists who made their chief contributions during the last half of the nineteenth century and the first part of the twentieth century. In this group should be mentioned Stal, who worked on collections from various parts of the world. Other conspicuous European workers during the period were Kirchbaum and Melichar in Germany; Flor and Sahlberg in Scandinavia; Marshall, Scott and Edwards in England; Walker

and Distant who worked over the rich collections in the British Museum; Van Duzee, Uhler, Ashmead, Osborn and Fitch in the United States and Berg in Argentina. Since the turn of the century many notable contributions have been made by Muir and Kirkaldy especially on the Pacific faunas; Crawford, Swezey, Ball, Dozier, Fowler, Beamer, Caldwell and others on the fauna of Americas; Matsumura, Esaki, Kato and others on the species from Japan; Oshanin and Kusneznove in Russia; Haupt, Jensen-Haarup, Ribaut and others in continental Europe and China in England. Metcalf (1943) was the first to take up the task of preparing a 'Catalogue on Araeopidae' which is a valuable contribution to the study of these insects.

The present workers on Delphacidae from different parts of the world appear to be Fennah, who is working on the collections from various parts of the world; Penner, McDermot and Zimmerman on American fauna; LeQuesne and Scudder on British species; Emel'yanov and Vilbaste in Russia; Wagner in Germany; Linnavouri and Lindberg in Finland; Diabola in Czecoslovokia; Ishihara in Japan and Ossainnilson in continental Europe.

Taxonomy of Delphacidae

From the number of species that have so far been brought to light by the above workers it is clear that this family appears to be the richest of all the families in Fulgoroidea. From the continuous flow of new species that are being described it is evident that a good deal of further

explorations and discoveries are needed to make our knowledge of the Delphacidae at least reasonably sound. At present it is even difficult to give a rough estimate of the total number of species recorded so far, though regional catalogues are available from the better explored areas of the world. However, on a very superficial estimate the author feels that there must be at least about two thousand species on record from the whole world.

The author has also been enduring to make a checklist of the delphacid genera of the world; the non-availability of the Zoological Records since the publication of the 102th volume in 1965 has resulted in this being far from up-to-date. Nevertheless, he has been able to enlist as many as 221 genera and 1700 species under this family, alphabetically arranged.

Coming on to the higher classification of the group, a good deal of lack of unanimity is evident. As mentioned elsewhere, the status of this group of insects as a family has been a matter of controversy. The foundations of the classification of the Fulgoroidea, as well as most other Homoptera, were laid by Stal, Fieber and others. Stal (1866) divided the Fulgoridan group of auchenorhynchan Homoptera into thirteen families, which include the Delphacida also. Distant (1906) classified the auchenorhynchan Homoptera into five families, viz., Cicadidae, Fulgoridae, Membracidae, Cercopidae and Jassidae in which Delphacinae is given only a subfamily rank in the family Fulgoridae. Muir (1930) recognised as many as

eighteen families within the Fulgorida of Stal, taking the Delphacidae as a family and this classification has been followed by other workers like Brues and Melander (1954) and Imms (1957).

The taxonomic studies of Delphacidae during the nineteenth century were very few and scanty and most of them were based mainly on superficial characters. Dohrn (1859) seems to have been the first to give a systematic arrangement of the delphacid genera and he prepared a list of the genera and species of the world. Walker (1860) studied the British genera and species. Fieber (1866) appears to have been the first to prepare a key for separating the different genera of the family and recognise the importance of male genetalia in specific determinations. Douglass and Scott (1876) prepared a catalogue of the British genera and species and Puton (1886) studied the palearctic genera and species.

The major contribution towards the classification of Delphacidae was started in the beginning of twentieth century. Kirkaldy (1900-1910) working on the Hawaiian fauna erected twenty five new genera and described a number of species. Referring to the genetalia in general he (1907) suggests "that the genetalia in the male are the final tests of species and even afford generic criteria". Matsumura (1900-1935) working on Japanese fauna erected thirteen new genera while Melichar (1903-1914) has done a good deal of work on the oriental fauna erecting eight new genera. Distant (1906-1917) worked on the

rich collections from the Indian sub-continent, erected thirteen new genera and described a number of species. Crawford (1914) prepared a monograph of the family Delphacidae by rearranging the genera and species on the basis of the relative lengths of the antennal segments, number of keels on the head and thorax and the nature and form of the calcar and he described 160 species under 25 genera including four new genera erected by him.

Muir (1907-1934) has done a very valuable contribution towards the taxonomy of delphacids and erected twenty eight new genera. It appears that he was the first in preparing a dichotomous key in 1915, for separating the family into sub-families, tribes and genera. He divided the family into two sub-families, Asiracinae and Delphacinae and subdivided the sub-family Delphacinae further into three tribes, viz., Alobini, Tropidocephalini and Delphacini on the basis of the morphological characters like the nature of calcar, presence or absence of teeth on calcar, nature of legs, carination on head and thorax and the nature of the antennal segments. Even though he covered most of the genera recorded from the world, he missed the following genera in his classification, viz., Eumetopina Breddin, Calligypona Sahlberg, Dichoneura Letheirry, Epeurysa Matsumura, Ilburnia White, Megamelanus Ball, Nesoplias Kirkaldy (= Nesorestias Kirkaldy) and Rhinotettix Stal. Muir (1919) examined the collections of Distant in British Museum and synonymised a number of his genera and

species. Giffard (1921) stressed the importance of male genetalia in the taxonomy of delphacids and studied its morphology. Muir (1921) studied some Delphacidae collected from South India. In 1922 he also realised the importance of male genetalia in specific determination and studied the phylogeny of the Fulgoridan Homoptera and suggested that the Delphacinae are evolved from Cixiinae by the acquisition of the mobile spur on the hind tibia. Muir and Giffard (1924) prepared a key for separating the American genera of Delphacidae.

Haupt (1929) divided this family into four sub-families, viz., Asiracinae, Tropidocephalinae, Delphacinae and Megamelinae and his characterisations are very far from conclusive, since the Alohini which form a very distinct group, find no place in his system. The division between the Delphacinae and Megamelinae is very artificial and does not have the same value as between Asiracinae and Delphacinae. Muir (1930) while classifying the Fulgoridae, examined about 100 genera and observed that in the sub-family Asiracinae, the aedeagus is divided into two segments whereas it consists of only one in the sub-family Delphacinae.

Metcalf (1943) prepared an exhaustive catalogue of the family covering all the genera and species of the world in which he listed 1,114 species under 137 genera. He has synonimized a number of genera and species, some of which were not approved by later workers. Kloet and Hincks (1945) while preparing a checklist of British Insects mentioned 82 species

of Delphacidae under 14 genera. Hassan (1948) also stressed the significance of genetalia in specific determination of Delphacidae. Zimmerman (1948) while studying the insects of Hawaii, prepared a monograph on Delphacidae and has given a key for separating 14 genera, including a new genus erected by him. The interesting feature of Hawaiian Delphacidae is the presence of only one sub-family Delphacinae with numerous Alohine species but very few Delphacine species.

Ishihara (1949) made revisional studies of the Araeopidae of Japan, Ryuku Islands and Formosa and described a number of new species including two genera erected by him. Metcalf (1949) revised 21 species which he had already described in 1923, purely on the basis of the male genetalia. Beamer (1949-1954) made revisional studies of some of the genera in North America and erected six new genera. China (1950) while preparing a checklist of the British auchenorhynchous Homoptera described 67 species of Delphacidae under 16 genera. Caldwell (1950) prepared a review of the auchenorhynchous Homoptera in which he has given a key for separating the genera including the three genera erected by him and described 51 species. McDermot (1952) revised the genus Megamelanus and its allies and erected three new genera.

Fennah (1951-1965) working on the delphacid fauna from different parts of the world made enormous contribution to the taxonomy of Delphacidae and erected about 38 new genera and he has synonymised a number of genera and species described

by earlier workers. In 1956, he prepared a key for separating the genera of Chinese Delphacidae and described 23 species.

√ Wagner (1962) made a comprehensive study of this group of insects and prepared a key for separating the family into sub-families and genera. He divided the family into nine sub-families, viz., Asiracinae, Kelesiinae, Jassidaeinae, Stirominae, Achrotilinae, Delphacinae, Chlorioninae, Stenocraninae and Megamelinae and described 80 species under 42 genera, including 18 new genera. His classification was mainly based on the phenotaxonomic approach. He had taken a series of characters presented by delphacids as of the first order and another series as of second order according to what he considered as of secondary importance. The characters he considered on the first order are the shortening of abdomen, development of brachyptery, development of anal styles, extent of the genital styles etc. The secondary characters are the arrangement of the lateral carinae of pronotum, the nature of the tibial spur, number of teeth on the spur, etc. The variations under each were assigned different points. Grouping of the species has been based on overall points secured by each of them. On the above basis he also interpreted the phylogenetic evolution of Delphacidae. But his classification has not been appreciated by most of the recent workers of this group of insects.

Fennah (1963) made a detailed study of the Sogata furcifera complex, mainly based on the bodily proportions, viz.,

submedian length of vertex, length of basal compartment, width of the anterior margin of pronotal disc, length of mesonotum and mesoscutellum, length of frons and width of postclypeal disc etc. He included the species under the complex into three distinct genera, viz., Matutinus Leach, Sogatella Fennah and Sogatodes Fennah and given a key for separating the species.

Scudder (1963-64) in his studies on Canadian and Alaskan Fulgoromorpha, revised a few genera purely on the basis of the male genetalia. LeQuesne (1960-64) has made some taxonomic observations of the British Delphacidae and modified the checklist prepared by China in 1950.

Dantis et al. (1964) while preparing keys for the insects of European U.S.S.R. separated 20 genera of delphacids on the basis of the nature of calcar, carination on head and thorax, antennal characters etc. and prepared a key for separating 347 species. Vilbaste (1968) studied the nymphs of the North European Delphacidae and prepared a key for separating 32 genera, including four new ones erected by him, on the basis of the number and arrangement of sensory pits distributed all over the body of the nymphs. He also prepared a monograph "Cicadan fauna of coastal region (Russian)" in which he has erected a new sub-family Saccharosydninae, taking Saccharosydne procera Matsumura as the type and described five new genera erected by him.

2. Taxonomy and nomenclature of Indian Delphacidae

As mentioned elsewhere, the taxonomic studies of Indian Delphacidae are very meagre. A perusal of literature reveals that very little work has been done on this group of insects and is thus a neglected group in our country. The main contributions towards the taxonomy of Indian Delphacidae were that of Distant (1906-1917) and Muir (1913-1934). Lanbertie (1902) appears to have been the first to describe a species of delphacid, Delphacodes propinqua Fieber, from our country. Distant (1906) gave a comprehensive account of the delphacids so far known from the Indian region (including India, Pakistan, Burma and Ceylon) in the third volume of the "Fauna of British India" series Rhynchota and prepared an appendix to this later in 1916. In his enumeration of the Indian delphacids, he described 15 genera including seven new ones. He prepared a synopsis for separating 11 genera, viz., Paranda, Pundaluoya, Upachara, Purohita, Sogata, Tova, Nilaparvatha, Kalpa, Sardia, Orchesma and Smara but the four other genera viz., Dicranotropis, Liburnia, Mestus and Eodelphax are not included in the synopsis, because he had not been able to examine the Indian species which were assigned to them. He gave the full taxonomy including specific descriptions with illustrations wherever possible of 34 species under the various genera mentioned above. From the fact that most of these species were described by him as new, it is evident that Distant should be considered as the pioneer worker on Indian Delphacidae.

In his later studies, apart from describing many additional species and genera he made some nomenclatural changes to his previous records. In 1907, Distant described a new species Purohita arundinacea collected from Darjeeling (3100') attacking bamboos. In 1912, he erected a new genus Zuleika and described nine additional species. In the appendix to the "Fauna of British India" (1916) he described 17 species including two new genera, viz., Onkelos and Akilas and synonymised Perigrinus maidis of Kirkaldy (1910) with his Pundaluoya simplicia obviously not knowing that the original Delphax maidis of Ashmead itself does not differ from his species. He also renamed Smara festiva Distant as Tropidocephala festiva (Distant) as suggested by Kirkaldy (1907), Matsumura (1907) and Muir (1913). In 1917, he described 10 new species including four new genera, viz., Ambarvila, Consualia, Matutinus and Opiconsiva.

Muir (1913) recorded Perkinsiella sinensis Kirkaldy from India and renamed Smara atrata Distant as Tropidocephala atrata (Distant). In 1917, he recorded Kelesia fiberi Muir from India. In 1919, after examining the types of the various species in the British Museum, he made several nomenclatural changes and transferred Pundaluoya simplex Distant to Perigrinus maidis Ashmead, Pundaluoya insignis Distant to Perkinsiella insignis (Distant), Pundaluoya facialis Distant to Perkinsiella facialis (Distant) and Pundaluoya pulchella Distant to Phyllodinus pulchella (Distant). He synonymised

Nilaparvatha Distant, Tova Distant and Kalpa Distant with Delphacodes Fieber; Matutinus Distant with Chlorionidea Low and Onkelos Distant with Punana Muir and considered Kalpa aculeata Dist. as Delphacodes sordescens Motsch; Opiconsiva insularis Dist., O. derelicta Dist., O. palleata Dist. and Sogata distincta Dist. as Megamelus furcifera (Horv.). He also renamed Opiconsiva fuscovaria Dist. as Delphacodes fuscovaria (Dist.), O. modesta Dist. as D. modesta (Dist.), Sogata thoracica Dist. as D. thoracica (Dist.) and considered Sogata pusana Dist. and S. sternalis Dist. very near to Kelesia fiberi Muir and K. kirkaldyi Muir respectively. He could not separate the other genera Consualia Distant from Ugyops Guerin; Zuleika Distant from Chloriona and Akilas Distant from Gelastodelphax Kirkaldy and considered Upachara Distant in the tribe Tropidocephalini since there is only one small thick tooth at the apex of the spur.

Muir (1921) while studying the species from South India erected a new genus Columbisoga, synonymised Orchesma signata Distant with Tropidocephala signata (Distant) and described four new species, viz., T. butleri, T. indica, Columbisoga campbelli and Sardia campbelli. He renamed Phyllodinus pulchella (Distant) as P. pulchellus (Distant) and synonymised the genera Akilas Distant with Gelastodelphax Kirkaldy. In 1922, he recorded a new species Euidella kashmirensis from Kashmir. Muir and Giffard (1924) synonymised Kalpa Distant with Nilaparvatha Distant and Nilaparvatha

greeni Distant with M. lugens (Stal). In 1934, Muir erected a new genus Platynaresia based on the type P. albinus collected from Darjeeling. Cheo (1935) recorded two new species Tropidocephala brunnipennis Signoret and Liburnia albovittata Mats. from India.

Metcalf (1943) while preparing the catalogue of the Delphacidae made a thorough revision of all genera and species and considered about 120 genera in synonymy with other genera. He synonymised Sogata Distant and Oniconsiva Distant with Liburnia Stal and renamed all the species described by Distant under these genera. But some of his revisions were not accepted by many workers. Caldwell (1950), Beamer (1952) and Fennah (1956) considered Sogata Distant as a distinct genus and described a number of species.

Fennah (1956) erected a new subgenus Sogatella under Chlorionа, taking Liburnia furcifera (Horvath) as the type. In 1963, he considered Sogata furcifera (Horv.) as a complex containing three distinct genera, viz., Matutinus Distant, Sogatella Fennah (raised to full generic rank) and Sogatodes, a new genus and described 30 species under these. He considered Sogata distincta Distant and S. pallescens Distant, as subspecies of typical Sogatella furcifera (Horv.). Disagreeing with the proposed synonymy of Matutinus Distant with Chlorionidea Low by Metcalf, he considered it as a distinct genus. Fennah (1964) separated a part of the Phyllodinus group and erected a new genus Cemus on the basis

of the many-toothed spur and the normal forelegs; and transferred Phyllodimus pulchellus (Distant) and P. sauteri (Muir) to Cemus pulchellus (Distant) and C. sauteri (Muir) respectively.

It will be observed from the enumeration given above that the taxonomy and nomenclature of the Indian Delphacidae have undergone a good deal of changes and Distant's volumes of the Fauna of British India series could no more be utilized for the correct settlement of their identities. The author's own observations point to the fact that in view of the excellent work on the taxonomy of the family undertaken in other countries particularly United States and the European countries, Distant's work on the Indian delphacid fauna needs drastic taxonomic revision.

B. Morphological

There hardly exists any detailed account of the morphology of delphacids except scanty work done by workers like Lindberg (1939), Liebenberg (1956), Mathur and Joseph (1961), Sexana and Joseph (1963), Joseph (1965 & 1969) and Vilbaste (1968). But workers like Myers, Quadir, Aziz and Akbar have studied the morphology of various other bugs in detail.

Lindberg (1939) and Liebenberg (1956) have done some morphological investigations on the sensory pits in certain genera of delphacid nymphs, the number and arrangement of

which provide the most valuable character for identification. Mathur and Joseph (1961) studied the external morphology of the head, thorax and abdomen of the maize leaf hopper, Peregrinus maidis Ashmead. They also made observations on the external morphology of Sogatella furcifera (Horv.) which is an important pest of rice in our country. Sexana and Joseph (1963) studied the morphology of the thorax of Araeopidae, taking S. furcifera (Horv.) (= Liburnia pallescens Dist.), Delphacodes propinqua Fieber and Purohita sevina Dist. Joseph (1965) made observations on the reproductive organs of S. furcifera (Horv.) and D. propinqua Fb. In 1969, he studied the morphology and musculature of the head capsule and mouth parts of the above mentioned insects. Vilbaste (1968) investigated the external morphology of the nymphs of Delphacidae with special reference to the sensory pits found all over the body and used this in the taxonomic segregation of different genera and species.

Head

The carination on the head and thoracic regions are of some importance in classification as the earlier workers on Homoptera have invariably made use of them in distinguishing the species. At the same time this has given rise to many complications as there is considerable variations in these characters. Giffard (1921) stated that the use of colour as a specific character has lead to synonymy on account of there sometimes being several colour forms in the same species, the

sexes of both the brachypterous and macropterous forms being different. In the present investigation, the author has come across even four colour forms of Nilaparvatha lugens (Stal), in which the male genetalia are identical. Caldwell (1950) noted that "for the most part generic concepts have been based upon chrotic characters such as shape of calcar, head and cranial topography which is often variable within the same species, is often obscure and is limited in possibilities. In smaller forms, this has resulted in considerable generic confusion".

Crawford (1914) considered that the trends of the lateral keels of pronotum, shape of the outline of the vertex and frons are all variable and cannot be taken as primary characters in separating the species. Also the venation of the forewings is so variable, even in the two wings of the same insect, that it cannot be used with constancy level. Similar observations have been made by the present author also. According to Crawford the form and relative lengths of the two antennal segments and the number of keels present on the head and thorax are very reliable characters.

Muir (1929) noted that there is a tendency in several genera (e.g. Embolophora, Dictyopharodelphax) towards the lengthening of the head. Kershew (1913) has shown that in some species like Dictyopharodelphax mirabilis S. the diverticulum from the crop enters the head capsule and continues to the tip of the greatly produced epicranium. He noted this phenomenon in Perkinsiella saccharicida Kirk. also.

Fennah (1963) while studying the Sogata furcifera complex, paid particular attention to the vertex and the frons and made measurements in settling the identities of the genera and species. A number of workers have indicated the presence of special organs (sensory pits) in almost all nymphs of Fulgoromorpha. These were investigated by Sluce (1928) and Liebenberg (1956). These pits consist of round or elliptical depressions in the cuticle, in one edge of which is inserted a hair-like structure which lies horizontally across the depression. They occur in all species of delphacid nymphs and in the adults of the genera Achrotila and Laccocera. These sensory pits are probably modified hairs transformed to sense organs as an adaptation to life among dense vegetation. Lindberg (1939) was the first to show that the number and arrangement of these pits is constant upto the second nymphal instar. This observation has been confirmed by Vilbaste (1968) and according to him it is the number and arrangement of the sensory pits that provide the most reliable characters for the identification of delphacid nymphs. He studied the morphology of the nymphs of Delphacidae and gave the important characters as follows. The nymphs have the keels like those that occur in the adults except that on the frons there are always two median keels. The two median carinae are usually situated quite near to each other, so that the interfrons (the space between them) is narrower than the lateral areas (laterofrontes). On the laterofrons there are usually three pairs of sensory pits on both sides, the upper and lower pits are situated

beside the median keels whereas the median pits lie near the lateral keels. On the forefront of the head there is one more pit at the lateral keel and already on the dorsal surface of the head two pits at the median keel. In Asiraca the number of pits is somewhat greater and their arrangement is also different.

Thorax

Saxena and Joseph (1963) studied the morphology of the thorax of Delphacidae in detail. The nature and direction of the lateral pronotal carinae are very important in the classification. According to them the metathorax is highly modified in araeopids especially the metapleuron, as a special leaping mechanism is developed in this segment which has no furca. The significance of the morphology of the calcar on the hind legs in the classification of the family was first pointed by Kirkaldy (1907) and later by Crawford (1914) and Muir (1915). Saxena and Joseph (1963) suggested that the jumping mechanism in delphacids is directly related to the modifications in the nature and structure of the hind coxa and trochanter. The function of the calcar has been a matter of speculation. Some early workers believed that it assists in some way or other to take longer leaps, but other homopterans without spur also leap equally well, if not better, and so the spur does not appear to have any direct bearing with the jumping mechanism. Saxena and Joseph (1963) suspected that these insects must be making use of their spurs for some such purposes as cleaning because of their structure and position, but the observations

in the field and experiments in captivity have failed on Sogatella furcifera (Horv.) (= Liburnia pallescens Dist.) and Delphacodes propinqua Fb. to exhibit any such action on the parts of insects under study.

Vilbaste (1968), while studying the morphology of the delphacid nymphs, gave particular attention to the sensory pits on the thorax and abdomen. The lateral keels of the pronotum usually appear only in the last instar and they do not generally reach the hind margin. Behind the lateral keels there are usually three sensory pits. In Asiraca there are only two pits, one of which lies medially and the other laterally. At some distance from this group there is one pit (behind the hind corner of the eye) and somewhat more laterally 3-4 pits. In the two younger instars the mesonotum to which the steadily enlarging wing pads are attached has two sensory pits in the middle and two in the lateral parts (on the wing pads), while in the three older instars one accessory pit exists in the forecorner. The median pits and the pits on the wing pads are separated by a somewhat oblique longitudinal keel. In the metanotum there is only one sensory pit lateral to the oblique longitudinal keel.

Wings

The wing venation of Fulgoroidea has been studied by a number of workers. Metcalf (1913) published an account of the wing venation of certain families of Fulgoroidea, using the Comstock-Needham system of nomenclature. A decade later,

Muir (1923) briefly discussed the Fulgorid wing venation and observed that the vein associated with the claval suture is the second main branch of the cubitus and not the first anal vein as hither to accepted and that the so-called X-vein is formed by the union of the first and second anal veins. He, however, raised the question whether the vein generally termed costa is not really an anterior (humeral) branch of the subcosta. Fennah (1944) categorically rejected this theory on two grounds: firstly "it is under the onus of demonstrating how the supposed humeral vein acquired in Fulgoroidea the same relationship to the humeral plate as the costal vein bears it in other orders of insects" and secondly it would necessitate the conclusion that the costal vein and in certain families even the costal cell have also been lost by specialisation. If this view is accepted, the region in front of the marginal vein is the costal cell, and consequently the reduction or disappearance of it indicates an evolutionary trend. Thus Flatidae and Ricaniidae where costal cell is present are more primitive than Cixiidae and Tettigometridae where it is absent. Muir (1923) himself disagreed with this conclusion since he has stated that the more primitive type of venation in Homoptera is found among Cixiidae.

Tillyard (1926) has termed the fulgorid second cubital vein the vena dividens on the ground that it separates off the very distinct anal area or clavus from the rest of the wing. But such a vein is not homologous with the vena dividens

in the forewing of Orthoptera nor with the true counterpart of the latter in the hind wing of certain Fulgoridae. Fennah (1944) observed that in all the specimens which he examined, Cu_2 lies posterior to the claval suture which is anteriorly bordered by a very narrow sclerotized band which is less conspicuous than the Cu_2 vein and unlike the latter is not tracheate nor ornamented with macrotrichia in those species which possess them. He also studied the wing coupling mechanisms and stridulatory organs in Fulgoroidea and gave a detailed account of the wing coupling apparatus and their mode of working among members of various families including Delphacidae.

Kirkaldy (1907) noted the occurrence of the stridulatory organs on the wings of some delphacids which are developed in both sexes. He reported stridulation in Perkinsiella vitiensis K. in which the inner margin of the anal lobe of the wing is thickened and corrugated which is rapidly scrapped across a group of setae situated on the side of the third abdominal tergite, when the wing is jerked. Fennah (1944) also noted the same thickening in some species of Delphacodes but he questioned whether effective stridulation is possible by this means.

In certain species like Sogatella furcifera (Horv.) (= Liburnia pallescens Dist.) and Delphacodes propinqua Fb., Saxena and Joseph (1963) observed sexual dimorphism in the first and third phragmata. In males the first phragma is

comparatively well developed and the third phragma much larger than the corresponding phragma in females. But in Purohita cervina Dist. the phragmata are uniformly developed in both sexes. So they suggested that in the tribe Delphacini the males are adapted for better flying than the females.

Abdomen

Mathur and Joseph (1961) while studying the abdomen of Perigrinus maidis Ashm. found that the morphology of the abdomen of the delphacids is similar to that of the other bugs. Vilbaste (1968) studied the sensory pits on the abdomen of the delphacid nymphs. In the nymphs the abdomen consists of only nine segments. The last 4-6 tergites bear sensory pits and their number and arrangement is of systematic value which will vary in different genera and species.

Genetalia

The importance of the male genetalia as a more efficient taxonomic tool in segregating species was recognized only in the second quarter of the present century. The earlier classifications of this family were mainly based on the external morphological characters like form, colouration, carination etc.

Dufur (1825) gave a very generalized description of the anatomy of the genetalia of several bugs. He described chiefly the ninth abdominal segment; his reference to "armare copulator", "verge" (aedeagus) and "crochet" (paramere) were made only on

the basis of their very superficial features. The male genetalia, particularly the claspers and certain details of the vesica have, however, been subsequently used to define species and to a certain extent to determine their mutual relationships.

Fieber (1866) appears to have been the first to use characters found in the pygofer, anal segment and genital styles for specific purposes and most workers with a few exceptions have continued their use in certain genera. Edwards (1896) was the first to dissect and figure the aedeagus of delphacids to distinguish certain allied species. Referring to genetalia in general, Kirkaldy (1907) suggests that the genetalia in the male are the final test of species and even afford generic criteria. Crawford (1914) briefly explained the morphology of the external male genetalia of delphacids. Giffard (1921) studied the systematic value of the male genetalia in Delphacidae and given a detailed account of the morphology of the genetalia and the methods of preparation of slides for microscopic studies. According to him the anal segment of the male is formed by the fusion of the tenth and eleventh abdominal segments.

Kershew and Muir (1922) classified the genetalia of Fulgoroidea into three subtypes based on the variation in aedeagus, viz., tettigometroid subtype, flatoid subtype and delphacoid subtype. In delphacoid subtype, the periandrum is greatly reduced or absent and the penis alone forms the aedeagus

and is generally tubular. The periandrum generally forms a small ring at the base of the aedeagus and is joined by a chitinous structure to the base of the anal segment. Certain genera of Delphacidae show the tettigometroid subtype also.

Muir (1923) also noted that the genetalic characters are without doubt the most valuable aids for specific work and that they also indicate the specific relationship more than any other character. According to him these characters can also be used for generic purposes and even for the separation of the families. Pruthi (1925) studied the morphology of the male genetalia in Rhynchota which is a valuable contribution to this subject, in which he has studied the genetalia of the delphacids, viz., Perkinsiella saccharicida Kirk., Chloriona glaucescens Fb., Javesella pellucida (F.) (= Delphax pellucida), Sogatella furcifera (Horv.) (= Opiconsiva colorata Dist.), Stiroma nigrolineata Scott., S. pteridis Boh., Dicranotropis hamata Fb., and Usvana kellersi M. But Muir (1925 & 1926) severely criticised the generalisation of some of the aspects mentioned by Pruthi.

Divergent views have been expressed by workers on the morphology of genetalia in delphacids. Kershew and Muir (1922) and Muir (1925) homologized the 'subgenital plates', of the male of auchenorhynchous Homoptera to the first valvulae of the hemipterous ovipositor. According to them the posterior area of the eighth sternite in male, on which they believe the subgenital appendages (gonophyses) develope, move to a position below the ninth tergum and fuse with it to form a pygofer.

Muir (1926) believed that the ninth abdominal sternite has not been reported in any homopterous male. This is no more valid as Fennah (1945) while studying the external male genetalia of Fulgoroidea has reported the presence of the ninth abdominal sternite in Perigrinus maidis Ashm. throughout the development. Further, he has denied the posterior drifting of the posterior part of the eighth sternite. Pruthi (1924) believed that the subgenital plates are homologous to the third valvulae of the female genetalia. In Perigrinus maidis Ashm. as has been reported by Fennah (1945) the buds arising at the corresponding positions of the male develop into parameres.

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 a thick, sclerotized 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 elongation and the expansion and sclerotization of the ejaculatory duct. Muir (1930) observed that in the subfamily Asiracinae the aedeagus is divided into two segments whereas it consists of only one in the subfamily Delphacinae.

Hassan (1948) studied the morphology of the external female genetalia of delphacids for the first time in connection with their systematics. However, he did not study the important structures in detail and consequently reported only

two valvulae instead of three as is found generally in insects. Joseph (1965) has done a detailed study of the female genetalia of Sogatella furcifera (Horv.) (= Liburnia pallescens Dist.) and Delphacodes propinqua Fb. and found that there are three valvulae and commented that Hassan might 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. Metcalf (1949) studied the morphology of the male genetalia in detail and showed that the connective between the aedeagus and the genital styles are composed of a basal connective and a pair of aedeagal struts which have a characteristic shape is of importance in identifying the species. According to him the anal segment is the modified tenth abdominal segment whereas the eleventh segment is transformed into the anal style.

Even though all systematists agree that specific identity rests entirely on phallic characters, not one has attempted generic revision by consultation of these characters. Work in this direction was contemplated by Dr. Beamer and his contemperories who have made a start in this direction and have illustrated that cogeneric species have similar phallic characters. After that all the modern taxonomists have recognised the genetalic characters as the most important taxonomic tool in settling the identities of the species.

C. Bionomics

Taxonomic interpretation based on the biological data of various species of insects, is a recent trend in insect classification. However, very little attempt to correlate such characters with adult morphological characters in assigning different species under various taxa has so far been made by workers on delphacid taxonomy, for evolving quite a sound system of classification. Hence an attempt is made here to present a review of the most important aspects of the bionomics of delphacids which may be found to aid the straightening of the taxonomic tangle existing at present in this family. These are dealt with under four heads, viz., (i) Habits and habitats, (ii) Biology and ecology, (iii) Role as vectors of virus diseases of plants and (iv) Natural enemies.

(i) Habits and habitats of the Delphacidae

The delphacids are found to be associated with the foliage of green vegetation. In the case of jassids Oman (1949) has made a distinction between 'host plants' and 'food plants', the former being those on which breeding takes place and the latter, those on which the adults may feed only and this interpretation may be applicable in the case of delphacids also. The host plants of individual species may be quite specific, or it may extend over a group of related plant species. Where a variety of host plants have been indicated in literature it is absolutely necessary to ascertain whether they fall really under the category of host plants or if some are really just food plants.

Among the two subfamilies of Delphacidae the members of Delphacinae are cosmopolitan in nature whereas Asiracine delphacids which are the most primitive forms are restricted in distribution. The absence of Asiracinae has been reported from Africa (Muir, 1929) and from Hawaii (Zimmerman, 1948). Here, it is interesting to note that the present author could not procure even a single asiracine specimen during his three years of intensive search from this country. Muir (1929) observed that all the members of the subfamily Asiracinae and the Alohine tribe of the subfamily Delphacinae are mainly attached to trees and bushes and none are widely distributed whereas many Tropidocephalini and Delphacini are attached to grasses and some are very widely distributed. Dantis et al. (1964) noted that the delphacids live only on grasses, mainly on graminae and cyperaceae in humid habitats. In the words of Oman "it appears likely that when sufficient accurate information is available for analysis, some interesting and useful correlations between the taxonomy of the leaf hoppers and classification of their hosts will be found". This statement may hold true in the case of delphacid leaf hoppers as well.

The delphacids are of great economic importance on account of their phytophagous habits. They cause injury to plants in any of the four different ways, viz., (i) by the direct removal of the plant food materials through feeding, (ii) by their role as vectors in the transmission of several

virus diseases, (iii) by the introduction of toxic substances along with their saliva into the plant tissues which affect the normal metabolic activities and (iv) by causing other miscellaneous injuries through their oviposition and defecation.

A number of delphacids have been recorded as important pests of crops like sugarcane, paddy, oats, wheat, barley, maize, colocassia etc. They suck the plant sap from the mesophyll tissues and cause a white stipling on the leaves. The chlorophyll is greatly reduced and the plant physiology is distinctly affected causing such results as stunting, retardation of plant growth, etc. The honey dew secreted by the insects on the leaves may in turn produce the growth of sooty mould.

In India a number of delphacids have been reported as pests of cultivated crops. In 1915, a serious outbreak of the rice leaf hopper Sogatella furcifera (Horv.) (= Sogata furcifera) in the Central Provinces was investigated by the Central Agricultural Research Institute, Pusa. Usman (1957) and Chandy (1963) recorded the occurrence of Tropidocephala marginepunctata M. as a pest of sugarcane in Mysore and Madras respectively. In 1958, there was a serious outbreak of the brown leaf hopper Nilaparvatha lugens (Stal) in the deep water paddy belt of Kuttanad in Kerala. Bajpai (1964) reported the occurrence of another rice leaf hopper Sogatella furcifera (Horv.) (= Liburnia pallescens Dist.) in an epidemic form in

Madhya Pradesh and Orissa. Rao (1965) indicated the association of Tropidocephala saccharivorella M. and T. signata D. with sugarcane in Mysore State. Chelliah and Basheer (1966) recorded the maize lantern fly Peregrinus maidis Ashm. on sorghum, maize, bajra and on other millets from Hyderabad. Atwal et al. (1967) reported an outbreak of Sogatella furcifera (Horv.) in Punjab and studied the biology and control of the pest. Grist and Lever (1969) studied the distribution of S. furcifera (Horv.) and Nilaparvatha lugens (Stal) and found that they are serious pests of rice in India. In addition to these, the collection data of the specimens in the N.P.C. reveal that a number of delphacid leaf hoppers have been collected from other crops like orange, gauva, cotton, tobacco, moong, soyabean, potato, mentha, etc.

(ii) Biology and ecology of Delphacidae

Our knowledge regarding the biology and ecology of delphacids is very meagre. A perusal of literature reveals that out of more than 2,000 species of delphacids recorded so far, only a few species have been studied in detail, and that too, due to their importance as vectors of virus diseases of plants. But very little of comparative studies are available on the biological and ecological data of the insects which may give any clue with regard to taxonomic interpretations.

The biology of a number of delphacids have been studied by different workers. These include studies on

Perkinsiella saccharicida Kirk., P. vastatrix Bred., Sogatella furcifera (Horv.), S. oryzicola Muir, Laodelphax striatella (Fall.), Javesella pellucida (Fall.), Nilaparvatha lugens (Stal), N. oryzae Mats., Perigrinus maidis Ashm., Saccharosydne saccharivora West., Dicranotropis hamata Boh., D. muri K., Tropidocephala saccharivorella Mats., Megamelus proserpina Kirk., etc.

Hassan (1939) has given a generalised account of the life history of delphacids in England. They are abundant on grasses, rushes and low herbaceous plants. The leaf hoppers lay their eggs in groups of 3 to 24 in slits made by the ovipositor within the stem of the food plants. Eggs are usually hyaline, whitish, oval in shape, regularly overlap each other and are covered with a substance secreted by the female. In those females which do not hibernate as adults, egg laying happens 28 to 45 days after the females attain the adult stage whereas in other cases the egg laying takes place usually late in the spring. They have one or more generations in a year. There are five moults and the instars vary in duration, the last being usually the longest. In the nymphs of the macropterous forms, the vestiges of the wings are visible to the naked eye in the second instar while in the brachypterous forms they only appear at the fourth instar stage. Nymphs are found usually near the ground and adults higher up the grasses. The insects may pass the winter as eggs, nymphs or as adults.

Delong (1965) gave a detailed account of the ecological aspects of the North American leaf hoppers including delphacids and their role in agriculture. Water and humidity relationship throughout the life of a leaf hopper seems to be very important and under adverse conditions very critical. The eggs are deposited in tender plant stems or in the under surface of the leaf ribs or veins. So the incubation period is passed in a saturated humidity within the tissue. After hatching the nymphs and the adults remain on and feed from the undersurface of the leaf. The majority of stomata are found on the undersurface of the leaf and since all or the major part of the transpiration occurs through these stomata, the leaf hoppers on the undersurface of the leaves live continuously in a highly humidified atmosphere. Experimental work with various species of leaf hoppers would indicate that high humidity is necessary for the existence of many species.

The factors responsible for the quick depletion of the leaf hopper population are the lowering of the relative humidity on the undersurface of the leaves and the reduction of the available liquids in the leaf which are needed constantly by the leaf hoppers for survival. When the leaf becomes limp by excess transpiration plant liquids too are depleted to supply the essential plant sap for the insect.

Studies on the ecology of a number of delphacids have been undertaken by various workers.

Caresche (1933) noted that nymphs and adults of the brown leaf hopper Nilaparvatha lugens (Stal) usually remain in

the lower parts of the plants near the water level feeding on the sap and secreting honey dew and they seldom leave a plant until it is completely exhausted. Kismoto (1956) studied the effect of crowding during the larval period on the determination of wing form of the adult of N. lugens (Stal). He found that low density with optimum conditions of food supply during the larval development is necessary for the appearance of the brachypterous females whereas optimal density under favourable conditions of food supply produces brachypterous males. Wilting of the host plants, overcrowding and contamination due to crowding have the effect of producing the macropterous forms and this effect is followed by lengthening of the developmental period of the larvae subjected to these conditions. Hinckley (1963) observed that the factors influencing the outbreak of the brown leaf hoppers include the amount of rainfall, type of cultivation, the age of the rice crop, the species composition of the plant hopper populations and the relative abundance of the parasites. Populations of delphacid are apt to reach the damaging levels on transplanted rice growing in pools of standing water after a dry period. Mochida (1964) stated that there is no difference in the number of egg per group between macropterous and brachypterous females or between groups laid on seedlings at different temperatures, though temperature affected the total fecundity of N. lugens (Stal). Kismoto (1965) studied the polymorphism and its role in the population growth of the brown leaf hopper and found that the preoviposition

period was shorter for brachypterous than the macropterous females. Studies indicated that the macropterous forms are better adapted to unfavourable conditions whereas the brachypterous forms are adapted to rapid multiplication under favourable conditions. Watanabe (1967) obtained the same findings of Kismoto, regarding the effect of density of the brown leaf hopper on the development of brachypterous females and males.

Miller and Pagden (1930) studied the ecology of Sogatella furcifera (Horv.) (= Sogata furcifera) and found that the later nymphal instars inclined to feed higher up on the rice plants in the early morning and to descend as the sun becomes powerful. They also noticed that under Indian conditions continuous rains are favourable to the development of the delphacid, but in Malaya heavy rains during an outbreak caused its disappearance. The degree of humidity seems to be the determining factor with regard to the duration of an outbreak. Lever (1939) observed that the yellowing of the leaves due to the infestation of Sogatella furcifera (Horv.) was invariably worst in areas where the rice was permanently flooded or had experienced heavy or persistent rain. Hinckley (1963) noticed that the species composition of the leaf hopper population is more related to the age of the crop than to any seasonal change in temperature. The process of transplanting rice generally has an adverse effect on the leaf hopper population. So the infestation will be more, if the rice

seedlings are transplanted with a minimum of wilting or if sowing is done by broadcasting. He also observed that the heavy infestation of S. furcifera (Horv.) will occur after a period of slight rainfall and the termination of outbreaks is usually coincided with renewed rainfall. This may be caused by the mechanical dispersal of the nymphs and brachypterous adults disturbed by the downpour.

Muller (1959) investigated the effect of day length on the development of brachypterous form and found that in Laodelphax striatella (F.) (= Delphacodes striatella) as the result of diapause induced by short days the number of brachypterous forms increase in the spring generation as compared to the summer ones. Naito (1965) observed that during feeding an adult plant hopper probes the rice plant with its probosis 50 to 150 times in 24 hours. The frequency of probing varies with temperature and the physiological state of the insect and it is greatest during the early stages of the ovarial development. Watanabe (1967) studied the effect of density of population of L. striatella on the appearance of two wing forms and found that the appearance of brachypterous females was induced under rearing conditions of low insect density. But the brachypterous males appeared very infrequently.

Hassan (1939) studied the ecology of Javesella pellucida (F.) (= Delphacodes pellucida F.) and found that the temperature and relative humidity prevailing during the

process of moulting is of great importance. The higher the temperature, the quicker the growth and shorter the stadium. Also if the old skin becomes too dry the insect cannot detach itself from it and if there is too much moisture the emerging insects cannot harden properly and is liable to the attack of moulds. Raatikainen and Tinnila (1969) found that oviposition of the delphacid will be more in oats when the stem is exposed and thin stalks are preferred to thicker ones. Nourteva (1962) showed that host plant selection of J. pellucida (F.) is not regulated by odours emanating from the plants whereas taste seemed to be of importance.

William (1967) found that the populations of sugarcane delphacids Perkinsiella saccharicida Kirk. and Dicranotropis muri K. are more in fields of young cane where the foliage had grown enough to provide adequate shelter but before the development of any appreciable length of stem whereas the population is less in varieties of cane with an erect habit of growth and comparatively straight leaves.

Metcalf (1965) found that when nitrogen content of the sugarcane leaves increased from 1.5 to 2.5 per cent of dry weight the number of eggs of Saccharosydne saccharivora W. laid per day was more than doubled. The population is high on young canes and least so on mature ones, but a sharp population decline occur on canes 6 to 12 months old. It has been observed that adult leaf hopper may migrate over a mile in search of young canes for oviposition.

(iii) Role of delphacids as vectors of virus diseases of plants

The importance of delphacids as vectors of virus diseases of plants was known in the earlier part of the present century. The vector-virus relationship of the maize lanternfly, Peregrinus maidis Ashm. and the maize mosaic virus was first established in 1923. Later on, a number of delphacids have been recorded as vectors of important virus diseases of major crops, viz., sugarcane, rice, oats, wheat, barley and maize. Carter (1966) gave a list of the important virus diseases of plants transmitted by the leaf hoppers which include maize mosaic, Fiji disease of sugarcane, stripe disease of rice, oats pseudorosette, oats sterile dwarfing, European wheat striate mosaic, rice white leaf, etc.

The vector-virus relationship of Perkinsiella saccharicida Kirk. and the virus of Fiji disease of sugarcane was first established by Kunkel (1934) in Fiji. Ocfemia (1934) recorded P. vastatrix Bred. as a vector of the disease in Philippines. Pemberton (1936) reported that the Fiji disease is also transmitted by P. vitiensis Kirk. Ocfemia et al. (1939) found that successful transmission of the disease is more with the fifth instar nymphs than the earlier nymphs and the first instar nymphs failed to transmit the virus. Breddin and Antoine (1963) reviewed the history of the Fiji disease of sugarcane and its delphacid vector P. saccharicida Kirk. in Madagascar.

The importance of the delphacid Sogatella cubana (Crawf.) in transmitting the hoja blanca or white leaf disease of rice was first reported by Lasaga (1957). Acuna (1958) established the vector-virus relationship of S. oryzicola (Muir) and the hoja blanca disease. Young et al. (1960) noted that the disease is also transmitted in wild grasses like Echinochola colonum and Digiteria sp. by S. cubana (Crawf.). Galuez et al. (1961) studied the interrelations of the two delphacids S. oryzicola and S. cubana and found that both the species of the leaf hopper can pass the virus from rice to the weed E. colonum but S. cubana is apparently the principal vector responsible for transmission to other grasses. Lamey et al. (1964) studied the host range of the virus and its vector S. oryzicola (Muir). Acunagale et al. (1966) investigated the nature and the mode of transmission of the disease and found that for transmitting the virus the infective delphacids will have to feed on the healthy plants for a period of two days and the symptoms will be more if the plants are infected at the earlier stage whereas if it is at a later stage there will be only stunting and reduced tillering of the plants.

Kuribayashi (1931) recorded Calligypona marginata F. as the vector of the stripe disease of rice in Japan. Atkins and McGuire (1958) noted another vector Laodelphax striatella (F.) and established its vector-virus relationship. Transmission studies of the rice stripe virus made by

Shinkai (1962) revealed that the virus is passed through the eggs laid by the viruliferous females of L. striatella F. and the rate did not decline even after 40 generations extending over six years. He also listed 22 species of graminaceous plants as hosts of the virus.

The transmission of the maize mosaic virus by its vector Peregrinus maidis Ashm. was first reported by Kunkel (1923). App (1942) recorded the disease as the yellow stripe of maize transmitted by the same delphacid. Herold and Hunz (1965) demonstrated the presence of virus like particles within the salivary glands and epithelial cells of the intestinal wall of P. maidis Ashm.

Harpez et al. (1965) made a comparative investigation on Javesella pellucida (F.) and Laodelphax striatella (F.) as vectors of maize rough dwarf disease. They found that even though J. pellucida (F.) is able to transmit the virus the transmission potential is less than L. striatella (F.). Gerola et al. (1966) detected virus like particles within the fat body of the abdomen of both the sexes of the delphacids.

Slykhuis et al. (1958) established the vector-virus relationship of the delphacid Calligypona pellucida F. and the European wheat striate mosaic virus in England. He also recorded a number of alternate hosts of the virus, viz., oats, barley, rye, perennial rye grass (Lolium perenne) and Italian rye grass (L. multiflorum). Sinha (1960) observed that the ability of C. pellucida F. to transmit the virus to its progeny and to wheat depends on the age at which the insect

acquires virus from diseased plants and is greater with the nymphs than the adults. The virus must pass through the gut wall of the insect to become infective and the permeability of the gut wall to the virus presumably decreases with increasing age of the insect. Ikaheimo and Raatikainen (1961) found that another delphacid C. obscurella Boh. is able to transmit the virus from wheat to wheat.

Heikinheimo (1957) reported that C. pellucida F. is also a vector of oat sterile dwarf disease. Diabola (1958) stated that the disease in oats is due to the toxic effect of the saliva injected by the insect or a virus transmitted by it. He also found that the inhibition of the growth of the plants is more due to the infestation by the females than by the males probably as a result of oviposition. Nourteva (1958) reported that the disease is not due to a virus but due to the phytotoxicity of the saliva probably caused by the nature of the food available. Ikheimo and Raatikainen (1961) recorded another delphacid C. obscurella Boh. which is able to transmit the virus from oats to oats. Lindsten (1961) noted Dicranotropis hamata Boh. as the vector of the dwarf tillering disease in Sweden. Nourteva (1962) revealed the existence of two viruses that are transmitted by C. pellucida F. and are highly pathogenic to oats. It has been found that the salivary phytotoxins are responsible for the disease symptoms in oats especially in conditions suboptimal to the plant growth and inhibition of tillering and differ clearly from those

caused by the viruses. Only the females of the leaf hopper inject phytotoxins into the plant whereas both sexes act as virus vectors.

Bruizgalova (1940) studied the vector-virus relationship of Laodelphax striatella (F.) and the oat mosaic virus. The virus is transmitted by the nymphs and the adults through its eggs. Sukhov (1943) obtained crystalline inclusions from the intestine of the infected delphacid.

Shinkai (1954) recorded L. striatella (F.) as the vector of black streak stunt of cereal crops. In 1962, he listed out 25 graminaceous plants including rice, barley, wheat and maize as the hosts of the virus. He also noted that this virus is not transmitted through the eggs of its vector. Ishii (1966) studied the distribution and wing form of another delphacid Delphacodes albifascia Mats. and its role in the transmission of northern cereal mosaic in Japan. Ou and Ling (1966) recorded the grassy stunt of rice in Philippines which is transmitted by the brown leaf hopper Nilaparvatha lugens (Stal).

(iv) Natural enemies

The importance of natural enemies in controlling the delphacids was first reported by Perkins (1918). The major role in this direction is played by the parasitic and predaceous insects, parasitic fungi, mites and nematodes and predaceous spiders. The parasitic and predaceous insects include the members of the orders Hymenoptera, Diptera,

Strepsiptera, Hemiptera and Neuroptera. Delphacid eggs are usually attacked by species of Mymaridae, Trichogrammatidae, Pteromalidae and Eulophidae. The control of the nymphal and adult stages are brought about by the members of Dryinidae, Pipunculidae and Strepsiptera. Among predators syrphids, mirids, reduviids, chrysopids and formicids attack different stages of the leaf hoppers. In addition to these various species of mites, nematodes and fungi have also been reported parasitizing the different stages of the insects.

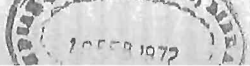
Zimmerman (1948) gave a detailed account of the effect of parasitisation on the host insect. Due to the attack of the parasites variable amount of castration takes place in the insects which may be slight in some cases but in others the entire assemblage of the genital processes of the pygofer are obliterated with only a simple concavity remaining in the pygofer. Apparently this differential castration is the result of differences in time of attack by the parasite or at least differences in time when the gonads have been attacked or the amount of damage done to them before the ultimate nymphal moult. He further stated that "it would not be surprising to learn that some partially castrated specimens form the type of 'new species' but the author of such species could hardly be blamed for considering them as distinct species if the series supplied to him for study was inadequate". The same phenomenon was also commented upon by Muir (1916). The present author was also able to see such distorted genetalic structures due to the attack of parasites.

Urbino (1927) recorded an egg parasite, egg predator and an entomogenous fungus infesting the nymphs and adults of Perkinsiella vastatrix B. in Philippines. Winson (1938) observed an encyrtid Ectopiognatha sp. parasitising P. saccharicida K. Hassan (1939) listed out the natural enemies complex of a number of delphacids in England. They include the parasitic insects, a mymarid (on eggs), a dryinid (on nymphs), and a stylopid (on nymphs and adults), parasitic mites and parasitic fungi infesting the nymphs and adults and predaceous spiders. He gave a detailed description of the biology and ecology of the strepsipteran parasites and also the effects of parasitisation on the hosts which include the reduction in powers of multiplication and alteration of general features and the external sexual characters of the hosts.

Fullaway (1940) reported that the outbreak of Nesamelus proserpina K. on colocassia in Hawaii was kept under control by introducing parasites like Paranagrus perforator G., Oötetrastichus nesameli and Gonatopus sp. and a predaceous capsid Cyrtorhinus fulvus K. Sukhov (1941) recorded a dryinid Pristogonatopus conjunctus K. parasitic on the nymphs of Laodelphax striatella (F.). Esaki and Mochizuki (1941) reported another dryinid Haplogonatopus atratus E. parasitising the same leaf hopper. Zimmerman (1948) recorded pipunculid flies, the dryinid wasps Echthrodelphax fairchildii P. and Pseudogonatopus perkinsi Ashm. and the strepsipteran Elenchus melanias P. and its variety silvestris P. attacking various leaf hoppers in Hawaii.

O'connor (1952) observed a mirid Cyrtorhinus vitiensis U. predaceous on the eggs, a trichogrammatid Oligosita sp. and a mymarid Anagrus sp. parasitic on eggs, a dryinid Haplogonatopus sp. and a strepsipteran Elenchus sp. parasitic on the nymphs and the adults of Sogatella furcifera (Horv.). Frappa (1954) mentioned an egg parasite Tetrastichus sp. on Perkinsiella saccharicida Kirk. William (1957) recorded a number of parasites and predators on P. saccharicida Kirk., Dicranotropis muri K. and Periarimus maidis Ashm. They include a eulophid Cotetrastichus nallidipes P., a mymarid Paranagrus optabilis P. and Anagrus flaveolus W. all egg parasites, a dryinid Pseudogonatopoides mauritianus W. parasitic on nymphs, a strepsipteran Elenchus templetoni W. and a pipunculid, Perilas mauritianus H., parasitic on the adults. Sigwalt (1962) estimated that eight per cent of eggs of P. saccharicida Kirk. and D. muri K. are destroyed by Anagrus optabilis P. and Cotetrastichus formosanus T. and two per cent of the nymphs and adults are parasitised by Elenchus sp.

Pu (1963) reported some nematode parasites on Laodelphax striatella (F.). Raatikainen and Vasarainen (1964) recorded a predaceous pteromalid Panstenon oxylus W. on eggs, a parasitic mite Achorolophus gracilipes K. on nymphs and a linyphid spider, Meioneta rurestris C., predaceous on nymphs of Dicranotropis hamata Boh. Marin (1964) observed an egg parasite Anagrus flaveolus W., the ant Dorn Lineare E. and



some red mites predaceous on nymphs and adults of Perigrimus maidis Ashm.

Metcalf (1965) reported that good control of Saccharosydne saccharivora W. in sugarcane is obtained in Jamaica by the egg parasite Tetrastichus sp. and Stenocranophilus quadratus P., Pseudogonatopus sp. and Chalcogonatopus sp. which are parasitic on nymphs and adults. He also recorded the predators Zelus longipes L. (Reduviidae) and Chrysopa sp. (Chrysopidae) feeding on all stages, syrphids (on nymphs), a mirid Tytthus parviceps R. (on eggs) and also the entomophagus fungi Metarhizium anisopliae, Fusarium sp. and Hirsutella sp. on the nymphs and the adults of the delphacid.

Raatikainen (1966) studied the effect of different sexes of the parasite Elenchus tenuicornis K. on the morphology of the adult of Javesella pellucida (F.). The male parasite has a greater influence on the morphological characters of a female delphacid than the male while the female parasite affects the morphology of a male host more markedly than does the male. So the sex of a parasitized leaf hopper can be determined quite accurately by detecting the presence of the parasites.

McQuillan (1968) observed that the integrated control of Nilaparvata lugens (Stal) in rice using the proprietory oil preparation containing 60 per cent mecarbam does not affect the mirid predators of the delphacid Tytthus chinensis Stal and Cyrtorhynus lividipennis Reut.

Male sterilization technique

In addition to the foregoing account of a review of our knowledge on the bionomics, a short resume of the recent approach with radio tracer technique for the control of these bugs may not be quite out of place. Shipp et al. (1966) investigated the possibility of eradicating sugarcane leaf hoppers of the genus Perkinsiella by the male sterile technique. They found that the fifth instar nymphs are the most suitable stage to irradiate. With P. saccharicida Kirk. they obtained sterility at 3500 rads (for females) and 10,000 rads (for males) of gamma rays from a cobalt 60 source. At these dose levels adult longevity and mating behaviour are not significantly affected. The higher doses render the sperm inactive, shorten adult longevity and adversely affect wing development. In preliminary release trials using normal fifth instars they were able to reduce progeny production according to the ratio of sterile to fertile insects. The results so far indicate that there is a larger safety margin within which sterility can be produced without significantly affecting sperm motility, mating behaviour or adult longevity.

P A R T II

STUDIES ON INDIAN DELPHACIDAE

I. Materials and Methods

A. Sources of the material studied

The Delphacidae in the National Pusa Collection (NPC) was found very poorly represented. Out of 30 Indian species so far recorded only 12 species were found in the NPC duly identified. A few specimens were also sorted out from the unidentified mixed specimens accumulated during the last 50 to 60 years. Therefore the author had to procure almost all the material studied during the course of this work.

A good deal of material studied by the author was collected by himself mainly through sorting out from huge mixed insect material usually collected inside lamp domes. Several species were found in such collections within the Division of Entomology, Indian Agricultural Research Institute, itself. Besides these the author has also secured a number of specimens by sweeping on grasses and different plants. Specialized traps were designed by several workers like Wheeler (1937) and Kismoto (1968) for collecting the leaf hoppers, which were not found necessary in the present investigation since the ordinary lamp domes used in the public places and private houses particularly on the verandhas and streets were found as efficient as specialized traps.

In addition to the collections made by the author the materials placed at his disposal by his guide, from whom he

received a number of interesting specimens formed additional source for these studies. Also light trap collections were obtained from different places, viz., Trivandrum, Tiruvalla, Pathanamthitta and Trichur (Kerala); Coimbatore (Tamil Nadu); Coorg (Mysore); Kalimpong (West Bengal); Gauhati and Shillong (Assam). The specimens in the NPC were mostly collected from Pusa and Ranchi (Bihar), Chapra and Darjeeling (West Bengal), Sholapur and Basin Fort (Maharashtra), Port Blair (Andamans), Mt. Abu (Rajasthan), Raipur and Gwaliar (Madhya Pradesh), Simla (Himachal Pradesh), Delhi and Afghanistan.

B. Methods of study

1) Collection, killing, mounting and preservation

a) Collection: Lamp dome collections were made periodically by the author in order to find the time of abundance of the different species and the possible host plants. In this connection it is interesting to note that the members of the genus Tropidocephala and all the brachypterous forms were not attracted to light domes and they were collected only by sweeping on the grasses and crop plants. The population of these species were found to be more in the winter season.

Sweeping was done with a fine-mesh hand-net and an aspirator was used for sucking the insects from the net. It was noted that earlier in the mornings before the sun had quite warmed up, it was rather easier to suck larger numbers into the aspirator.

b) Killing: After making collections in the aspirator it was brought into the laboratory, held with the bottom of the aspirator towards the light through the glass window, its cork with the tubes gently removed and a closed cork fitted. By keeping the bottom towards the light it was noted that all the insects would go to the lighted end and the cork changed without permitting any insect to escape. Then a strip of paper dipped in benzene was introduced into the aspirator and the paper held in position by trapping its outer end between the cork and the tube. The tube was kept vertically for a few minutes and all the dead insects collected at the bottom of the tube without being wetted with benzene. Care was taken to use only just enough benzene on the paper strip in order to avoid direct contact of the benzene with the insects and consequent decolourisation.

The specimens can also be killed by putting them in special killing tubes prepared by keeping a wad of cotton wool soaked in benzene from which the excess fluid squeezed out, and tucked down to the bottom of the specimen tube and padded with discs of white blotting paper.

c) Mounting: Tag mounts of specimens were made for studies on the general form, colouration, etc. Triangular paper tags were cut out from the cards by means of a clipper and pinned with ordinary pins. At the conical point of the tag was gummed a single specimen with insect gum prepared by diluting 'Quickfix', with amyl acetate. The specimen was stuck to the

paper point with the right mesopleura so that the head was turned to left and the tip of the abdomen to the right. This orientation of specimens was found very useful for the examination of all desired parts in situ and also to remove the wings of left side and abdomen for further studies if desired with great ease. Each tagged specimen was labelled with the collection data.

d) Preservation: Mounted specimens of the delphacids were preserved in insect store boxes fumigated with naphthalene vapours. In addition many specimens were also preserved in different homeopathic vials, serially numbering each vial. Collection data were also noted under each serially numbered species. Dry preservation in these vials was found to be more useful than wet preservation. In order to keep any fungal attack off, small pellets of para dichlorobenzene were put into the vials periodically. Introducing paper strips soaked in formalin was also found to be effective.

ii) Preparation of parts for detailed studies

For the detailed studies, slide mounts of all the parts had necessarily to be prepared. Giffard (1921) employed the traditional technique of processing for the preparation of microscopic slides of the genetalia of delphacids. But it was observed that this ordinary procedure adopted in the preparation of microscopic slides was quite unsatisfactory and time consuming. This was particularly so with regard to

studies on wing venation since balsam or gum arabic mounting media made the venation absolutely indiscernible on prepared slides. Therefore special techniques were adopted.

Dry mounts of wings were found the most desirable for venational studies as well as for markings. For this purpose the wings were gently removed from specimens by means of fine microneedles made out of No.20 entomological pins as described by Menon (1965). The wings were first dropped in 90 per cent alcohol or glacial acetic acid and from there transferred to a droplet of acetic acid placed on a slide. It has been found that the unfolding of jugal lobe could be made much easier if the wings are floated in acetic acid on the slide. Once the stretching has been accomplished the wings would float well stretched and the acid could be sucked out by means of a blotting paper and the wings arranged and allowed to dry on the slide. Minute droplets of the insect gum were put on the four corners of a cover slip which was gently placed over the dried wings and gently pressed. Care was taken to arrange the wings at one end of the slide so that the other parts of the same insect could also be mounted on the same slide.

For the study of genetalia and other parts, special techniques had to be employed. Where dry preserved specimens were used they were first relaxed in a relaxing box. Then the insect, after removing the wings, was dropped into a test tube with a small quantity of 10 per cent KOH solution and gently boiled over a mild flame for about a minute or two.

The time required for this treatment was adjusted in accordance with the amount of sclerotization of the parts. Fresh specimens took less time than dry preserved ones. When only the genetalia was to be studied, the whole abdomen of the tagged specimen or its tip was gently detached by means of the above mentioned. microneedles and treated likewise. On cooling, the boiled material was transferred to a cavity block containing glacial acetic acid. After some time the material was again transferred to another cavity block containing glacial acetic acid with a trace of acid fuchsin. By this method it was found that the alkali could be neutralized, form gained if shrivelled, staining quickened and part of the clearing accomplished. All these could be completed in about ten to fifteen minutes. When well stained the specimen was transferred to another cavity block containing carbol-xylol (carbolic acid and xylol mixed in the ratio of 1:3) complete clearing was found to be accomplished in this within five to ten minutes. Different parts, viz., head, thorax, abdomen and legs were separated by means of the micro-needles in the cavity block itself. Further dissections were made, if desired, in a drop of canada balsam put on the slide. All these dissections were accomplished under a stereoscopic binocular microscope.

For dissecting out the genetalia, the cleared and stained abdomen was transferred into a drop of canada balsam on the slide. The genital capsule was gently separated from the rest of the abdomen by means of the microneedles. For the

dissection of the internal genetalia the pygofer was pressed to the slide by inserting the tip of the needle held in the left hand through the cephalic opening whilst inserting the other through the anterior opening and pushing outward the internal genetalia complex together with the anal tube complex, leaving the pygofer intact. Utmost care was taken to avoid crushing or smothering of the parts during manipulation and handling. Then the pygofer was arranged in the centre of the canada balsam in such a manner so as to get a clear view of postero-ventral plane. All the other parts were also arranged in the canada balsam. In order to prevent the pressing of the pygofer small pieces of cover slip were placed in three or four corners of the canada balsam one above the other so as to have the same thickness of the pygofer. Then a cover slip was gently placed over the pygofer. The slides were labelled together with collection data and kept in the slide tray for drying. By this method the whole procedure of mounting was found to take even less than an hour.

The slides were carefully studied for all details by means of a high magnification compound microscope and by the vertical projector. Drawings were made by the author with the help of the mirror camera lucida. Orientation of specimens for drawing was made in such a way that clearly depicted the distinctive features of the species. For purpose of comparison, various structures are drawn under the same view. Along with

the genetalic parts other structures as head, pronotum, mesonotum, frons, antenna, hindleg etc. have also been drawn.

Abbreviations used in illustrations:

a = head, dorsal view; b = head, lateral view; c = frons; d = antenna; e = hind leg; f = pygofer; g = genital style; h = aedeagus; i = anal segment; j = penis guide.

Magnifications

There is no uniformity regarding magnifications and different magnifications are used for different parts of the same species. Therefore, scales of magnification is given separately. The line on the left shows the scale of the figures on the right side of the line. All lines drawn are 0.2 mm.

Measurements are in mm. upto two decimal points and are as follows:

Length	:	Total length from apex of head to the tip of the abdomen.
Head	:	Breadth from outer margin of one eye to outer margin of the other eye, at the point where it is maximum.
Pronotum	:	Maximum breadth.
Tegmen	:	Maximum length.
Antenna	:	Lengths of first segment + second segment.
Hind tarsus	:	Lengths of basitarsus + second and third segments.
Calcar	:	Length.

II. External morphology of delphacids

Delphacids in general can be readily recognised from all the other members of the superfamily Fulgoroidea and other homopterans by the large mobile spur (calcar) borne on the inner side of the apex of the hind tibia. Muir (1929) states that without the tibial spur most, if not all, of the genera would be placed in the family Cixiidae. The main classification of this family is based on the shape and structure of the calcar which may be spine-like or subulate, solid and cultrate with both surfaces convex or inner surface concave or laminate or tectiform. In many cases the inner margin of the calcar possess a row of minute teeth.

Generally the delphacids are small, rather narrow and somewhat delicate leaf hoppers, never measuring over a centimeter in length to the tip of the forewings and many small forms measure even less than 2 mm. The majority of them are uniformly coloured but many are brown to black or shaded with patches of yellow, green, orange or black. A generalized account of the external morphology and the variation met with in the different parts of the insects are given below.

Head

The head is usually small and relatively simple but in a few genera it is elaborately developed, being sometimes as long as the rest of the body. Generally head is opistognathous. When the insect is oriented in such a way that the dorsal surfaces of the head and pronotum lie in the

same horizontal plane, the visible part of the head is the crown or vertex. The vertex is seen to project medially to a greater or lesser extent beyond the anterior margin of the eyes, the extent of projection being determined by the anterior declivity of the head. The vertex may be broadly and smoothly rounded at apex and flush with the anterior margin of eyes or projected in front of the eyes; the apex itself being acute or obtusely rounded. The carination on vertex may be distinct or obscure. The submedian carinae of vertex join together on the vertex or continued separately on to frons where they meet, posteriorly they are connected by a Y-shaped carina in between the eyes, the stalk of which usually devides the basal compartment into two cells. The frons is rectangular, generally tricarinate, one median and two lateral, the median carina may be simple or bifurcated, thin or ridged. The lateral carinae of frons run anteriorly apposing the inner side of the compound eye and continue to the vertex. Clypeus is triangular, convex dorsally, usually tricarinate. The clypeus may be divided into an anterior small anteclypeus and a large posterior postclypeus, the separation being marked off by two lateral constrictions. The carination on the vertex, frons and clypeus are very important taxonomic characters for classification.

The compound eyes are well developed, reniform and occupy a considerable area of the dorsolateral regions of the head capsule. 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. There may be another pair of minute ocellus-like structure 'blemma' (Fennah, 1963) situated immediately above the ocellus and almost contiguous with it.

The antennae are usually simple, with a short basal segment and a short or sometimes elongate, terete second segment with a terminal flagellum, usually covered with sensoria. The antennal segments together are usually not much longer than the head and thorax combined. Occasionally either the first or the second or both segments are greatly enlarged and may be considerably flattened (Purohita, Perkinsiella).

Generally the mouth parts extend beyond the forecoxae. Labrum is lobe-like, tapers distally, strongly convex dorsally, concave ventrally with a medio-longitudinal groove, extending upto the middle of the 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 mandibular stylets are a pair of long, slender, sclerotized needle like structures, thickened basally and narrowed gradually to a blunt apex. Inner side of the stylets are concave and match against the convex sides of the maxillary stylets. The maxillary stylets are thinner and longer than the mandibular stylets, which are basally swoolen and distally narrowed to a bristle. 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, forming two canals popularly known as food canal or suction canal and salivary canal or ejection canal. Labium is four segmented and the segments are of equal length, provided with a groove ventrally for enclosing the bristles. Hypopharynx is a sclerotized pad-like structure with a cylindrical central mass tapering anteriorly. The salivary syringe is fused ventrally with the central mass at its posterior side.

Thorax

In delphacids the thorax is usually short with the pronotum and mesonotum conspicuous whereas the metanotum is covered by the basal area of the tegmina. The cervix or neck is concealed beneath the overlapping anterior region of the pronotum dorsally as well as ventrally.

Prothorax: This is an independent segment in which the tergum, pleuron and sternum are fused together. Pronotum is collar shaped devoid of any sutures unlike that of the pterothoracic nota. It has three longitudinal carinae or keels, one median and the others lateral running from the anterior to the posterior margin. These may be thick or thin, lateral carinae may be straight or divergingly curved latero-caudad which may or may not reach the hind border.

Mesothorax: This constitutes the largest part of the thorax. The mesonotum is large, arched and a somewhat triangular plate. It has three to five longitudinal carinae, one in the middle and the remaining at the lateral sides and gradually narrowing from the proximal to the distal region. The carinae may or may not reach the hind margin. The mesonotum can be primarily divided into an anterior large wing bearing alinotum and a posterior narrow postnotum. Towards the anterior end, the alinotum has a prescutal or transverse notal suture dividing the alinotum into an anterior narrow prescutum and a posterior large scutellum. The lateral areas of the scutellum are folded beneath the middle raised region and are V-shaped.

Metathorax: This is highly modified in delphacids, especially the metapleuron, as a special leaping mechanism is developed in the segment. The metanotum is V-shaped anteriorly and is divisible into a large wing bearing alinotum and a posterior narrow postnotum situated between the corners of the posteriorly projecting areas of the notum.

Legs

Generally the fore and middle legs are similar in structure and equal in length but the length of the individual regions are dissimilar. The hindleg is large and its various components have undergone modifications partly to fit in the role of a leaping mechanism.

In fore and middle legs coxa is elongated with a medially narrow region, the distal region is stouter than the proximal part. The trochanter is the smallest segment and is highly sclerotized. The femur is equal in length or slightly shorter than the tibia which has four or five longitudinal rows of spines of varying sizes. The tibia is generally the longest segment having four or five longitudinal rows of spines as in femur. In the genus Phyllodinus anterior and intermediate femora and tibiae are compressed or foliaceous which is an important character in segregating that group of insects. The tarsus is considerably shorter than the tibia and is subdivided into three tarsomeres. Of these, the basal two are equal in length while the distal one is longer and approximately equal to the combined length of the basal two. The pretarsus arises from the end of the tarsus. It consists of a pair of lateral claws which are hollow, curved, distally tapering structures and a median lobe, the arolium which is a small sclerotized sac. The claws are hinged to a dorso-median process at the distal end of the last tarsomere, the ungifer. Beneath the bases of claws there are small plates which are called auxiliae. On the ventral surface of the arolium the pretarsus bears a median basal plate, the ungitractor which is partly invaginated into the distal end of the last tarsomere.

The hind legs (Plate IV, Fig. 1, C & D) are remarkable for their large size in comparison to the two anterior pair of legs. The coxa is highly modified which is short, broader than

long. Posteriorly it is articulated with the trochanter by means of two small projecting areas. This type of hinge permits a wider area of movement to the trochanter than the type of articulation found in the forelegs. The coxa is strengthened by a complicated system of ridges which prevent it from collapsing. The femur is shorter than tibia and forms a distinct head proximally. Tibia is long, slender and distally broad. It has a large basal, a middle and five distal spines. The distal spines gradually decrease in size from one end to the other and occur in clusters of four and one. Posterior to these spines the tibia bears a characteristic spur (calcar) with or without teeth in the inner margin whose shape and structure are of utmost importance in the primary classification of this family. The first tarsomere bears at the hind margin two clusters of large spines, one with five spines gradually decreasing in size from one end to the other and the other with two spines. The number of the clusters and the spines may vary in certain genera. The second tarsomere bears at the hind margin one cluster of three spines of unequal size and another independent spine. There is difference in the comparative length of the tarsomeres with that of the foreleg, the basal one being the longer than the other two. The relative length of basitarsus to other two segments together is an important character in segregating some of the genera like Euidella, Dicranotropis, etc. The last tarsomere ends with the pretarsus. The structure of the pretarsus and

the number of rows of spines is more or less similar to that of the fore and middle legs.

Wings (Plate IV, Fig. 1, A & B)

In Delphacidae wings show polymorphism and are found in three different forms, viz., macropterous, koeliopterous and brachypterous. In macropterous forms the tegmina are fully developed usually surpass the apex of the abdomen and have fully developed venation. In koeliopterous forms the tegmina are of moderate length covering most of the abdomen with somewhat reduced venation. In brachypterous forms the tegmina are very short with greatly reduced venation and cover only the base of the abdomen. The hind wings are fully developed only in the macropterous forms. Some species are known to include individuals of all these forms whereas others are known only from the macropterous or brachypterous forms or both. Tegmina or the forewings are of slightly harder in consistency, longer and narrower than the hind wings. The former are variously coloured in different species, the latter are invariably transparent.

The wing venation is comparatively well developed in delphacids. Unlike the members of other families of Fulgoroidea like Flatidae and Ricaniidae there is no precostal region in araeopids. In tegmen the costa is well developed, unbranched vein running along the anterior margin. Subcosta forms a common stalk basally with costa and distally branches into two Sc_1 and Sc_2. Radius coalesces with the subcosta

(Sc + R) for nearly half of its length, diverges from it and after some distance bifurcates into R_1 and Rs. Media arises independently from the base and soon after its origin it coalesces with the combined Sc + R for a short distance. Distally it has three branches M_1, M_2 and M_3. An important character observed by the author is that the veins R_1, Rs and M_1 usually arise from a common stalk before branching in Delphacini whereas in Tropidocephalini R_1 is separate. Cubitus is forked into two, Cu_1 and Cu_2 soon after its origin, the former branch distally bifurcates into Cu_1a and Cu_1b. The anal vein is two branched IA and IIA, they distally fuse together to give a Y-vein, a characteristic feature of the superfamily Fulgoroidea. All the veins of the tegmen except Cu_2 are characterised by the presence of macrotrichiae throughout their length. In some they are found on either side apposing the veins and not always on the veins.

The hind wing is conspicuous for the absence of macrotrichiae and the enlarged anal area. The costa is similarly disposed as the tegmen. The subcosta is unbranched and runs very close to the costa. The radius is represented by a single vein. Basally subcosta, radius and media all unite together and run for a short distance apposing the costa anteriorly. An interesting feature observed by the author during the present investigations is that in the hind wings of the tribe Tropidocephalini, M and Cu_1 are fused together after a short distance from the base and continue as a single vein

which separates as M, Cu_1a and Cu_1b and he considers this as an important taxonomic character in separating the tribe from others. The branching of the cubital vein is similar to that of the tegmen except that Cu_1a coalesces with the media for almost its entire length being separated only near the distal margin. The first anal vein is unbranched and the second is three branched in Delphacini and two branched in Tropidocephalini to support the enlarged anal area, which is also an important character in separating the two tribes.

Tegula is a well developed sclerotized plate overlapping the base of the tegmen and movably articulated with the base of the costal vein.

Abdomen

The abdomen consists of eleven segments and the morphology of the same is similar as in other fulgorids, the last three segments constitute the terminalia.

Terminalia

Since the genetalia and the postgenital segments are very closely associated, they are all taken together for descriptive purposes. While a certain amount of taxonomic importance has been attached in recent years to the female genetalia, it is only the genetalic armatures of males that have received considerable attention in taxonomic segregations. Hence the author has devoted his attention in the present work only to a study of the male genetalia in different species.

The male genetalia of delphacids consists of the modified ninth, tenth and eleventh abdominal segments. The ninth segment is specialized into a more or less chitinised ring, the pygofer, which is greatly swollen and without any clear separation into tergum, sternum or pleura. The pygofer opens caudad, the opening is known as pygopheral opening. The posterior edge of the pygofer is more or less deeply emargi-nate, the anal emargination, which surrounds the anal segment. The corners of this emargination are more or less angular and in some species these are considerably produced. The lateral margins of the pygopheral opening vary in shape, being straight and entire, produced or excavated. The pygopheral opening is usually divided into two areas: the more dorsal anal region surrounding the anal segment and the ventral area or the genital region. The anal angle which is usually prominent separates the anal region from the genital region. The genital region is divided into an inner compartment and an outer compartment by a diaphragm. The aedeagus and its connectives are in the inner compartment and the genital styles in the outer compartment. The ventral area of the pygopheral opening is sometimes distinctly separated from the lateral margins by the ventral angles and in some genera a pair of distinct plates are formed on the ventral border which are known as genital plates (Metcalf, 1949). The dorsal and ventral margins of the diapharagm are having various shapes and thickenings. The dorsal margin is generally provided with a chitinised armature.

A pair of genital styles or parameres are present which vary much in size and shape; each style has an inner and outer margins and a basal angle. The aedeagus arises from behind the diaphragm and when at rest its apex projects above the middle of the dorsal margin of the diaphragm just above the armature. It consists of an ejaculatory duct surrounded by a sheath and passes right through a long chitinous lobe, the aedeagal periandrum, having various shapes, and opens externally at the gonopore. Generally the aedeagus is provided with rows of small teeth. The aedeagus is supported at the proximal end by chitinous plates, the basal plates of Pruthi (1925). The basal plates have a chitinous bridge called the basal plate bridge, bearing a sclerotic ring, the wing of the basal plate. The basal plate is connected with the genital styles by a sclerite termed basal plate prolongation which is bifurcated distally, an arrangement which enables the insect to move the parameres along with the aedeagus. The base of the aedeagus is produced towards the anal segment as a small sclerite, the aedeagal basal strut, which connects the aedeagus to the anal segment. A characteristic feature observed by the author during the present investigations is the presence of a long, narrow, pointed, generally curved 'penis guide' usually on the left side of the aedeagus closely adpressed with it, which is found only in the tribe Tropidocephalini and he considers it as an important taxonomic character in separating

the tribe from others. The tenth and eleventh abdominal segments fused to form a small ringlike tube, termed as the anal segment which lies more or less surrounded by the anal emargination of the pygofer. The anus opens on the latter segment and below or ventrad of the anus, a posterior conical projection called the anal style is present, which is generally wrinkled and beset with minute hairs. The anal segment is usually provided with one, sometimes two pairs of ventral spines which may be short, produced as anal lobes or very long and narrow reaching in certain genera to the lower margin of the pygopheral opening. In the species of the tribe Tropidocephalini, the anal spines appear to be lacking.

The female genetalia are very similar throughout the group except minor variation in some genera. In the female genetalia the ovipositor is well developed and represent the typical homopterous type which extends upto the hind region of abdomen or projects even beyond that. The opipositor 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 membraneous ventro-lateral parts of the eighth segment and extending a considerable distance over the ninth tergum to articulate

with it. 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 arrangement, 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 arrangement, one valvulae 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 highly sclerotized and narrow down towards the distal end. Anteriorly it is continuous with the base of the second valvifers. Dorsally it bears serrations extending more than half of its length

which facilitates to pierce the plant tissue for depositing eggs. The accessory lobes or third valvulae are paired, sclerotized, 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 some genera like Stenocranus the third valvulae are highly developed and cover the seventh sternum to a greater extent. In many of the delphacids it has been observed that the seventh sternite bears a small subgenital plate roofing over the base of the ovipositor.

III. Taxonomic studies on Indian Delphacidae

The subfamilies and tribes mentioned in this contribution can be readily recognized by the following key (Muir and Giffard, 1924).

1. Spur subulate, cross section circular or angular, apex acute, without teeth on side ..... ASIRACINAE

-. Spur cultrate or sub-cultrate or thin, with or without teeth on hind margin ..... DELPHACINAE 2.

2. Spur cultrate, thick, convex on both sides, or slightly concave on inner surface with teeth on hind margin ..... ALOHINI

-. Spur thin or if thick, then with no teeth on hind margin ..... 3.

3. Spur thick, concave on inner surface, margin without teeth ..... TROPIDOCEPHALINI

-. Spur thin, often tectiform, hind margin with or without teeth ..... DELPHACINI

Among the material before the author there are no representatives of the subfamily Asiracinae and the tribe Alohini of the subfamily Delphacinae.

TRIBE: TROPIDOCEPHALINI

This is a small tropical group comprising very few genera. There are seven distinct species before the author that can be assigned to this tribe. These present very remarkable differences between themselves. Judging from the characters that have been used by other workers for generic

segregations, they can be put under three distinct genera including a new genus proposed by the author.

Genus : Purohita Distant

Distant, 1906, Fauna British India, 3 : 470.

Large, robust forms. Head narrower than pronotum; vertex narrow, longer than wide, laterally strongly ridged; frons narrow, obliquely widened to clypeus; first joint of antennae very long and broad with a central ridge, laterally obliquely reclined, second joint barely half the length of first, thickened but much narrower; hind tibial spur long, flat, devoid of spines.

The two species with the author may be separated on the basis of the following key:

-. Postero-ventral margin of pygofer 4-lobed; penis guide sickle shaped; aedeagus and genital styles much longer than broad, the former roundly hooked at tip ..... P. cervina

-. Postero-ventral margin of pygofer bilobed; penis guide only slightly bent, aedeagus and genital styles relatively much shorter in comparison to its width; apex of aedeagus hammer-shaped ..... P. arundinacea

1. Purohita cervina Distant (Plate I, Fig. 1)

Distant, 1906, Fauna British India, 3 : 470.

Colouration: General colour light ochraceous brown, lower half of frons and genae distinctly paler, upper half

PLATE I

Fig. 1 : *Purohita cervina* Distant

Fig. 2 : *Purohita arundinacea* Distant

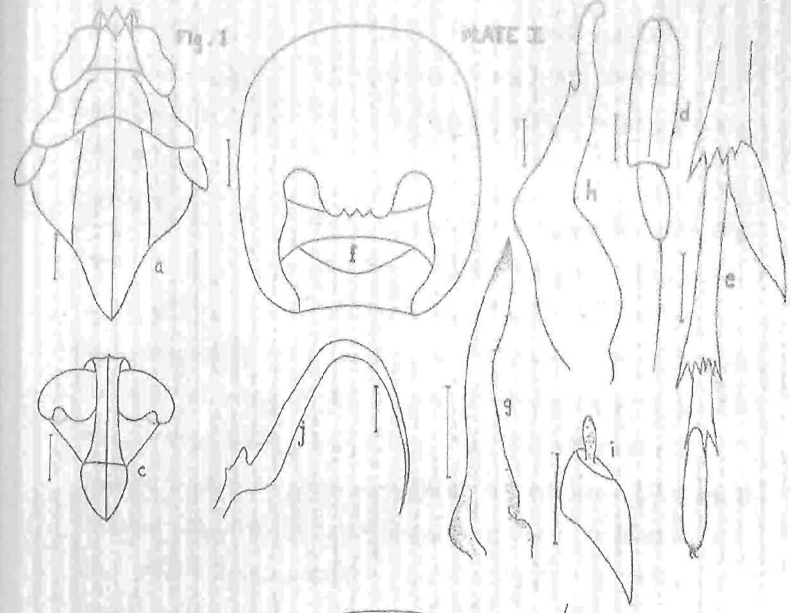


Fig. 1
PLATE II
a
f
d
h
e
c
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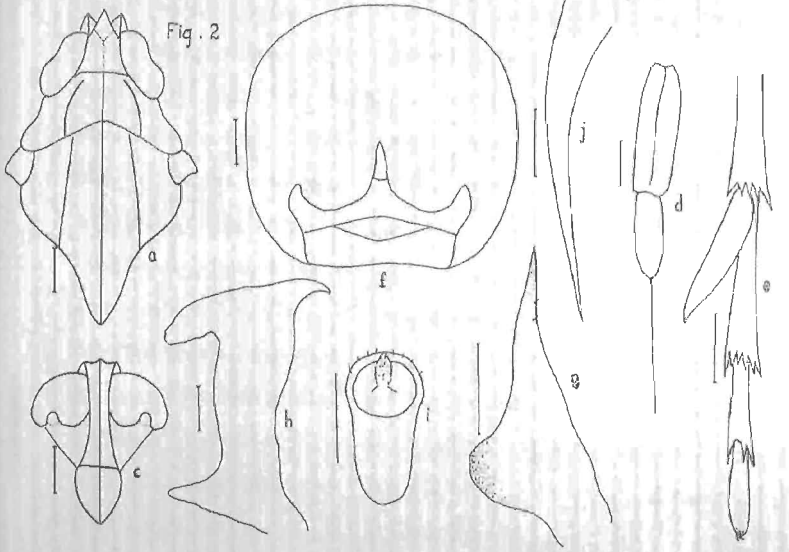
Fig. 2
a
f
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with fuscous mottling; fore and middle tarsi fuscous. Tegmina hyaline, cubital commissure and veins distally progressively fuscous; basis of hairs of all veins mottled fuscous.

Form: Head small, distinctly narrower than pronotum. Eyes kidney shaped laterally. Vertex elongate, about 1.3 times longer than basal width, apex W-shaped on account of the well projecting median carina, narrower than base, projecting in front of eyes, lateral margins shallowly concave; carination strong forming deep ridges, X-shaped carina feeble, submedian carinae prominent meeting at extreme apex enclosing a diamond shaped cell; basal compartment wider in hind margin than median length; lateral margin elevated; divided by a feeble median carina. Frons elongate, narrow about 2.5 times longer than maximum width; lateral margins shallowly concave, apex wider than base; carination strong, median and lateral carinae form deep ridges; clypeus broadly triangular, base slightly wider than apex of frons, tricarinate; antennae elongate, basal segment long, flat, oar-like about 3 times longer than second, second segment short, not so flat as first. Pronotum narrow, posterior margin deeply incised, tricarinate, lateral carinae elevated, slightly arcuate, reaching hind margin; mesonotum about twice longer than vertex and pronotum together, tricarinate. Hind basitarsus slightly longer than other two together; calcar solid, flat, acuminate, shorter than basitarsus, without teeth on hind border.

Male genetalia: Pygofer longer than broad, posterior opening a little longer dorso-ventrally than broad; ventral margin produced into a lobe forming a shield covering basal portion of genital styles, apex divided into four lobes, the median pair triangularly acute and lateral pair broadly rounded; anal angle entire; diaphragm without any armature; aedeagus forming a bizzare-shaped structure, somewhat like dorsal part of the head and trunk of an elephant, laterally compressed, broad at base, narrowed apically, a slight bend in middle, turned dorsad, a dorsal tooth about middle, apex bluntly rounded and hooked, directed ventrad. A long narrow sickle-shaped penis guide, pointed apically, originating dorsally from the inner side of the pygofer, reaching the base of genital styles. Genital styles elongate, laterally compressed, upright in position, slightly narrowed in middle, apex pointed, covered with minute hairs on the posterior margin of apical half. Anal segment small, ring-like with dorsal plate elongate, obliquely produced laterally with a bluntly pointed apex, devoid of spines; anal style long and fusiform.

Measurements: Length - 6.00; Head - 0.78; Pronotum - 1.02; Antenna - 1.25+0.61; Hind tarsus - 0.66+0.54; Calcar - 0.52; Tegmen - 5.00.

Material examined: 2 ex. from NPC; 4 ex. from Coimbatore.

2. Purohita arundinacea Distant (Plate I, Fig. 2)

Distant, 1907, Ent. Monthly Mag., 43 : 10.

Colouration: General colour ochraceous, face carmine red to posterior margin of eyes, then cretaceous white to clypeus; antennae fuscous, legs ochraceous; fore and middle legs striped with black; apices of tarsi black. Tegmina hyaline, venation spotted with fuscous, marginal spots largest.

Form: General characters more or less same as in P. cervina. Body slightly narrower; basal compartment as wide as long.

Male genetalia: Pygofer ring-shaped, slightly longer than broad, posterior opening a little longer dorso-ventrally than broad, ventral margin deeply bilobed covering the basal portion of parameres, lobes broadly rounded; diaphragm without any armature; aedeagus short, broad, hammer-shaped, laterally compressed, slightly narrow above the base, basal angle produced ventrad; gonopore at the tip of ventral prolongation at apex; penis guide elongate, narrow, pointed apically, slightly curved ventrad, closely adpressed to the left side of aedeagus. Genital styles short, broad at base, narrow apically, basal inner angle humped, minute hairs in groups on the inner and outer border. Anal segment small ring-like, dorsal plate very long, obliquely produced laterally, devoid of any ventral spines; anal style short, fusiform.

Measurements: Length - 5.80; Head - 0.63; Pronotum - 0.91; Antenna - 1.30+0.61; Hind tarsus - 0.64+0.55 Calcar - 0.50; Tegmen - 4.81.

Material examined: One ex. male from NPC with the locality data "Barnesbeg, Darjeeling, 3,000 ft., Oct. 1906, H.H. Mann".

Genus : Tropidocephala Stal

Stal, 1855, Ofv. Svenska. Vet. Akad. Forh., 12 : 93.

Delicate forms. Head narrower than pronotum; vertex turbinate, projecting in front of eyes; face longer than broad, lateral pronotal carinae concave, meeting hind margin; antennae short terete, annular; tibial spur solid, flat, devoid of teeth on hind border.

The three species before the author may be separated on the basis of the following key:

1. Vertex in profile distinctly declivate ventrad ..... T. festiva
-. Vertex in profile straight ..... 2.
2. Infuscation of wings forming distinct bands, in addition to three spots ..... T. lutecola
-. Only three spots without much infuscation on wings ..... T. signata

3. Tropidocephala festiva (Distant) (Plate II, Fig. 1)

Matsumura, 1907, Ann. Mus. Nat. Hungarici., 5 : 62.

= Smara festiva Distant, 1906, Fauna British India, 3 : 478.

Colouration: General colour darker. Head, pro- and meso-nota and middle of frons greenish blue; carinae fine and lighter, median carina from tip of vertex to scutellum bordered on outer side by a streak; apex and base of frons, clypeus, genae, pro- and meso-sterna and abdomen dorsally except for a basal band dark chocolate brown. Antennae ochraceous brown with fuscous annulations, legs fuscous; tegmina dark fuscous except for the bases of anal veins which are creamy green and with hyaline patches along the distal half of the anterior and apical borders.

Form: Head narrower than pronotum. Eyes reniform. Vertex elongate, triangular, longer than broad, broadly conical apically, projecting in front of eyes; tricarinate, lateral carinae ridged, median carina simple; Y-shaped carina absent; frons elongate, about 2.5 times longer than maximum width, lateral margins strongly arcuate; tricarinate, median carina simple; in profile distinctly declivate at basal third; clypeus triangular, tricarinate; antennae short, terete, first segment annular, second about twice the length of first. Pronotum narrow, posterior margin incised, tricarinate, lateral carinae slightly arcuate, attaining posterior margin; mesonotum as much or slightly longer than vertex and pronotum combined. Hind basitarsus longer than the other two together; calcar solid, flat, shorter than basitarsus, without teeth on hind margin.

PLATE II

Fig. 1 : Tropidocephala festiva (Distant)

Fig. 2 : Tropidocephala signata (Distant)

Fig. 1

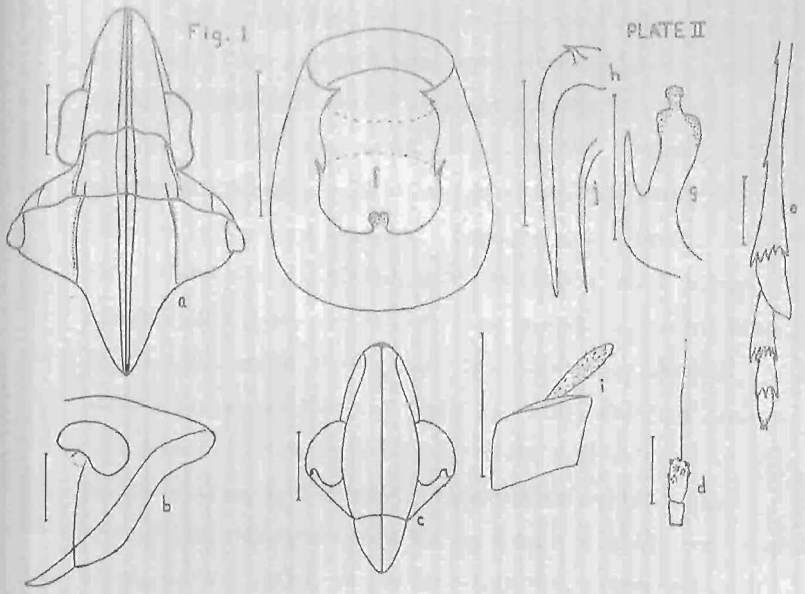
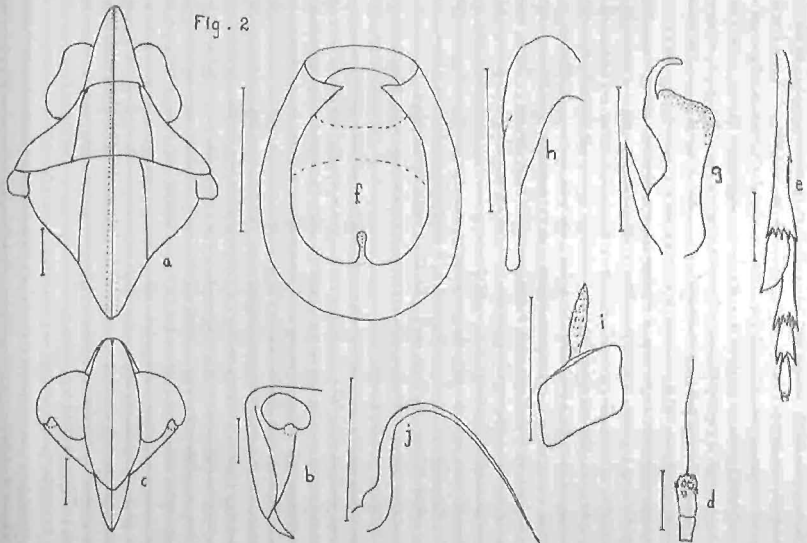


Fig. 2



Male genetalia: Pygofer ring-shaped, longer than broad, posterior opening longer dorso-ventrally than broad, a medio-ventral button-like prolongation with its apex bilobed, latero-ventral margin with a spinous process; anal emargination narrow, pointed, directed inwards; diaphragm delicate without any armature. Aedeagus long tubular, curved with pointed apex, a lateral spine basally; a short narrow pointed penis guide on the left side, closely adpressed with it. Genital styles short, laterally compressed, basally narrow, curved and directed dorsad, a median elongate finger-like process at the inner margin, apical half slightly broad, turned laterad, apex truncate, with a short, button-like process near the inner angle having a bulbous head; anal segment broad, narrow, apical margin obliquely cut, latero-apical angles devoid of spines, anal style short, oblong.

Measurements: Length - 3.50; Head - 0.58; Pronotum - 0.85; Antenna - 0.10+0.18; Hind tarsus - 0.38+0.32; Calcar - 0.24; Tegmen - 2.30.

Material examined: 6 ex. from Trivandrum.

4. Tropidocephala signata (Distant) (Plate II, Fig. 2).

Muir, 1921, Proc. Hawaiian Ent. Soc., 4 : 480.

= Orchesma signata Distant, 1912, Ann. Mag. Nat. Hist., (8)9 : 192.

Colouration: General colour ochraceous; carinations on vertex, pro- and meso-nota pale white, bordered with narrow

brown lines; frons and genae reddish, carinae fine orange yellow; clypeus and body ventrally with testaceous tinge; antennae ochraceous, with brown annulations; legs creamy. Tegmina pale shining ochraceous; two transversely ovate fuscous patches on the disc about middle of apical half; slightly enfumed along veins.

Form: General characters more or less same as T. festiva. Frons shield like with apical border broadly rounded; in profile frons straight without declivity, clypeus curved ventrad.

Male genetalia: Pygofer ring-shaped, longer than broad, posterior opening longer dorso-ventrally than broad, a medio-ventral short stumpy process; latero-ventral margins without spinous process; anal emargination produced, turned inwards; diaphragm delicate without any armature. Aedeagus long, tubular, curved, basally broad, narrowed distally ending in a blunt slightly swollen apex; a long narrow, curved penis guide basally swollen, pointed at tip, closely adpressed to aedeagus; genital styles short, laterally compressed, broad basally with inner angle produced to an elongate spine, medially narrow, slightly twisted, apex truncate, inner angle produced into a long narrow process with a blunt head, curved laterad; anal segment small, broad, apical margin obliquely cut, latero-apical angles devoid of spines; anal style short, oblong.

Measurements: Length - 4.40; Head - 0.76; Pronotum - 0.91; Antenna - 0.09+0.18; Hind tarsus - 0.36+0.28; Calcar - 0.31; Tegmen - 3.40.

Material examined: 6 ex. from Coimbatore.

5. Tropidocephala lutcola Distant (Plate III, Fig. 1)

Distant, 1912, Ann. Mag. Nat. Hist., (8)9 : 193.

Colouration: Vertex, pro- and meso-nota greenish ochraceous; lateral areas of pro- and meso-nota, basal two-third of frons, fore and middle legs and hind tibiae infuscated, apical third of frons, clypeus, genae, prosternum and hind femora dark fuscous; all carinae slightly bordered with fuscous on both sides; antennae ochraceous with annulations; body ventrally creamy. Tegmina pale, fuscous brown, irrorated with greyish white, an irregular transverse macular fascia near middle, a cluster of about three dark spots immediately beyond the transverse fascia; fuscous along veins in apical half, leaving hyaline area in between veins at apex.

Form: General characters more or less same as T. festiva. Frons in profile straight, clypeus curved ventrad.

Male genetalia: Pygofer ring-shaped, longer than broad, posterior opening longer dorso-ventrally than broad; a medio-ventral minute conical projection from inside the ventral border; latero-ventral margin with a spinuous process; anal emargination narrow, turned inwards; diaphragm delicate

without any armature. Aedeagus long, tubular, curved, basal third broad, rest narrow curved with pointed apex; a short, narrow, curved, pointed penis guide closely adpressed to the aedeagus; genital styles short, laterally compressed, basally broad with a spine at inner angle, medially narrow, slightly twisted with a spine on the inner border, apex broader, outer angle broadly round, inner corner produced into a long, narrow process with a bulbous head; anal segment small, broad, apical margin obliquely cut, latero-apical angles not produced; anal style long, narrow.

Measurements: Length = 3.30; Head = 0.44; Pronotum = 0.66; Antenna = 0.10+0.21; Hind tarsus = 0.36+0.29; Calcar = 0.23; Tegmen = 2.53.

Material examined: 12 ex. collected from Delhi; 10 ex. from Gauhati.

Genus : Paratropidocephala, nov.

Head narrower than pronotum. Eyes reniform. Vertex turbinate, elongate, projecting in front of eyes, lateral margins elevated; Y-shaped carina absent. Frons elongate, lateral edges arcuate, median carina ridged; antennae long, cylindrical, about length of face; first segment about two-third length of second; pronotum narrow, lateral carinae reaching posterior margin; mesonotum slightly longer than vertex and pronotum combined; hind basitarsus longer than other two together; spur short, solid, flat, devoid of teeth on hind border.

PLATE III

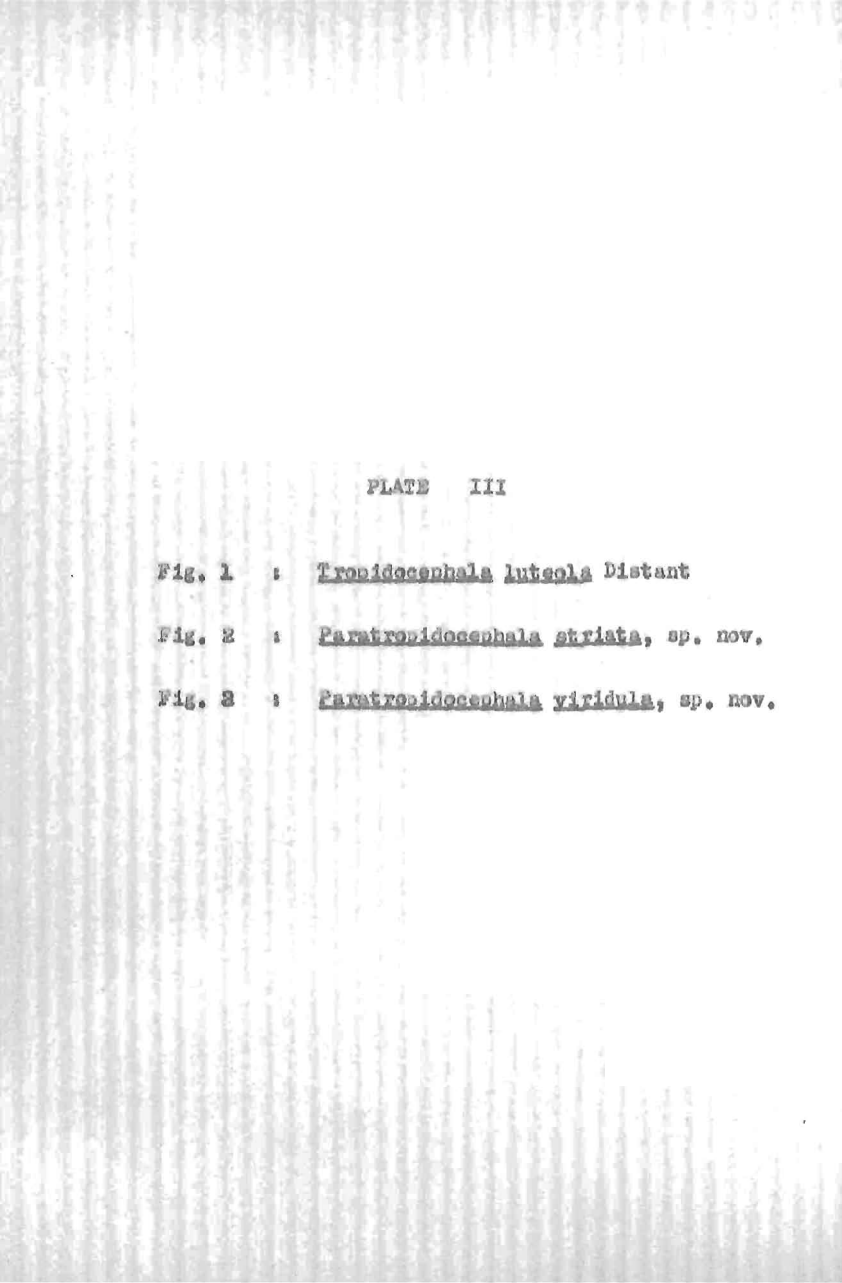


Fig. 1 : Tropidocephala lutcola Distant

Fig. 2 : Paratropidocephala striata, sp. nov.

Fig. 3 : Paratropidocephala viridula, sp. nov.

Fig. 1

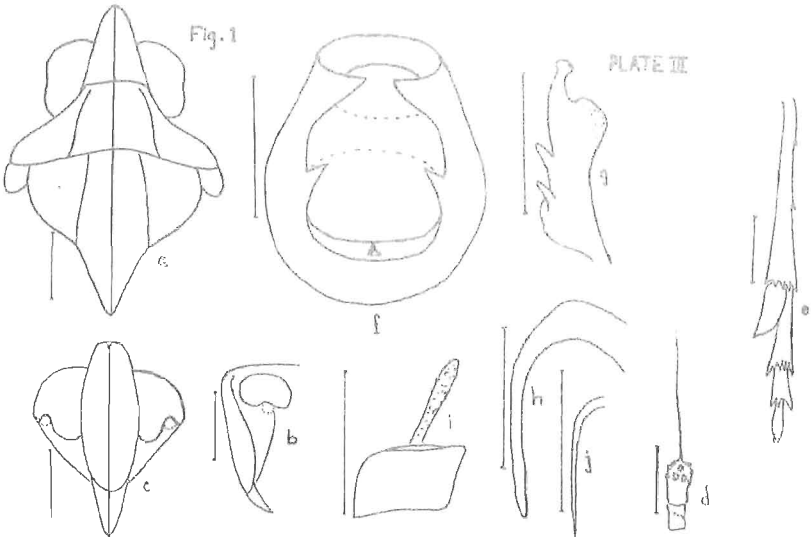


Fig. 2

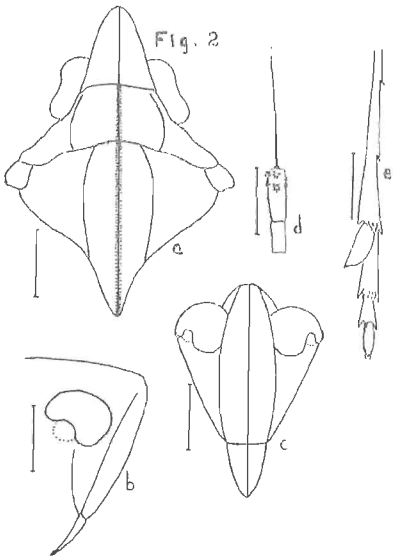
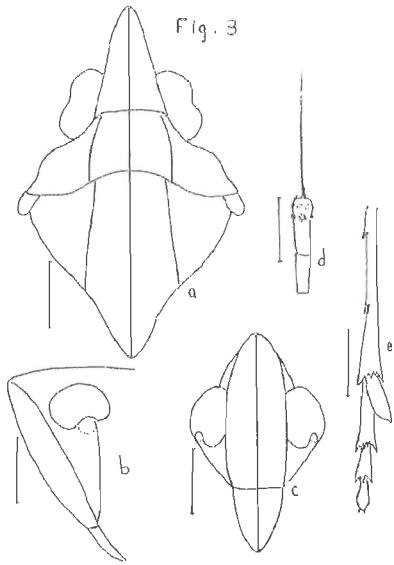


Fig. 3



Type of genus : Paratropidocephala viridula, sp. nov.

This genus differs from Tropidocephala by the comparatively long, cylindrical antennae and from Arcofacies by the turbinate vertex. The two species before the author may be separated by the following key:

-. Vertex relatively long and narrow, lateral carinae of pro- and meso-nota slightly arcuate, apex of tegmina round ..... P. viridula, sp. nov.

-. Vertex relatively short and broad, median carina of pro- and meso-nota bordered with brown lines, lateral carinae more curved, apex of tegmina distinctly angulate ..... P. striata, sp. nov.

6. Paratropidocephala viridula, sp. nov. (Plate III, Fig. 3)

Colouration: Vertex, pro- and meso-nota yellowish green, frons and clypeus green, genae anterior to eyes green, posterior border beyond ocellus towards clypeus orange; ocelli crimson; eyes anterior half orange, posterior half ferrugineous; antennae ochraceous green with brown speckles; body ventrally pale green; legs pallid. Tegmina hyaline, venation spotted with dark dots all along.

Form: Delicate form. Head narrower than pronotum. Eyes reniform. Vertex triangular, longer than basal width, projecting in front of eyes, lateral margins elevated; tricarinate; Y-shaped carina and basal compartment absent; frons elongate, narrow about 3 times longer than maximum width

in middle, base narrower than apex, lateral margins convex, tricarinate, median carina simple with a very small aerolet at base; clypeus triangular, tricarinate; antennae long, cylindrical, basal segment short, about two-third length of second. Pronotum narrow, disc flattened, tricarinate, lateral carinae slightly arcuate, reaching posterior margin; mesonotum slightly longer than vertex and pronotum combined; hind basitarsus longer than other two together, calcar solid, flat, shorter than basitarsus, devoid of any teeth on hind margin. Apical margin of tegmina round.

Measurements: Length - 3.50; Head - 0.45; Pronotum - 0.63; Antenna - 0.11+0.17; Hind tarsus - 0.38+0.32; Calcar - 0.25; Tegmen - 2.90.

Material examined: Holotype female: "Inside lamp dome, I.A.R.I., New Delhi; June'70, Coll. K.V. Mammen".

7. Paratropidocephala striata, sp. nov. (Plate III, Fig. 2)

Colouration: Vertex, pro- and meso-nota creamy with a slight greenish tint; median carina bordered with narrow brown lines except on the vertex; frons, clypeus and genae slightly infuscated, median carina of frons broad, creamy white bordered with brown lines; antennae pale yellow with brown annulations; body ventrally greenish yellow; legs ochraceous. Tegmina hyaline, venation creamy with fuscous band along veins in apical half.

Form: General characters more or less same as in P. viridula. Vertex relatively shorter and broader; median carina from vertex to scutellum comparatively broader; lateral carinae of pro- and meso-nota more curved; apex of tegmina distinctly angulate.

Measurements: Length - 3.50; Head - 0.53; Pronotum - 0.74; Antenna - 0.12+0.18; Hind tarsus - 0.38+0.32; Calcar - 0.23; Tegmen - 3.00.

Material examined: Holotype female "Inside lamp dome, I.A.R.I., New Delhi; June'70; Coll. K.V. Mammen".

TRIBE: DELPHACINI

The major portion of delphacids collected from this country belongs to this group. They present very remarkable differences between themselves. There are 38 distinct species before the author which fall under this tribe. Twenty of these are already recorded of which 9 species are recorded for the first time from India. Remaining species are new to science. Out of these 13 could be assigned to already known genera, 6 species could not be placed under any of the known genera and hence 4 new generic names are proposed herein.

Genus : Paranerkinsiella, nov.

Stout built forms. Head short, distinctly narrower than pronotum; vertex shorter than basal width; submedian

carinae not meeting at apex, lateral carinae elevated; frons subrectangular, longer than wide, tricarinate, forking of median carina far below eyes, carinae form deep ridges; clypeus subtriangular, tricarinate; antennae long, flattened, first segment long, slightly broader apically, second segment as long or slightly shorter than first. Pronotum narrow, tricarinate, lateral carinae curved, not reaching hind margin; mesonotum as long as vertex and pronotum together; hind basitarsus longer than other two combined; calcar foliaceous, acuminate, many toothed.

Type of genus : Paraperkinsiella coimbatorensis, sp. nov.

This genus differs from Perkinsiella by the narrow head, nature of antennae and the furcation of median frontal carina.

8. Paraperkinsiella coimbatorensis, sp. nov. (Plate IV, Fig.2)

Colouration: Vertex, pro- and meso-nota tawny; frons and genae beyond level of eyes ochraceous, basally more infuscated; first antennal segment ochraceous, second more deep; body ventrally and legs ochraceous brown; tegmina light fuscous, venation brown.

Form: Head distinctly narrower than pronotum; vertex broad, shorter than basal width, lateral margins shallowly concave, elevated, posterior margin transverse, apex emargi-nate with submedian carinae prominent, less wide as base;

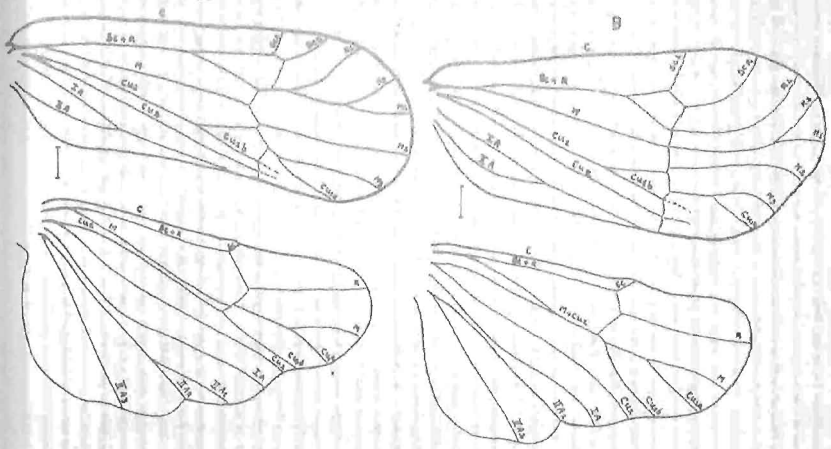
PLATE IV

Fig. 1 : A & C - Wings and hind leg of Delphacini

B & D - Wings and hind leg of Tropidocephalini

Fig. 2 : Paraperkinsiella coimbatorensis, sp. nov.

Fig. 1 PLATE IV



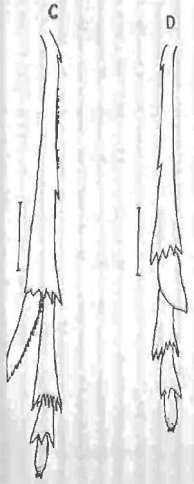
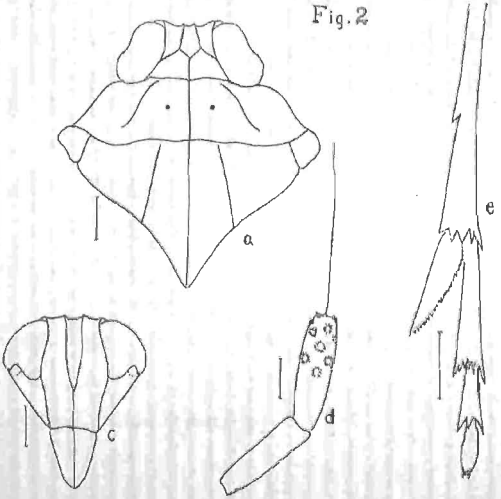


Fig. 2



carination strong, X-shaped carina distinct, submedian carinae not meeting at apex, basal compartment wider at hind margin than median length; frons subrectangular, about 2.5 times longer than maximum width at lower margin of eyes, lateral margins arcuate, carination strong forming deep ridges, median carina forked far below eyes, about two-third from base, deep furrows on either side of median carina; clypeus subtriangular, convex, tricarinate; antennae long, flattened, reaching beyond clypeus; basal segment long, slightly broader apically, about 3 times longer than wide, second segment long, bluntly rounded, as long or slightly shorter than first. Pronotum narrow, broad, wider at base than long in middle, posterior margin incised, tricarinate, lateral carinae divergingly curved latero-caudad not meeting hind margin; mesonotum as long as vertex and pronotum combined, tricarinate; hind basitarsus longer than other two together, calcar foliaceous, acuminate, shorter than basitarsus with 26-27 teeth on hind margin.

Measurements: Length - 5.56; Head - 0.76; Pronotum - 1.24; Antenna - 0.50+0.46; Hind tarsus - 0.58+0.40; Calcar - 0.48; Tegmen - 5.00.

Material examined: Holotype female "Inside lamp dome, Coimbatore, Nov.-Dec.'59, Coll. R.A. Agarwal". Paratypes: females, 2 ex. labelled as the holotype.

Genus : Parkinsiella Kirkaldy

Kirkaldy, 1903, Entomologist, 36 : 179.

Robust forms. Head as wide or slightly wider than pronotum; median frontal carina bifurcates about one-third from base. Antennae flattened and dilated; basal segment triangular, apical margin much broader than base.

The four species before the author can be separated on the basis of the following key:

1. Pygofer with a shield-like medio-ventral extension produced into two broadly triangular lobes; anal spines very long; apex of genital styles bluntly rounded with a laterally directed acute point .....P. insignis

-. Pygofer with a pair of long, acute medio-ventral processes ..... 2.

2. Medio-ventral process of pygofer shorter, about twice as long as their basal width; anal spines shorter, extending only slightly beyond base of anal segment; apex of genital styles more or less foot like ..... P. sinensis

-. Medio-ventral process of pygofer much longer and narrower in relation to their basal width; anal spines and apex of genital styles quite different ..... 3.

3. Diaphragm with a dorso-median armature; apex of genital styles with a long finer-shaped process; anal spines short, apically forked, the forks diverging and pointed ..... P. andamanensis, sp.nov.

-. Diaphragm without dorso-median armature; apex of genital styles forked into two opposingly directed finger-shaped processes; anal spines short, simple and acutely curved basad ..... P. facialis

9. Perkinsiella insignis (Distant) (Plate V, Fig. 2)

Muir, 1919, Canadian Ent., 51 : 7.

= Pundaluoya insignis Distant, 1912, Ann. Mag. Nat. Hist., (8)9 : 190.

Colouration: Vertex, pro- and meso-nota ochraceous, lateral area of pro- and meso-nota black; frons deep brown, apex with narrow ochraceous band, two narrow transverse bands at forking of median carina and above, ochraceous spots apically and medially on either side of median carina; genae deep brown with an ochraceous speckle in centre; clypeus tawny; antennae brownish black, second segment deeper; body ventrally black; legs pale testaceous, femora and apices of tibiae mostly black; tegmina subhyaline, basal half brownish ochraceous, apical area piceous, marginal series of triangular hyaline spots.

Form: Head slightly wider than pronotum; vertex slightly broader than long, posterior margin transverse, lateral margins shallowly concave, apex quadrate, narrower than base; carination strong, Y-shaped carina distinct, submedian carinae not meeting on vertex, basal compartment wider in hind margin than median length; frons elongate, broad, about 2.5 times longer than maximum width one-third from apex, lateral margins slightly arcuate, tricarinate, median carina forked above the level of lower margin of eyes; clypeus triangular, base as wide as apex of frons, tricarinate; antennae long, flattened, basal segment short, triangular,

longer than broad, second segment about 1.5 times longer than first. Pronotum narrow, broader at base than long in middle, posterior border incised, tricarinate, lateral carinae divergingly curved latero-caudad, not attaining hind margin, mesonotum longer than vertex and pronotum combined; hind basitarsus longer than other two together, calcar foliaceous, long, shorter than basitarsus with 32-36 minute teeth along hind margin.

Male genetalia: Pygofer broad, posterior opening a little longer dorso-ventrally than broad, latero-dorsal border feebly produced and inflected, anal angle entire, a medio-ventral flat shield produced into two broadly triangular lobes, cover the base of genital styles; dorsal border of diaphragm deeply concave without any armature. Aedeagus elongate, tubular, broader at apical half, with a median bend ventrally; apex conical, with two flagella produced from dorsal to tip which are directed backwards with pointed tip. Genital styles elongate, laterally compressed, basally broad with inner angle bulged out, slightly twisted in middle, narrow towards apex. Anal segment short, ring-like, apical margin transverse, latero-apical angles strongly produced ventrad in a pair of long, narrow spinose processes, reaching the base of genital styles; anal style, short, oblong.

Measurements: Length - 4.65; Head - 0.80; Pronotum - 0.72; Antenna - 0.22+0.38; Hind tarsus - 0.54+0.38; Calcar - 0.35; Tegmen - 3.65.

PLATE V

Fig. 1 : Perkinsiella facialis (Distant)

Fig. 2 : Perkinsiella insignis (Distant)

PLATE V

Fig. 1

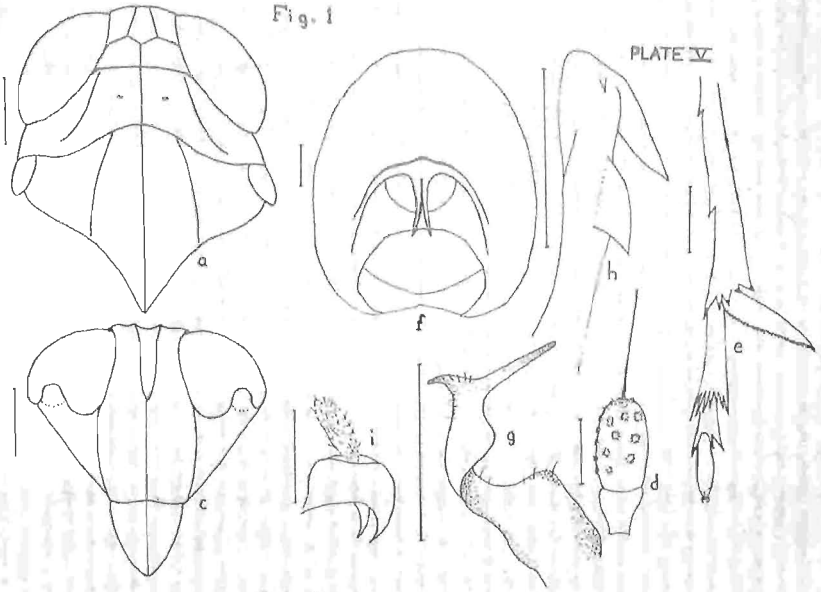
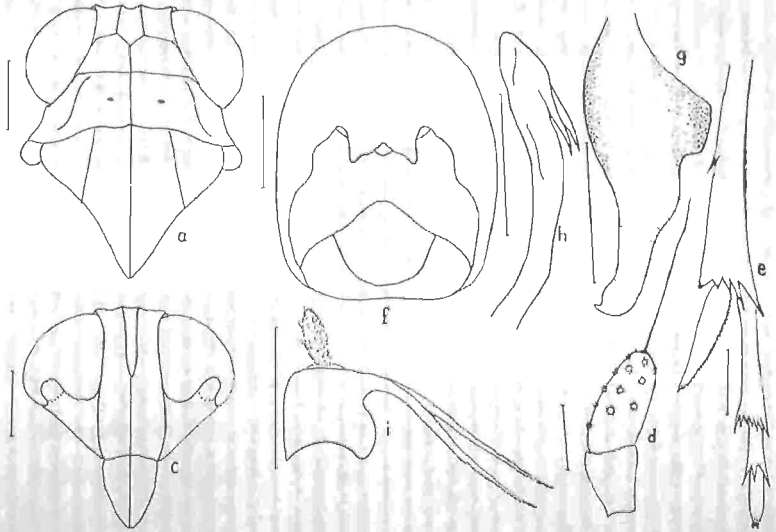


Fig. 2



Material examined: 4 ex. from NPC; 2 ex. from Kerala; 6 ex. from Delhi.

10. Perkinsiella sinensis Kirkaldy (Plate VI, Fig. 1)

Kirkaldy, 1907, Bull. Hawaiian Sugar. Pl. Assoc., 3 : 138.

Colouration: Vertex, pro- and meso-nota ochraceous, lateral area of pro- and meso-nota black; frons brown with a broad flavo-testaceous transverse band from middle to a little above apex, a narrow brown band just above apex, two fine transverse ochraceous bands one on either side of median carina medially; clypeus brown; genae ochraceous with a brown area at apical angle; antennae tawny, basal segment apically piceous, second segment deep; body ventrally ochraceous; legs ochraceous with narrow elongate brown stripes laterally on femora and tibiae; tegmina subhyaline, apical half piceous, fuscous along veins, bearing hyaline areas along marginal cells of apex.

Form: General characters same as in P. insignis.

Male genetalia: Pygofer longer than broad, posterior opening a little broader dorso-ventrally than long, a pair of short, pointed medio-ventral spinose processes covering half of genital styles, anal angle narrowed, pointed; diaphragm bridge-shaped, without any armature; aedeagus cylindrical, elongate, with a slight bend in middle, tip directed dorsad, basal half slightly broader, apex bluntly rounded with a small

tooth ventrally just behind tip, directed backwards, dorso-lateral tooth at the median bend, one on either side, directed backwards; genital styles curiously twisted, with the inner margin irregular, basal angle wider, an ear-shaped lobe in middle, inner apical angle with a small peg-like structure, outer angle narrowed apically ending in a foot-like structure; anal segment short, apical margin transverse, latero-apical angles produced ventrad in a pair of moderately long spinose processes; anal style short, fusiform.

Measurements: Length - 5.60; Head - 1.10; Pronotum - 1.15; Antenna - 0.29+0.42; Hind tarsus - 0.66+0.45; Calcar - 0.44; Tegmen - 4.30.

Material examined: 7 ex. from NPC (Pusa, Bihar); 1 ex. from Kerala; 3 ex. from Coimbatore.

11. Perkinsiella andamanensis, sp. nov. (Plate VI, Fig. 2)

Colouration: Vertex, pro- and meso-notal discs tawny, lateral area ochraceous, carination creamy; frons, clypeus and genae tawny, ochraceous dots on frons and the middle of genae; antennae ochraceous brown, basal segment apically tawny; body ventrally brown; legs ochraceous with brown streaks; tegmina hyaline with yellowish tint, fuscous in apical half, leaving hyaline cells along border.

Form: General characters same as in P. insignis.

Male genetalia: *Pygofer longer than broad, posterior* opening a little longer dorso-ventrally than broad, anal angle produced inward, a pair of long, narrow medio-ventral processes; diaphragm ventrally concave, dorsally a median tongue-like armature with slight swelling laterally, diaphragm lateral to armature less sclerotized; aedeagus long, tubular, medially narrow, apex bluntly pointed, a long pointed spine dorsal to tip, another one ventro-laterally behind tip; genital styles short, basally broad, inner margin irregular, basal inner angle with two short spikes, medially narrow and twisted, a long finger-shaped median process arising from inner margin, distally narrow, outer angle humped, inner angle produced to a finger-like process, turned inwards; anal segment small, ring-shaped, apical margin transverse, latero-apical angles produced into short, stout spines, apically forked, the forks diverging and pointed; anal style short, stumpy.

Measurements: Length - 4.50; Head - 0.80; Pronotum - 0.98; Antenna - 0.25+0.39; Hind tarsus - 0.43+0.37; Calcar - 0.35; Tegmen - 3.50.

Material examined: Holotype male "On Sugarcane, Dhanikhari, Port Blair, Andamans, March'25, P.V. Isaac Coll." (male genetalia on slide).

12. Perkinsiella facialis (Distant) (Plate V, Fig. 1)

Muir, 1919, Canadian Ent., 51 : 7.

= Pundaluoya facialis Distant, 1912, Ann. Mag. Nat. Hist., (8) 9 : 191.

PLATE VI

Fig. 1 : Perkinsiella sinensis Kirkaldy

Fig. 2 : Perkinsiella andamanensis, sp. nov.

PLATE VI

Fig. 1

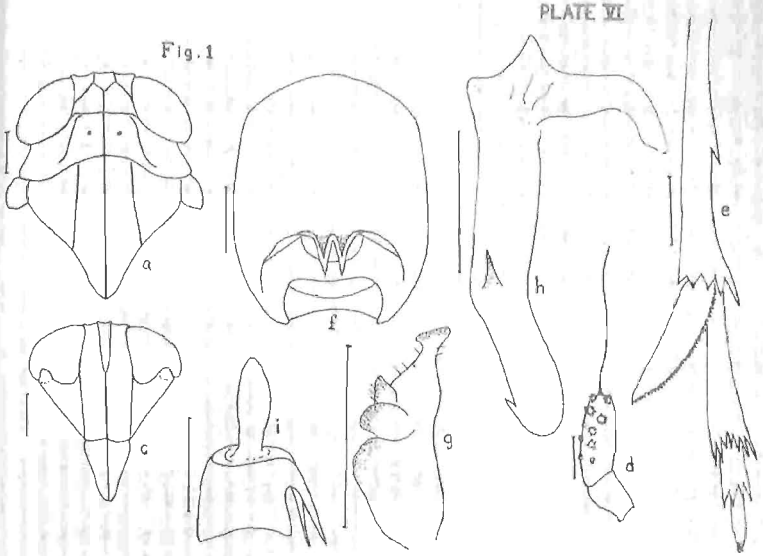
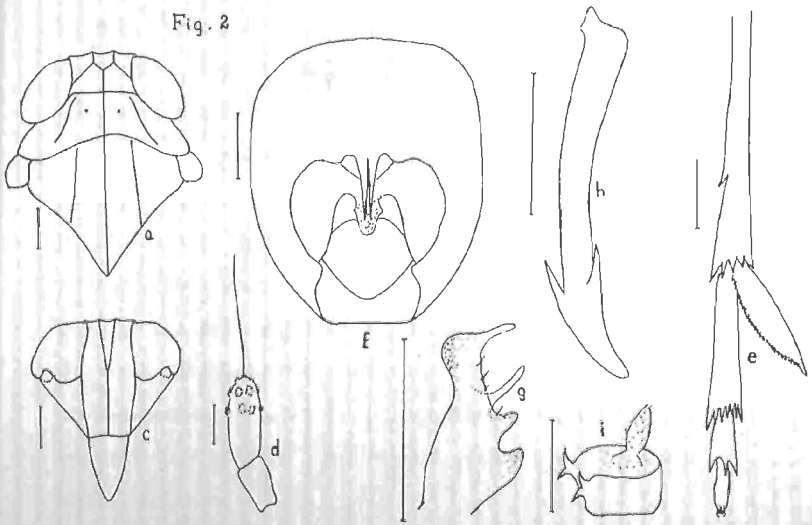


Fig. 2



Colouration: Vertex pro- and meso-nota ochraceous, lateral areas of pro- and meso-nota deep brown; frons ochraceous, castaneous in between eyes; clypeus black; genae ochraceous; antennae castaneous, basal segment apically ringed fuscous; body ventrally fuscous brown; legs ochraceous, fore and middle coxae with brown stripes; tegmina hyaline, veins rather thickly speckled with fuscous, a curved longitudinal fascia from about middle, parallel to the posterior border upto apex leaving hyaline patches in marginal cells.

Form: General characters same as in P. insignis.

Male genetalia: Pygofer longer than broad, posterior opening longer dorso-ventrally than broad, anal angles not produced, a pair of long, narrow medio-ventral spinose processes reaching the basal half of genital styles; diaphragm without any armature; aedeagus elongate, tubular, laterally compressed, apex slightly broader with a broadly conical blunt tip, a wing-like triangular flap about the middle laterally on either side, apically a less chitinised, dorsal flange, directed backwards; a small peg-like projection laterally on either side of apex; genital styles laterally compressed, appear like a sickle, basal half broad, medially elbowed and twisted laterad, narrowed apically, forked into two opposingly directed finger-shaped processes; anal segment short, narrow, apical margin transverse, latero-apical angles produced ventrad in a pair of short spines, acutely curved; anal style short, oblong.

Measurements: Length = 4.10; Head = 0.86; Pronotum = 0.90; Antenna = 0.18+0.33; Hind tarsus = 0.42+0.37; Calcar = 0.32; Tegmen = 3.00.

Material examined: 1 ex. from NPC (Pusa, Bihar); 3 ex. from Delhi.

Genus : Phyllodimus Van Duzee

Van Duzee, 1897, Bull. Buffalo Soc. Nat. Sci., 5 : 240.

Robust forms. Head slightly narrower than pronotum; vertex short, wide, broadly rounding into frons; median frontal carina forking at level of ocelli, fore and middle femora and tibiae a little compressed or feebly foliate.

The two species before the author can be separated by the following key:

-. Dorso-median cleft of diaphragm narrow; dorsal flagellum of aedeagus with a median peg-like structure; genital styles simple, narrow ..... P. pulchellus

-. Dorso-median cleft of diaphragm more wide; flagellum without peg-like structure; genital styles axe-shaped ..... P. punctata

13. Phyllodimus pulchellus (Distant) (Plate VII, Fig. 1)

Muir, 1921, Proc. Hawaiian Ent. Soc., 4 : 485.

= Pundaluoya pulchella Distant, 1912, Ann. Mag. Nat. Hist., (8) 9 : 190.

Colouration: Vertex much suffused with ochraceous; pro- and meso-nota brownish black, carination ochraceous;

frons deep brown, carinae ochraceous, speckled with ochraceous spots, apex with a narrow white stripe; clypeus ochraceous in basal half, apex deep brown, median carina creamy and thickened; genae tawny; antennae ochraceous, basal segment deep brown; legs brown, hind tarsal segment except basitarsus ochraceous; body ventrally deep brown. Tegmina hyaline, venation ochraceous, thickly speckled with fuscous granules, a curved fascia extending from middle to posterior angle, upwardly recurved near apex, short oblique fasciae beyond middle, a marginal line near apex of clavus.

Form: Head broad, only slightly narrower than pronotum; vertex shorter than basal width, broadly and obtusely rounding into frons, lateral margins slightly concave, apex quadrate, slightly wider than base; carination strong, stalk of Y-shaped carina obsolete, submedian carinae not uniting at apex; basal compartment wider at hind margin than median length; frons elongate, more than twice longer than maximum width at level of ocelli, lateral margins weakly arcuate, tricarinate, median carina forked at level of ocelli; clypeus subtriangular, tricarinate; antennae moderate, cylindrical, basal segment short, longer than broad, second segment about 1.5 times longer than first. Pronotum narrow, shorter in middle line than broad at anterior margin, deeply incised posteriorly, tricarinate, lateral carinae divergingly curved latero-caudad, not attaining hind margin; mesonotum longer than vertex and pronotum combined, tricarinate. Fore and middle

PLATE VII

Fig. 1 : *Phyllodinus pulchellus* (Distant)

Fig. 2 : *Phyllodinus punctata* Muir

PLATE VII

Fig. 1

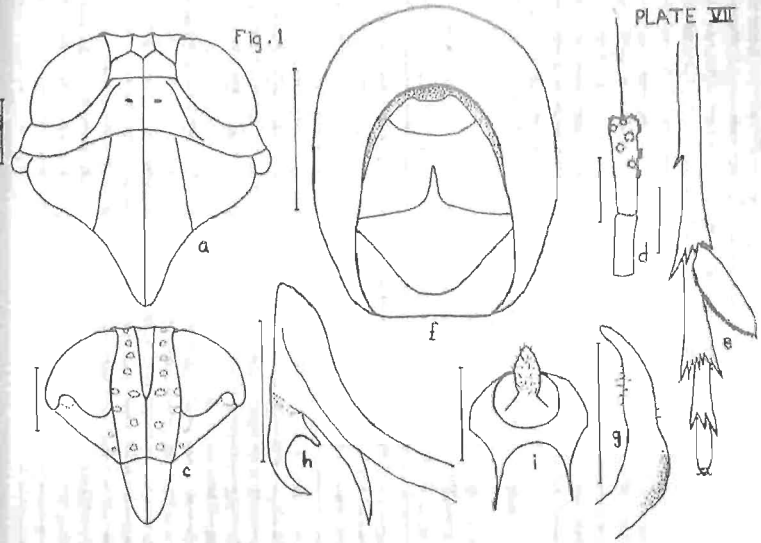
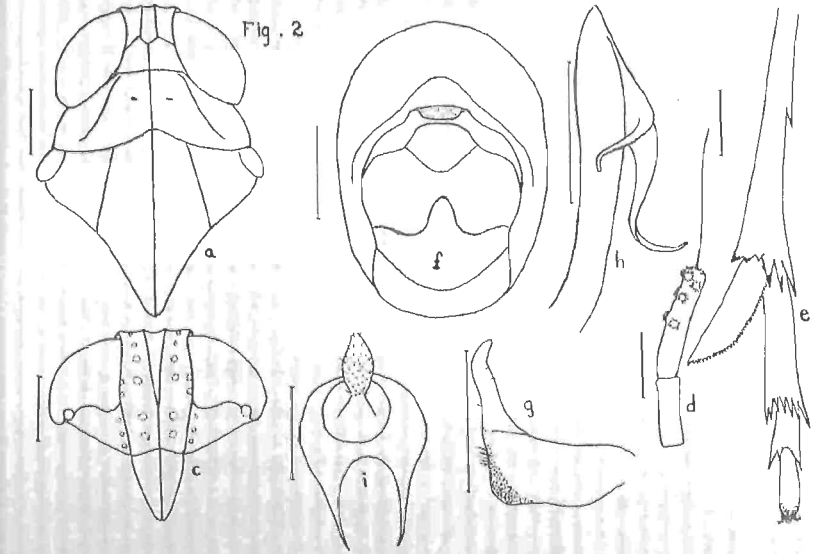


Fig. 2



femora and tibiae and femora of hind legs a little compressed or feebly foliated, hind basitarsus longer than other two together; calcar foliaceous, shorter than basitarsus, 23-30 minute teeth on hind margin.

Male genetalia: Pygofer shorter than broad, posterior opening longer dorso-ventrally than broad, dorso-lateral angles feebly produced and inflected, anal angle entire, medio-ventral edge with a small lip; diaphragm ventrally weakly concave, dorsal margin deeply cleft medially; aedeagus long, club-shaped, slightly decurved distad, two flagella pointed at tip arising dorsal to apex, directed cephalad, dorsal one with a process medially; genital styles simple, narrow, tapering distally to acute apex, directed dorsad; anal segment short, ring-like, latero-apical angles produced ventrad in a pair of slender spinose processes; anal style short, fusiform.

Measurements: Length - 4.15; Head - 0.85; Pronotum - 0.92; Antenna - 0.20+0.35; Hind tarsus - 0.50+0.38; Calcar - 0.31; Tegmen - 3.50.

Material examined: 11 ex. from Coimbatore; 2 ex. from Pathanamthitta (Kerala).

14. Phyllodinus punctata Muir (Plate VII, Fig. 2)

Muir, 1917, Proc. Hawaiian Ent. Soc. 3 : 320.

Colouration: Vertex light brown, pro- and meso-nota dark brown, carination creamy white, frons deep brown, speckled

with ochraceous spots; clypeus fuscous, distally deep; genae deep brown; antennae dark brown; body ventrally black; legs deep brown, hind legs less deep, tarsal segments and distal end of tibia pallid; tegmina fumose, venation dark brown, thickly speckled with fuscous granules; smoky brown bands apically.

Form: General characters same as P. pulchellus except slightly shorter in appearance.

Male genetalia: Pygofer shorter than broad, posterior opening longer dorso-ventrally than broad, dorso-lateral angles feebly produced and inflected, anal angles entire; medio-ventral edge produced into a small quadrate plate, wider than long with apical margin round; dorso-median cleft of diaphragm wider; aedeagus long, club-shaped, slightly decurved distad, two flagella arising at apex dorsally, directed cephalad, one on right small, acute, other on left longer and twisted; genital styles axe-shaped, laterally compressed, basal two-third broad, apical third narrow and twisted; anal segment short, ring-like, latero-apical angles produced ventrad in a pair of moderately long spinose processes; anal style short, fusiform.

Measurements: Length - 3.70; Head - 0.87; Pronotum - 0.92; Antenna - 0.22+0.38; Hind tarsus - 0.57+0.40; Calcar - 0.41; Tegmen - 3.10.

Material examined: 4 ex. from Tiruvella (Kerala).

Genus : Upacharella, nov.

Small, shiny insects. Head as wide as pronotum; vertex quadrate, as long as broad, broadly rounding into frons; carination feeble, submedian carinae feebly uniting at apex of vertex; frons longer than wide, convex, shining with fine pits, carination feeble; antennae short, terete, second segment about twice as long as first. Pronotum narrow, carination obsolete; mesonotum longer than vertex and pronotum together; hind basitarsus longer than other two combined; spur narrow, many toothed. Pygofer rather short, diaphragm without armature; aedeagus pillar-shaped, anal segment short.

Type of genus : Upacharella indica, sp. nov.

The external morphological character of the genus is more or less same as Upachara Distant, but for the presence of a row of minute teeth on the hind border of tibial spur. Hence this new genus is erected.

16. Upacharella indica, sp. nov. (Plate VIII, Fig. 1)

Colouration: Head and thorax shiny; vertex yellowish brown, pro- and meso-nota chocolate brown, tip of scutellum ochraceous; frons and genae dark chocolate brown; clypeus flavescent; basal segment of antenna brown, second segment ochraceous brown; body ventrally chocolate brown; legs ochraceous; tegmina hyaline, venation light brown.

Form: Head as wide as pronotum; vertex broad, as long as wide, lateral margins shallowly concave, apex round slightly wider than base, broadly rounding into frons; carination feeble, Y-shaped carina obsolete, submedian carinae feebly visible uniting at apex; basal compartment wider in hind margin than median length; frons broad, convex, shiny with fine pits, about two times longer than maximum width one-third from apex, lateral margins arcuate, carination not clear, median carina very feebly visible; clypeus triangular, carinae obsolete; antennae short, terete, basal segment longer than broad, second segment about twice as long as first. Pronotum narrow, shorter in middle line than broad at anterior margin, carination obsolete; mesonotum longer than vertex and pronotum combined, carination not clear; hind basitarsus longer than other two together, calcar foliaceous, narrow, shorter than basitarsus with 15-16 minute teeth on hind border.

Male genetalia: Pygofer short, longer than broad, posterior opening a little longer dorso-ventrally than wide, a medio-ventral invagination with an internal flap below, latero-ventral angles produced into conical projections; anal angle entire; diaphragm without any armature; aedeagus pillar-like, cylindrical, basally broad, narrow towards apex which is encircled by three small hook-like teeth diverging cephalad, gonopore just behind apex ventrally, another tooth opposite to gonopore dorsally; genital styles short, somewhat hammer-

PLATE VIII

Fig. 1 : Unacharella indica, sp. nov.

Fig. 2 : Liburniellana bengalella, sp. nov.

Fig. 1

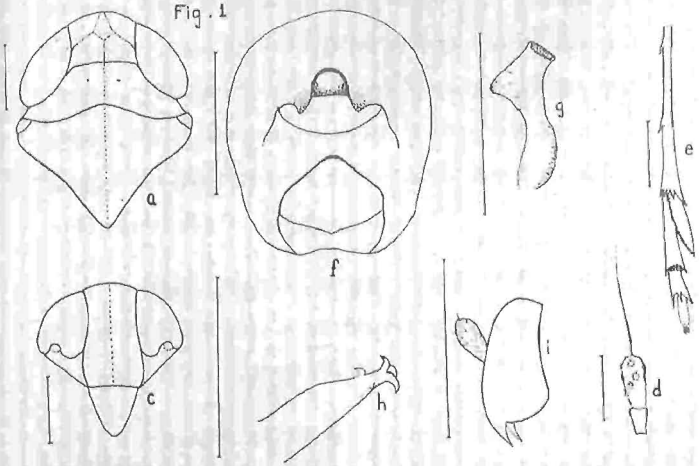
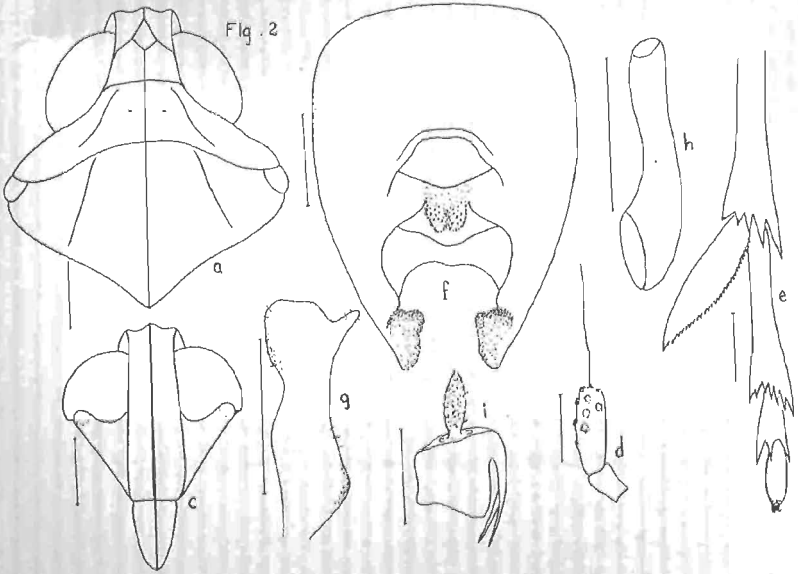


Fig. 2



shaped, laterally compressed, basal half narrow, apical half broadened, diverging laterad forming a head apically with inner angle tumid, outer angle truncate and the margin slightly folded backwards; anal segment short, ring-like, latero-apical angles produced ventrad in a pair of short spiny processes; anal style short, stumpy.

Measurements: Length - 2.20; Head - 0.58; Pronotum - 0.57; Antenna - 0.10+0.20; Hind tarsus - 0.32+0.28; Calcar - 0.21; Tegmen - 2.00.

Material examined: Holotype male "Inside lamp dome, I.A.R.I., Delhi; Ramdas Menon, Coll." (male genetalia on slide); allotype female with same data; paratypes: females 2 ex. labelled as the holotype.

Genus : Liburniellana, nov.

Head narrower than pronotum, vertex longer than broad, submedian carinae meeting before apex enclosing an areolet; frons narrow, longer than broad, lateral margins slightly sinuate; antennae short, terete; pronotum narrow, lateral carinae concave, not reaching hind margin; mesonotum as long as vertex and pronotum combined; hind basitarsus distinctly longer than other two combined, calcar short, many toothed. Pygofer moderately long, anal emargination produced, diaphragm with a dorso-median armature, aedeagus tubular.

Type of genus : Liburniellana bengalella, sp. nov.

This genus differs from the genus Liburniella by the presence of a row of minute teeth on the hind border of the tibial spur and thus goes under the tribe Delphacini. The three species before the author can be separated by the following key:

1. Anal emargination of pygofer greatly produced into a crumpled structure; dorso-median armature of diaphragm lobe-like; aedeagus tubular ..... L. bengalella, sp. nov.

-. Anal emargination not produced; dorso-median armature not lobe-like ..... 2.

2. Dorso-median armature of diaphragm slightly produced with a shallow notch apically; aedeagus tubular with a medio-ventral shallow depression ..... L. malabarica, sp. nov.

-. Dorso-median armature of diaphragm conical; aedeagus tubular without medio-ventral depression .. L. travencorensis, sp.nov.

16. Liburniellana bengalella, sp. nov. (Plate VIII, Fig. 2)

Colouration: Vertex, pro- and meso-nota piceous, hind edge of pronotum creamy white, carination pale ochraceous; frons, clypeus and genae brownish black, carination ochraceous brown; antennae and legs tawny; body ventrally brownish black; tegminal membrane fuscous, venation brownish black.

Form: Stout built form. Head distinctly narrower than pronotum; vertex broad, nearly twice longer than basal width,

lateral margins subparallel, apex truncate, as wide at apex as base, projecting in front of eyes; in profile somewhat bluntly acute, not following anterior border of eyes; carination strong, Y-shaped carina moderate, submedian carinae uniting before the apex enclosing an aerolet, basal compartment wider in hind margin than median length; frons elongate, narrow, about 3.5 times longer than maximum width one-third above apex, lateral margins slightly sinuate, tricarinate, median carina simple; clypeus, small, triangular, tricarinate; antennae short, terete, basal segment longer than broad, second segment about 2.5 times longer than first. Pronotum narrow, wider at base than long in middle, posterior margin incised, tricarinate, lateral carinae divergingly curved latero-caudad not reaching hind margin; mesonotum as long as vertex and pronotum combined, tricarinate; hind basitarsus distinctly longer than other two together, calcar foliaceous, shorter than basitarsus, 22 minute black teeth on hind border.

Male genetalia: Pygofer longer than broad, posterior opening longer dorso-ventrally than broad, anal emargination produced into an elongate structure, turned ventrad, ending in crumpled head, anal angle dorso-laterally invaginated; diaphragm with a dorso-median flap-like armature which is shallowly notched apically; aedeagus tubular, base slightly wider, apex, bluntly rounded, gonopore lateral to tip, genital styles short, laterally compressed, inner basal angle tumid, medially narrow, slightly twisted, turned dorsad, apex capitate with inner angle

produced into a small peg-like structure; anal segment narrow, ring-like, apical margin transverse, latero-apical angles produced ventrad in a pair of moderately long spinose processes; anal style short, stumpy.

Measurements: Length - 3.40; Head - 0.56; Pronotum - 0.76; Antenna - 0.14+0.33; Hind tarsus - 0.55+0.38; Calcar - 0.41; Tegmen - 2.60.

Material examined: Holotype male "Inside light trap, Kalimpong, Oct.'70, Coll. Basu". (male genetalia on slide).

17. Liburniellana malabarica, sp. nov. (Plate IX, Fig. 1)

Colouration: Vertex yellowish brown, pronotum creamy white with a few fuscous spots, mesonotum orange, anterior border with deep brown blotches; frons, genae, clypeus, prosternum and meso- and meta-coxae piceous, carination creamy white; antennae tawny; body ventrally deep brown; legs pallid; tegmina hyaline, venation ochraceous.

Form: Delicate insect. General characters same as in L. bengalella. X-shaped carina feebly developed; apex of vertex slightly narrower than base.

Male genetalia: Pygofer short, longer than broad, posterior opening a little longer dorso-ventrally than broad, anal emargination produced into a cone; diaphragm with a dorso-median, broadly conical armature having a shallow notch

PLATE IX

Fig. 1 : *Liburniellana malabarica*, sp. nov.

Fig. 2 : *Liburniellana travancorensis*, sp. nov.

Fig. 1

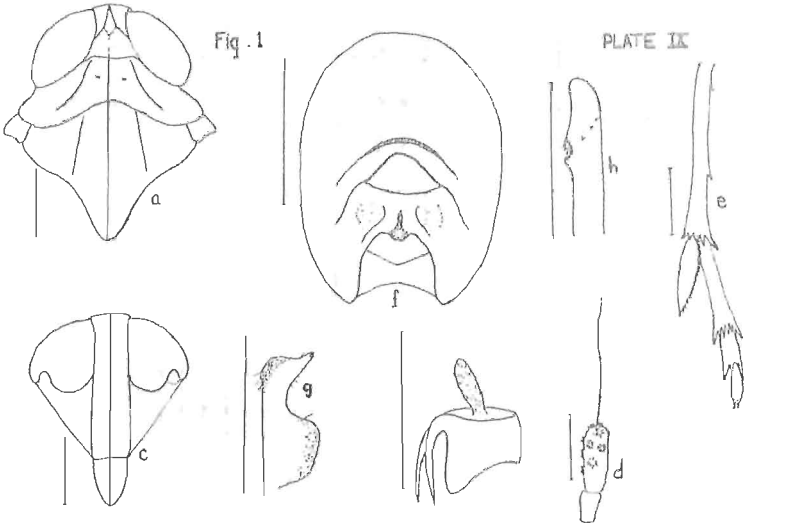
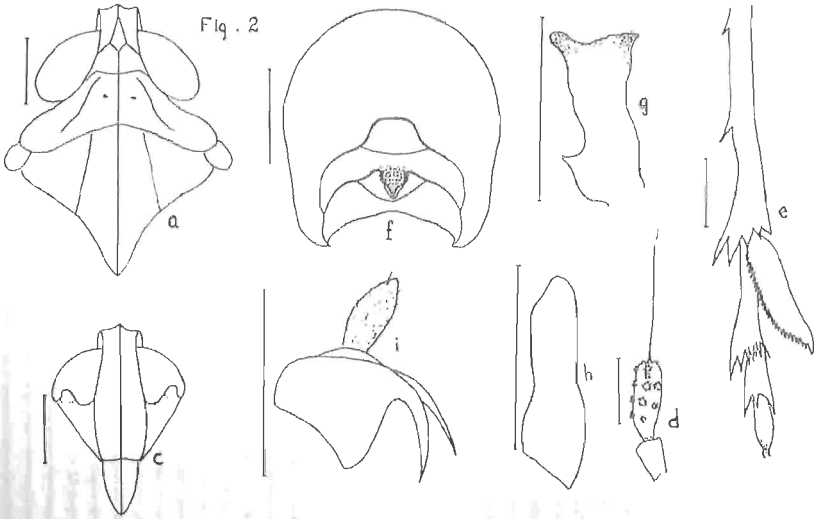


Fig. 2



at apex; aedeagus small, finger-shaped, tubular, with a blunt tip, a medio-ventral shallow depression with few teeth inside, 3-4 teeth in a diagonal line laterally, gonopore lateral to tip; genital styles short, laterally flattened, broad at base with inner angle produced, narrow in middle, turned latero-dorsad, apex truncate, outer angle round, inner angle produced to a narrow conical tip turned inward; anal segment narrow, ring-like, apical margin transverse, latero-apical angles produced ventrad in a pair of moderately long spinose processes; anal style short, stumpy.

Measurements: Length - 2.90; Head - 0.55; Pronotum - 0.64; Antenna - 0.10+0.25; Hind tarsus - 0.33+0.23; Calcar - 0.22; Tegmen - 2.30.

Material examined: Holotype male "Inside lamp dome, Tiruvella, Sept.'69, Coll. K.V. Mammen". (male genetalia on slide).

18. Liburniellana travencorensis, sp. nov. (Plate IX, Fig. 2)

Colouration: Vertex, pro- and meso-nota ochraceous with infuscations; frons, clypeus, genae and antennae tawny, carination ochraceous; body ventrally chocolate brown; legs pallid; tegmina hyaline, venation brown.

Form: General characters more or less same as in L. bengalella. Calcar as long as basitarsus.

Male genetalia: Pygofer longer than broad, posterior opening as long as wide dorso-ventrally; diaphragm forms a narrow bridge with a dorso-median conical armature covered with minute teeth; aedeagus tubular, basal half broad, narrowed apically with gonopore at tip; genital styles short, laterally compressed, basally broad with inner angle produced to a pointed appendage, medially narrow, slightly decurved dorsad, apex truncate with inner angle produced to a small finger-like projection, outer angle slightly produced laterad; anal segment short, apical margin transverse; latero-apical angles strongly produced ventrad in a pair of moderately long stout spinose processes; anal style short, oblong.

Measurements: Length - 3.40; Head - 0.63; Pronotum - 0.75; Antenna - 0.15+0.28; Hind tarsus - 0.51+0.39; Calcar - 0.50; Tegmen - 2.60.

Material examined: Holotype male "Inside lamp dome, Tiruvella, Feb.'70, Coll. K.V. Mammen"; allotype female with same data as the holotype; paratypes: 7 ex. from Tiruvella; 2 ex. from Delhi.

Genus : Megamelodes LeQuesne

LeQuesne, 1960, Entomologist, 93 : 13.

Small forms, usually brachypterous. Vertex longer than broad; lateral pronotal carinae divergingly curved, reaching posterior margin, distance between their posterior

ends much greater than the median carina; pygofer without any accessory lobes or outgrowths.

19. Megamelodes delhiensis, sp. nov. (Plate X, Fig. 1)

Colouration: Vertex brownish ochraceous, pro- and meso-nota and a transverse band along the last three abdominal tergites creamy; frons, clypeus, genae, antennae, body ventrally and legs tawny; tegmina smoky.

Form: Brachypterous forms. Head slightly narrower than pronotum; vertex narrow, about 1.5 times longer than basal width, apex round, slightly projecting in front of eyes, lateral margins shallowly concave; carination strong, Y-shaped carina distinct, submedian carinae uniting at apex, basal compartment shorter than basal width; frons elongate, narrow, about 3 times longer than maximum width in middle, lateral margins arcuate, median carina simple; clypeus subtriangular, tricarinate, median carina widened distally; antennae small, basal segment short, somewhat conical, longer than wide, second segment about twice longer than first. Pronotum narrow, tricarinate, lateral carinae divergingly curved latero-caudad, reaching posterior margin, distance between their posterior ends much greater than length of median keel; mesonotum triangular, shorter than vertex and pronotum combined, tricarinate; hind basitarsus longer than other two together, calcar tectiform, acuminate, 17-20 minute black teeth on hind margin, shorter than basitarsus.

PLATE X

Fig. 1 : Neramelodes delhiensis, sp. nov.

Fig. 2 : Phrictonyxa indica, sp. nov.

PLATE X

Fig. 1

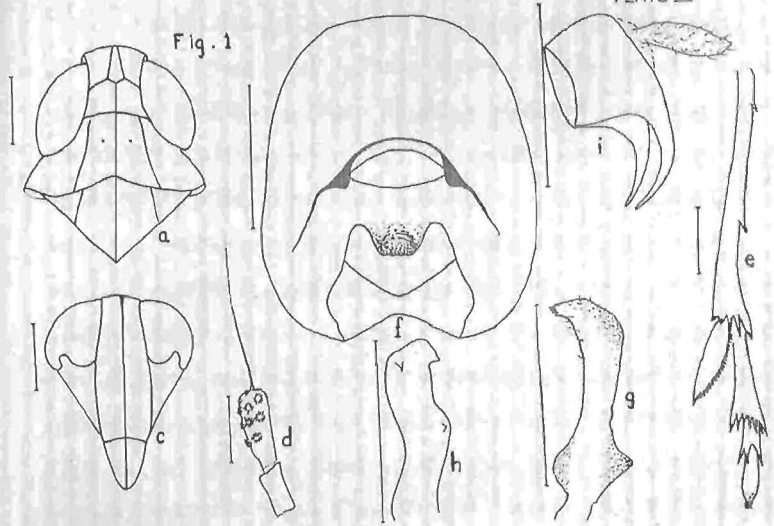
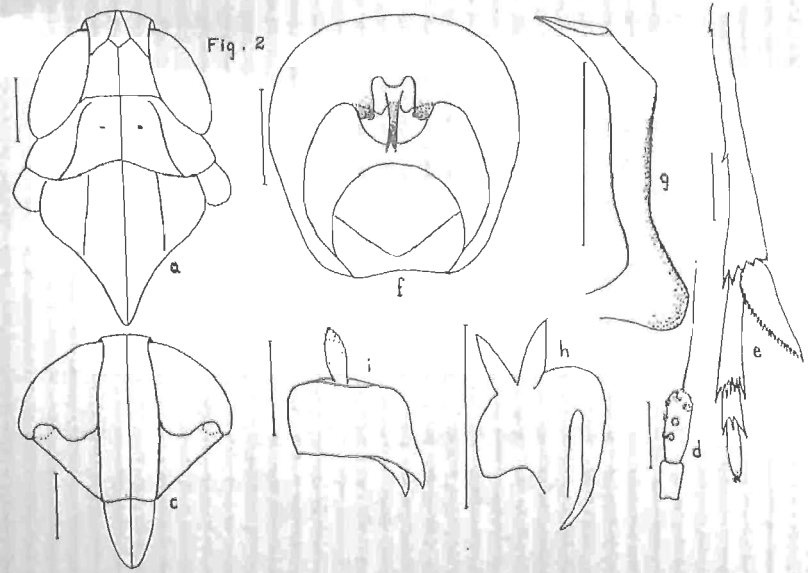


Fig. 2



Male genetalia: Pygofer longer than broad, widened posteriorly, posterior opening shorter dorso-ventrally than wide, ventro-lateral angle slightly produced, anal angle conically produced; diaphragm with a dorso-median flap, highly sclerotized with corrugated apex and transverse striations basally; aedeagus short, laterally compressed, a flexure ventrad in middle, apex obliquely blunted, turned dorsad, a tooth-like projection laterally near the ventral border just behind apex, another one near dorsal margin at median flexure; genital styles short, laterally compressed, directed dorsad, then curved laterad, inner basal angle truncate, produced into a cone, narrowed in middle, widened towards apex with outer angle narrowed ending in 4-5 teeth; anal segment ring-like, apical border transverse, latero-apical angles strongly produced ventrad in a pair of moderately long, curved, stout spinose processes; anal style oblong.

Measurements: Length - 1.80; Head - 0.61; Pronotum - 0.70; Antenna - 0.15+0.25; Hind tarsus - 0.42+0.30; Calcar - 0.27; Tegmen - 1.00.

Material examined: Holotype male "Swept on grass, Delhi, I.A.R.I., 14-10-1963, R. Menon, Coll."; allotype female with the same data; paratypes: 9 ex. labelled as the holotype.

Genus : Phrictonyxa Caldwell

Caldwell & Martorell, 1950, Jl. Agri. Univ. Puerto. Rico., 34(1) : 170.

Elongate forms. Head narrower than pronotum; vertex longer than broad; lateral pronotal carinae reaching hind margin; pygofer always with a medio-ventral process notched apically.

20. Phrictopyga indica, sp. nov. (Plate X, Fig. 2)

Colouration: Vertex, pro- and meso-nota ochraceous, suffused with creamy white blotches along lateral carinae; frons, genae and clypeus yellowish brown, frons with 5-6 dot-like creamy blotches on either side of median carina and a pallescent narrow stripe at apex; antennae ochraceous; body ventrally creamy brown; legs pallid; tegmina hyaline, venation in apical half fuscous.

Form: Head slightly narrower than pronotum; vertex elongate, about 1.25 times longer than broad, lateral margins subparallel, apex rounded, as wide as base, slightly projecting in front of eyes; carination strong, Y-shaped carina distinct, submedian carinae uniting at apex, basal compartment slightly shorter than hind margin; frons elongate, with subparallel margins, narrow at base, about 3 times longer than maximum width, tricarinate, median carina simple, ridged, lateral carinae elevated; antennae short, terete, basal segment short, longer than broad, second segment more than twice as long as first. Pronotum broad, posterior margin incised, tricarinate, lateral carinae divergingly curved latero-caudad, meeting hind border; meso-notum shorter than vertex and

pronotum combined, tricarinate; hind basitarsus longer than other two together, calcar elongate, foliaceous, shorter than basitarsus, 20-24 minute black teeth on hind margin.

Male genetalia: Pygofer longer than broad, posterior opening a little longer dorso-ventrally than broad, a medio-ventral elongated blade-like process vertically placed which is notched apically, ventro-lateral angles produced to small flaps covering bases of genital styles, anal angles entire; diaphragm without any armature; aedeagus short, laterally compressed, basal half broadly conical, apical half narrow, tubular curved backwards with pointed tip, genital orifice about the middle of tubular portion, two long ear-like appendages on the dorsal side about one-third from base, directed laterad; genital styles long, narrow, outer angle tumid, decurved dorsad, gradually widened, apex turned inwards, obliquely cut; anal segment broad, apical margin transverse, latero-apical angles produced ventrad to a pair of short, conical processes; anal style short, oblong.

Measurements: Length - 3.30; Head - 0.87; Pronotum - 0.92; Antenna - 0.12+0.22; Hind tarsus - 0.48+0.34; Calcar - 0.35; Tegmen - 3.00.

Material examined: Holotype male "Inside lamp dome, Delhi, I.A.R.I., Sept.'58, R. Menon, Coll.", allotype female labelled as the holotype; paratypes: 13 ex. with the same data.

Genus : Matutinus Distant

Distant, 1917, Trans. Linn. Soc. Zool., 17 : 278.

Vertex much longer than broad, in profile abruptly acute, angulately rounding into frons, submedian carinae meeting at apex of vertex or at extreme base of frons.

The three species with the author can be separated on the basis of the following key:

1. Dorso-median armature of diaphragm conical, broader than long; aedeagus narrowing towards apex ..... M. pusanus
-. Dorso-median armature of diaphragm lobe-like, longer than broad ..... 2.
2. Apex of diaphragmal armature notched, lateral margins folded ventrally, anal spines long ..... M. indicus, sp. nov.
-. Apex of diaphragmal armature without notch, lateral margins not folded, anal spines moderate ..... M. malabaricus, sp.nov.

21. Matutinus indicus, sp. nov. (Plate XI, Fig. 1)

Colouration: Vertex and pronotum ochraceous, a brownish speck internal to lateral pronotal carinae distally, mesonotum more deep, lateral area deep brown; frons, genae and clypeus deep brown; antennae and legs testaceous, tegmina hyaline with yellowish tint, a brown macula at claval apex, a smoky fascia beyond middle which proceeds to apex, parallel to apical margin and covering the anal apical area.

Form: Stout built forms. Head slightly narrower than pronotum, vertex elongate, narrow about twice longer than

PLATE XI

Fig. 1 : Matutima indicus, sp. nov.

Fig. 2 : Matutima malabaricus, sp. nov.

PLATE XI

Fig. 1

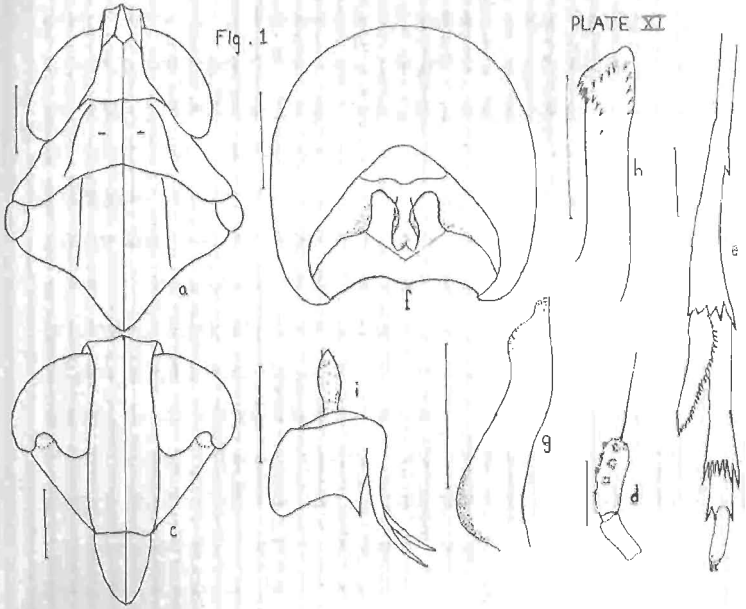
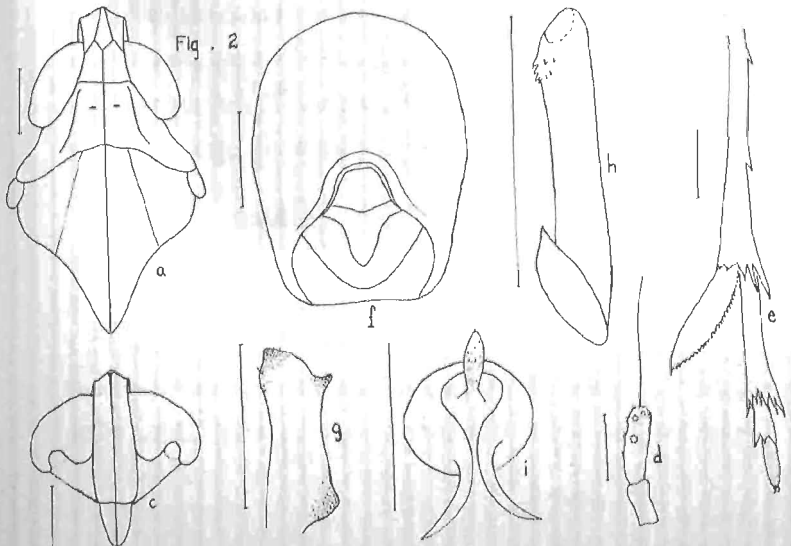


Fig. 2



basal width, apex truncate with median carina prominent, slightly narrower than base, projecting in front of eyes, angulately rounding into frons, lateral margins subparallel, elevated; carination strong, stalk of Y-shaped carina obsolete, submedian carinae uniting at apex, basal compartment little longer than broad; frons elongate, narrow, widened apically, about 3 times longer than maximum width at two-third from base, lateral margins slightly arcuate, carination distinct, median carina simple ridged, lateral carinae elevated; clypeus triangular, basal width slightly narrower than apex of frons, tricarinate; antennae small, basal segment short, terete, longer than broad, second segment about twice longer than first. Pronotum narrow, posterior border incised, in middle line distinctly shorter than vertex, tricarinate, lateral carinae divergingly curved latero-caudad, not attaining hind margin; mesonotum about the same length as vertex and pronotum combined, tricarinate; hind basitarsus slightly longer than other two together, calcar foliaceous, large, 18-19 minute teeth on hind margin, as long as basitarsus or slightly shorter.

Male genetalia: Pygofer longer than broad, posterior opening a little wider dorso-ventrally than long, latero-dorsal angle feebly produced and inflected; anal angle produced in a conical tip; diaphragm with a dorso-median flap, apically notched at middle, lateral margins folded ventrally; aedeagus short, cylindrical, laterally compressed with an obliquely

truncated apex, a row of teeth encircling the apical gonopore, another row starting from dorsal tip proceed laterally upto middle on either side, one row on ventral border starting from tip proceed upto middle; genital styles stout, long, laterally compressed, basally wider, directed dorso-laterad, narrowed, a slight swelling at inner apical angle, outer angle produced into a narrow truncated stump; anal segment narrow, apical margin moderately short, transverse, latero-apical angles strongly produced ventrad in a pair of moderately long, stout, spinose processes; anal style short, stumpy.

Measurements: Length - 4.20; Head - 0.72; Pronotum - 0.84; Antenna - 0.15+0.28; Hind tarsus - 0.53+0.34; Calcar - 0.45; Tegmen - 3.40.

Material examined: Holotype male "Inside lamp dome, I.A.R.I., New Delhi, Oct.'69, Coll. K.V. Mammen", allotype female labelled as the holotype; paratypes: 2 ex. from Coimbatore.

22. Matutinus malabaricus, sp. nov. (Plate XI, Fig. 2)

Colouration: Vertex, pro- and meso-nota coppery brown, shiny; frons and genae tawny; clypeus lighter than frons; antennae ochraceous; body ventrally brown; legs pallid; tegmina smoky, venation brown.

Form: General characters as in M. indicus; apex of vertex slightly conical, as wide as base; Y-shaped carina prominent.

Male genetalia: Pygofer longer than broad, posterior opening a little wider dorso-ventrally than long, a median invagination on ventral border, anal angle produced to a blunt cone; diaphragm narrow, bridge-like, a dorso-median tongue-like armature with numerous small teeth-like projections; aedeagus small, tubular, apex bluntly rounded, gonopore lateral to apex, minute teeth behind apex dorsally and laterally; genital styles short, stout, laterally compressed, inner basal angle wide, medially narrow, apex obliquely cut with a small conical projection at the inner angle; anal segment narrow, apical margin transverse, latero-apical angles produced ventrad in a pair of moderately long spinose processes; anal style short, oblong.

Measurements: Length - 3.40; Head - 0.63; Pronotum - 0.75; Antenna - 0.15+0.28; Hind tarsus - 0.52+0.40; Calcar - 0.46; Tegmen - 2.60.

Material examined: Holotype male "Inside lamp dome, Tiruvella, Sept.'69, Coll. K.V. Mammen", allotype female labelled as the holotype; paratypes: 5 ex. with the same data.

23. Matutinus pusanus (Distant) comb. nov. (Plate XII, Fig. 1)

= Sogata pusana Distant, 1912, Ann. Mag. Nat. Hist., (8)9 : 191.

= Liburnia pusana Metcalf, 1943, General Catalogue Hemiptera, 4(3) : 368.

Colouration: Vertex, pro- and meso-notal discs yellow, lateral field of pro- and meso-nota brownish fuscous; frons

and genae deep brown, carination ochraceous; clypeus and antennae tawny; body beneath deep brown; legs ochraceous except fore and middle coxae tawny; tegmina subhyaline, an upper claval streak becoming macular at claval apex, a transverse linear discal spot beyond middle, a subapical marginal suffusion continued along veins to apical margin leaving hyaline marginal spots in the cells.

Form: General characters as in M. indicus; frons elongate, about 4 times longer than maximum width.

Male genetalia: Pygofer longer than broad, posterior opening a little longer dorso-ventrally than broad, anal angle feebly produced; diaphragm produced into a dorso-median conical projection with two longitudinal thickenings forming a subtriangular area having numerous minute teeth; aedeagus long, tubular, broader at base, narrowed apically, gonopore at tip with a row of spines all around, a row of 4-5 teeth laterally and two teeth ventrally about one-third from apex; genital styles short, broad at base, medially narrow, broadened towards apex with the outer angle produced into a narrow prolongation diverging laterad; anal segment short, apical margin transverse, latero-apical angles produced ventrad in a pair of moderately long stout spinose processes; anal style short, oblong.

Measurements: Length - 3.20; Head - 0.54; Pronotum - 0.72; Antenna - 0.13+0.23; Hind tarsus - 0.44+0.35; Calcar - 0.32; Tegmen - 2.40.

PLATE XII

Fig. 1 : *Matutinus pusanus* (Distant) comb. nov.

Fig. 2 : *Nilaparvata lugens* (Stal)

PLATE XII

Fig. 1

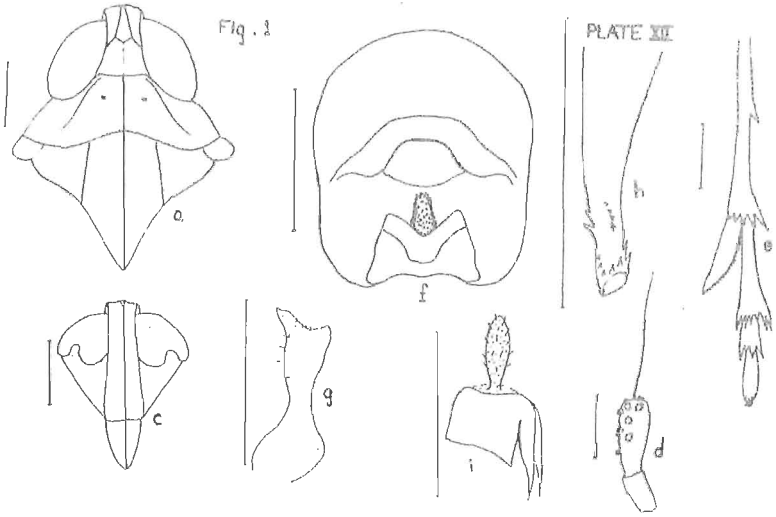
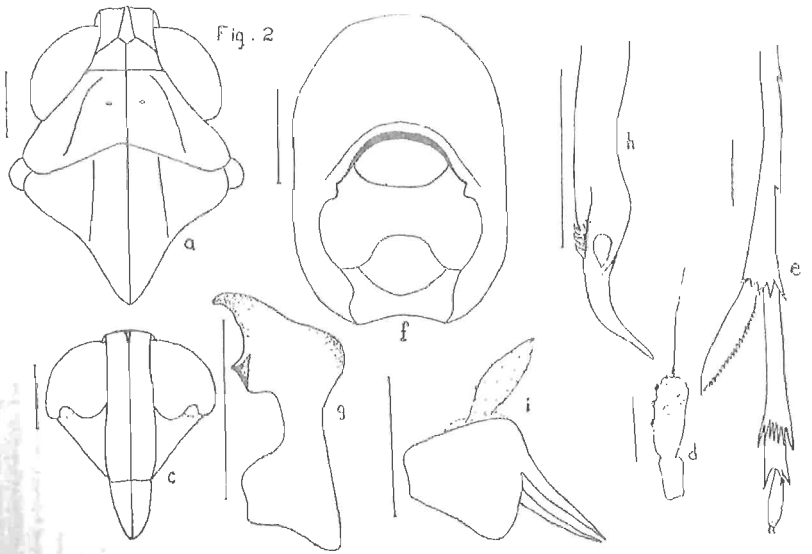


Fig. 2



Material examined: 3 ex. from NPC (Pusa, Bihar), 2 ex. from Coimbatore; 3 ex. from Tiruvella and 14 ex. from Delhi.

Genus : Nilaparvatha Distant

Distant, 1906, Fauna British India, 3 : 473.

Head narrower than pronotum; vertex longer than broad, submedian carinae forked at extreme apex or base of frons, lateral pronotal carinae curving behind eyes, not reaching hind margin; hind basitarsus with one or more lateral spines.

24. Nilaparvatha lugens (Stal) (Plate XII, Fig. 2)

Muir and Giffard, 1924, Bull. Hawaiian Sugar Pl. Assoc., 15 : 16.

= Delphax lugens Stal, 1854, Ofv. Svenska Vet. Akad. Forh., 11 : 246.

= Nilaparvatha greeni Distant, 1906, Fauna British India, 3 : 473.

= Kalpa aculeata Distant, 1906, Fauna British India, 3 : 474.

= Nilaparvatha sordescens Muir, 1922, Rec. Indian Mus., 24 : 350.

Colouration: (Typical form) Vertex, pro- and mesonota castaneous brown; frons, clypeus and genae ochraceous brown, carination pale ochraceous; antennae and legs ochraceous brown; body ventrally brown; tegmina subhyaline with a dull yellowish tint, transverse and apical veins fuscous, an elongate black macula at claval apex.

Colour variations from the above are commonly noticeable forming mixed populations.

Form: Head narrower than pronotum; vertex elongate about 1.5 times longer than basal width, lateral margins subparallel, apex truncate, slightly projecting in front of eyes, posterior margin transverse; carination strong, Y-shaped carina distinct, submedian carinae not uniting at apex, basal compartment wider at hind margin than median length; frons elongate, narrow, about 3.5 times longer than maximum width, lateral margins subparallel, tricarinate, median carina furcate at extreme base; clypeus triangular, tricarinate; antennae moderate, terete, basal segment short, longer than broad, second segment about twice as long as first. Pronotum narrow, as long as vertex, incised posteriorly, tricarinate, lateral carinae curved, not meeting hind margin; mesonotum slightly longer than vertex and pronotum combined, tricarinate, hind basitarsus distinctly longer than other two together, 2-3 small spines on the sides; calcar foliaceous, shorter than basitarsus, 28-30 minute black teeth on hind margin.

Male genitalia: Pygofer longer than broad, posterior opening a little longer than broad, anal angle entire; diaphragm without any armature, dorsal border shallowly concave; aedeagus elongate, tubular, wider in middle, apex narrow, directed dorsad, ending in a pointed tip, gonopore one-third from tip laterally, a row of 3-5 teeth ventral to gonopore; genital styles short, laterally compressed, base

wider with inner angle, tumid, medially narrow, twisted, apex crumpled, inner angle produced into two elongate processes, the lower one deflected inwards, outer angle bulged round; anal segment broad, apical margin transverse, latero-apical angles produced ventrad in a pair of strong spinose processes; anal style long, fusiform.

Measurements: Length - 3.50; Head - 0.75; Pronotum - 0.82; Antenna - 0.16+0.28; Hind tarsus - 0.62+0.40; Calcar - 0.44; Tegmen - 3.00.

Material examined: 30 ex. from Kerala (Tiruvella, Pathanamthitta and Trivandrum); 5 ex. from NPC; 3 ex. from Delhi; 3 ex. from Kalimpong (West Bengal).

Genus : Sardia Melichar

Melichar, 1903, Homop-Fauna Ceylon, 96.

Elongate forms. Head narrower than pronotum; vertex very long, narrow, projecting in front of eyes, submedian carinae meeting before apex; frons long, narrow, broadened apically; lateral pronotal carinae not meeting hind margin.

25. Sardia rostrata Melichar (Plate XIII, Fig. 1)

Melichar, 1903, Homop-Fauna Ceylon, 96.

Colouration: Vertex, pro- and meso-nota carineous, anterior and posterior border of pronotum flavescent, tip of scutellum pale yellow; frons, clypeus and genae brownish black,

basally frontal carinae in between eyes pale yellow; antennae ochraceous; body ventrally dark brown, legs ochraceous except fore and middle coxae brown; tegmina smoky, venation all along fuscous in apical half.

Form: Head oblong, narrower than pronotum; vertex elongate, narrow, about three times longer than basal width, about half the length project in front of eyes as a beak, lateral margins subparallel; Y-shaped carina feeble, submedian carinae unite slightly before apex, continue as a single carina, basal compartment distinctly longer than broad; frons narrow, elongate, lateral margins from base to level of eyes straight and subparallel, thence arcuate to give a general lyrate appearance, about 4 times longer than maximum width just above apex, tricarinate, median carina simple, forms a blade at base; clypeus narrow, triangular, tricarinate; antennae terete, basal segment short, longer than wide, second segment about twice as long as first. Pronotum narrow, tricarinate, lateral carinae straight, diverging, tip not reaching posterior margin; mesonotum shorter than vertex and pronotum combined, tricarinate; hind basitarsus longer than other two together, calcar foliaceous 18-25 teeth on hind margin, shorter than basitarsus.

Male genetalia: Pygofer longer than broad, posterior opening longer dorso-ventrally than broad, anal angle entire; diaphragm dorsally produced into a broad shield, the apex

PLATE XIII

Fig. 1 : *Sardia rostrata* Melichar

Fig. 2 : *Eosarysa bispinosa*, sp. nov.

Fig. 1

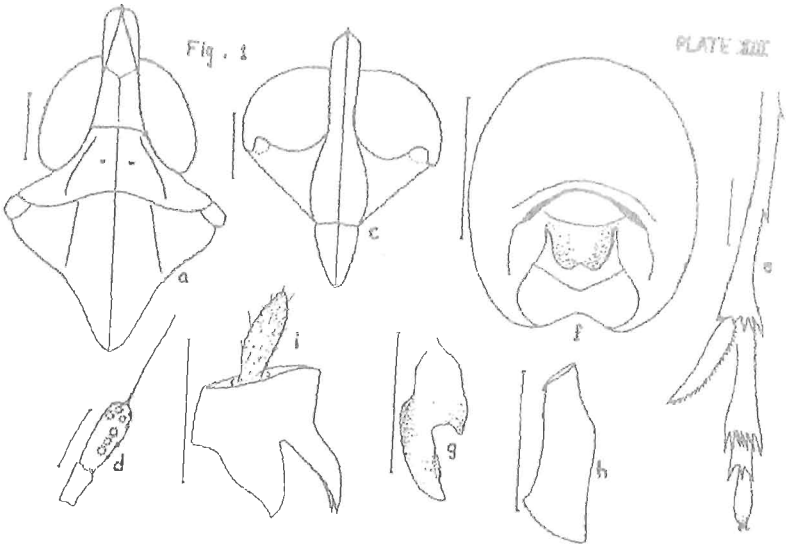
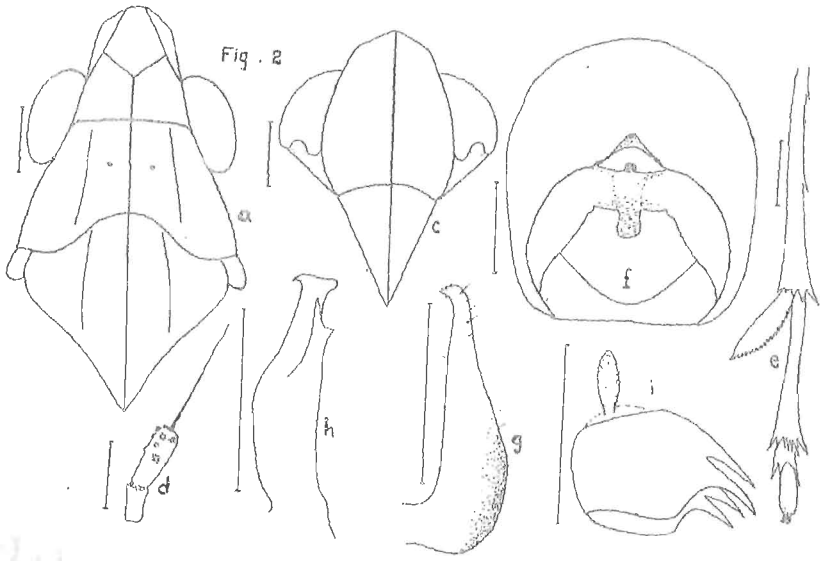


Fig. 2



notched; aedeagus tubular, basally broadened with a slight median bend ventrally, apex obliquely cut with gonopore at tip, a few minute teeth dorsal to gonopore, genital styles somewhat sickle-shaped, laterally compressed, base much broader than distal region, inner basal angle produced into a conical prolongation, apex narrow, pointed with two teeth-like processes at tip; anal segment ring-like, apical margin transverse, latero-apical angles strongly produced ventrad in a pair of moderately long, stout spinose processes; anal style oblong.

Measurements: Length - 5.00; Head - 0.63; Pronotum - 0.80; Antenna - 0.15+0.29; Hind tarsus - 0.47+0.33; Calcar - 0.36; Tegmen - 3.25.

Material examined: 12 ex. from Kerala (Tiruvella and Trivandrum); 7 ex. from Coimbatore; 3 ex. from Delhi.

Genus : Eosurysa Muir

Muir, 1913, Proc. Hawaiian Ent. Soc., 2 : 249.

Stout built forms. Vertex elongate, at base more than twice as broad as an eye in the same line, in profile junction of vertex and face acutely angular; genital styles articulated on the ventral edge of pygofer, not within it.

26. Eosurysa bispinosa, sp. nov. (Plate XIII, Fig. 2)

Colouration: Vertex and pronotum ochraceous, anterior border of pronotum brownish black, mesonotum piceous; frons jet black with an yellow band basally; clypeus black; genae

ochraceous in front of eyes, posteriorly black; antennae and body ventrally brownish black; fore and middle legs brown, hind legs less deep; tegmina dark smoky, apically more deep, venation dark brown.

Form: Head narrower than pronotum; vertex elongate, broad, subconical about 1.25 times longer than basal width, at base, about 2.5 times more than the width of an eye, apex broadly conical, narrower than base, project in front of eyes, lateral margins straight; carination distinct, Y-shaped carina prominent, submedian carinae broadly uniting at apex, basal compartment wider at hind margin than median length; frons short, broad, flat about 2 times longer than maximum width at level of ocelli, surface very finely pubescent, tricarinate, junction of vertex and frons acutely angular in profile, fronto-clypeal suture distinctly arched; clypeus long, triangular, convex, median carina obsolete; antennae small, terete, basal segment short, longer than wide, second segment about twice as long as first. Pronotum about the same length as vertex, deeply incised posteriorly tricarinate, lateral carinae straight, not attaining hind margin; mesonotum shorter than vertex and pronotum together, tricarinate; hind basitarsus distinctly longer than other two combined, calcar acuminate, shorter than basitarsus, 16-18 minute teeth on hind margin. Tegmina narrow and long.

Male genetalia: Pygofer broad, posterior opening as long as wide dorso-ventrally, slightly emarginate medio-

ventrally, anal angle entire; diaphragm with a small button like median projection on ventral margin, a median trunk-like prolongation dorsally; aedeagus boat-shaped, laterally compressed, distally divided into two, ventral one longer than dorsal, apex truncate with a small thorn ventrally; dorsal half short, narrow, pointed, not reaching the tip of the other, having a median thickening; genital styles attached to the medio-ventral edge of pygofer, elongate, curved dorsad, basally narrow, gradually enlarged upto basal half, then narrowed towards apex which is curved inwards; anal segment short, broad, apical margin transverse, latero-apical angles produced ventrad into two pairs of small spinose processes; anal style small.

Measurements: Length - 4.30; Head - 0.70; Pronotum - 0.80; Antenna - 0.10+0.21; Hind tarsus - 0.52+0.30; Calcar - 0.34; Tegmen - 3.00.

Material examined: Holotype male "On maize, Jalpaiguri, Bengal, 30-4-68, Coll. Battacharya"; allotype female labelled as the holotype; paratypes: 6 ex. labelled as "On sugarcane, Gauhati, July 1970, R. Menon, Coll."

Genus : Stenocranus Fieber

Fieber, 1866, Verh. Zool. Bot. Ges. Wien., 16 : 519.

Vertex elongate, second antennal segment about 3 times longer than first; in males aedeagal periandrum passes through

an accessory appendage, in females third valvula distinctly broader.

27. Stenocranus aimerensis Joseph (Plate XIV, Fig. 1)

Joseph, 1964, J. Bombay nat. Hist. Soc., 61(2) : 460.

Colouration: Vertex, pro- and meso-nota stramineous, lateral area of mesonotum stramineous suffused with ochraceous, carination creamy; frons piceous; clypeus and genae tawny, carination creamy white; antennae tawny; body ventrally ochraceous; legs stramineous with castaneous streaks; tegmina subhyaline, venation in apical half pale brown.

Form: Elongate forms. Head slightly narrower than pronotum, vertex elongate, about twice as long as basal width, lateral margins slightly arcuate, apex round, projecting in front of eyes, less wide than base; carination distinct, Y-shaped carina prominent, submedian carinae abruptly converging towards each other about a third from apex and continued on upto the clypeus as two independent but closely approximated carinae, basal compartment wider in hind margin than median length; frons elongate, about three times longer than maximum width, lateral margins subparallel; clypeus subtriangular, tricarinate; antennae short, terete, basal segment longer than wide, second segment about 3 times longer than first. Pronotum narrow, incised posteriorly, lateral carinae diverging not meeting hind margin; mesonotum almost equal to

PLATE XIV

Fig. 1 : *Stenocranus simerensis* Joseph

Fig. 2 : *Thimuvella longicornis*, sp. nov.

Fig. 1

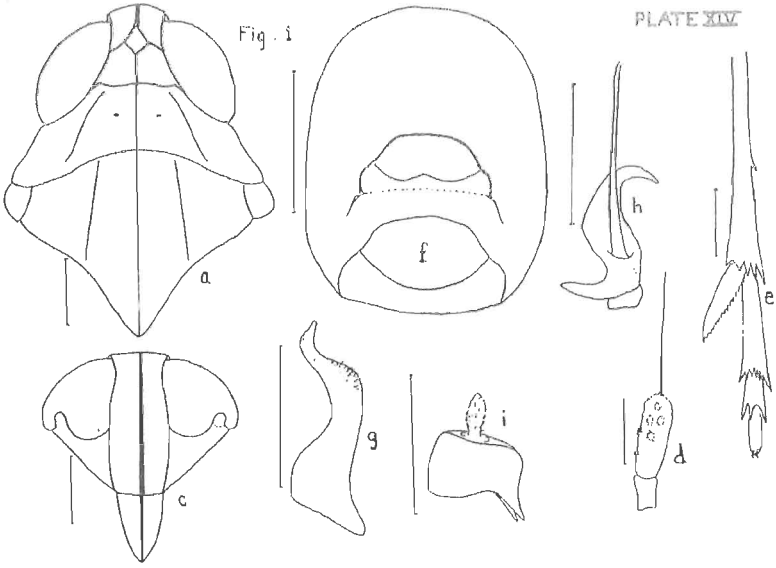
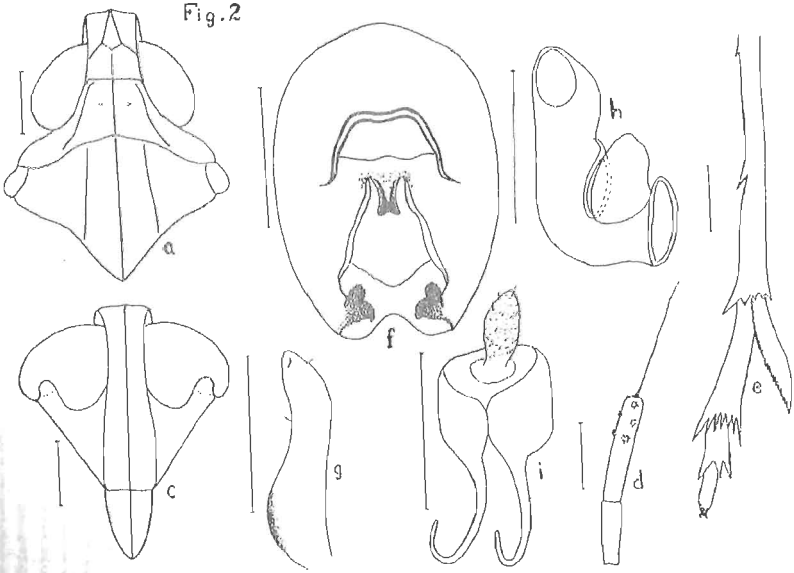


Fig. 2



vertex and pronotum combined; hind basitarsus slightly longer than other two together, calcar foliaceous, shorter than basitarsus, 12-15 teeth on hind margin.

Male genetalia: Posterior opening of pygofer as broad as long, with a medio-ventral invagination, anal angles entire; diaphragm without armature; aedeagus long tubular, narrowing gradually from base to tip with the apex turned backwards; from the aedeagus basal strut arises a sickle-shaped structure with a swollen cylindrical base which has a hole through which the aedeagus projects out; genital styles basally swollen, broadly sickle-shaped with the distal end directed dorso-laterad, apex pointed; anal segment ring shaped, apical margin transverse, latero-apical angles produced ventrad in a pair of short, blunt processes; anal style short, oblong.

Measurements: Length - 4.50; Head - 0.70; Pronotum - 0.84; Antenna - 0.12+0.34; Hind tarsus - 0.48+0.41; Calcar - 0.36; Tegmen - 3.85.

Material examined: Holotype male "Inside lamp dome, I.A.R.I., Delhi, Sept.'59, R. Menon, Coll."; allotype female and 7 paratypes with same data as the holotype; 2 ex. collected from Delhi.

Genus : Tiruvella nov.

Stout built form. Head narrower than pronotum; vertex longer than broad, projecting in front of eyes;

carination strong, submedian carinae meeting at apex; frons narrow, distinctly longer than wide, lateral margins more or less straight, diverging; apex broader than base, tricarinate; antennae long, cylindrical, basal segment more than half length of second. Pronotum narrow, tricarinate, lateral carinae not meeting hind margin; mesonotum shorter than vertex and pronotum combined; hind basitarsus longer than other two together, calcar foliaceous, as long as basitarsus, many toothed. Pygofer long, anal emargination produced to a crust-shaped apex; diaphragm with a dorso-median thick, apically bifid armature; aedeagus forms a half of a horse-shoe, laterally compressed; genital styles knife-like; anal segment with a pair of long spinous process.

Type of genus : Tiruvella longicornis, sp. nov.

This genus comes near to Platyparsia by the long, slender antennae and the calcar characters, but the elongate vertex and the forking of submedian carinae on vertex place it in a new genus.

28. Tiruvella longicornis, sp. nov. (Plate XIV, Fig. 2)

Colouration: Vertex and mesonotum tawny, pronotum creamy white, anterior border and lateral area brown; frons tawny, clypeus ochraceous, genae black; antennae and legs ochraceous brown; body ventrally brown; tegmina hyaline, venation brown.

Form: Head narrower than pronotum; vertex elongate, about 1.5 times longer than basal width, posterior margin transverse, lateral margins parallel, elevated, apex quadrate with median carina prominent, as wide at apex as base, projecting in front of eyes; carination strong, Y-shaped carina feebly developed, submedian carinae uniting at apex, basal compartment as wide as median length; frons elongate, narrow at base widened towards apex, about 4 times longer than maximum width, lateral margins straight, slightly diverging towards apex, tricarinate, median carina simple; clypeus triangular, convex dorsally, tricarinate, median carina more elevated; antennae long, cylindrical, basal segment short, more than half length of second. Pronotum narrow, posterior margin deeply incised, tricarinate, lateral carinae straight, divergingly curved latero-caudad, not attaining hind margin; mesonotum shorter than vertex and pronotum combined, tricarinate; hind basitarsus longer than other two together, calcar foliaceous, acuminate, as long as basitarsus with 20 minute black teeth on hind margin.

Male genetalia: Pygofer long, posterior opening longer dorso-ventrally than broad, anal emargination deeply produced into a crust-shaped prolongation, turned ventrad, ending in a bifid apex with tuberculations; ventral border of diaphragm straight, dorsally produced into a thick median laterally flat, long, apically bifid armature; aedeagus short,

flat, laterally compressed, shaped like half of a horse-shoe; a basal rectangular shield ventrally, apex conically blunt with gonopore lateral to tip, a chitinized ring-like structure ventrally in between the basal shield and ventral margin; genital styles long, knife-like, laterally compressed, inner basal angle broadened, medially narrow, turned laterad and curved dorsad, tip obtusely blunt; anal segment ring-like, apical margin transverse, latero-apical angles strongly produced ventrad in a pair of long, narrow, stout spines with curved tips, and style short, stumpy.

Measurements: Length - 3.50; Head - 0.75; Pronotum - 0.83; Antenna - 0.24+0.40; Hind tarsus - 0.68+0.40; Calcar - 0.65; Tegmen - 2.90.

Material examined: Holotype male "Inside light trap, Tiruvella, Feb.'70, Coll. K.V. Mammen"; (male genetalia on slide).

Genus : Coronacella Metcalf

Metcalf, 1950, Occass. Pap. Bernice P. Bish. Mus., 20(5) : 59.

Head nearly as broad as pronotum, vertex quadrangular, lateral carinae strongly elevated, submedian carinae meeting at apex; lateral pronotal carinae not reaching hind margin; hind basitarsus about twice as other two combined.

29. Coronacella curvipenis, sp. nov. (Plate XV, Fig. 1)

Colouration: Vertex ochraceous brown, pronotum yellowish white except lateral area behind eyes brown, mesonotum deep brown, apex of scutellum creamy white, lateral area posterior to tegulae orange yellow; frons, clypeus and genae brownish black, carination creamy white; antennae ochraceous, basal segment deep; body ventrally brown; legs ochraceous; tegmina hyaline, venation ochraceous, a brownish black macula at claval apex.

Form: Head slightly narrower than pronotum; vertex quadrangular, longer than basal width, apex quadrate with median carina prominent, slightly narrower than base, lateral margins subparallel, strongly elevated; Y-shaped carina obsolete, submedian carinae uniting at apex, basal compartment wider at hind margin than median length; eyes large; frons elongate, narrow, about three times longer than maximum width in middle, narrowest at base in between eyes, lateral margins slightly arcuate, elevated, median carina simple; clypeus subtriangular, tricarinate; antennae short, terete, first segment longer than broad, second segment about twice longer than first. Pronotum broad, narrow at base than long in middle, tricarinate, lateral carinae straight, diverging latero-caudad not meeting hind margin; mesonotum as long as or slightly shorter than vertex and pronotum together, tricarinate; hind basitarsus slightly longer than other two

PLATE XV

Fig. 1 : *Coronacella curvipenis*, sp. nov.

Fig. 2 : *Unkanodes straminacoma*, sp. nov.

PLATE XV

Fig. 1

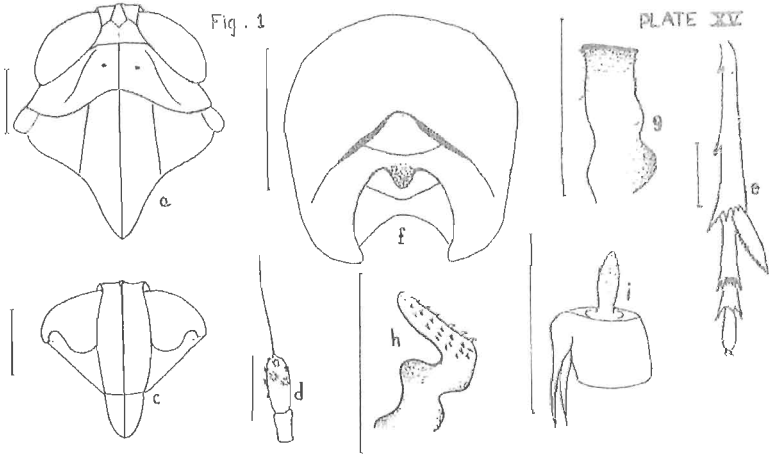
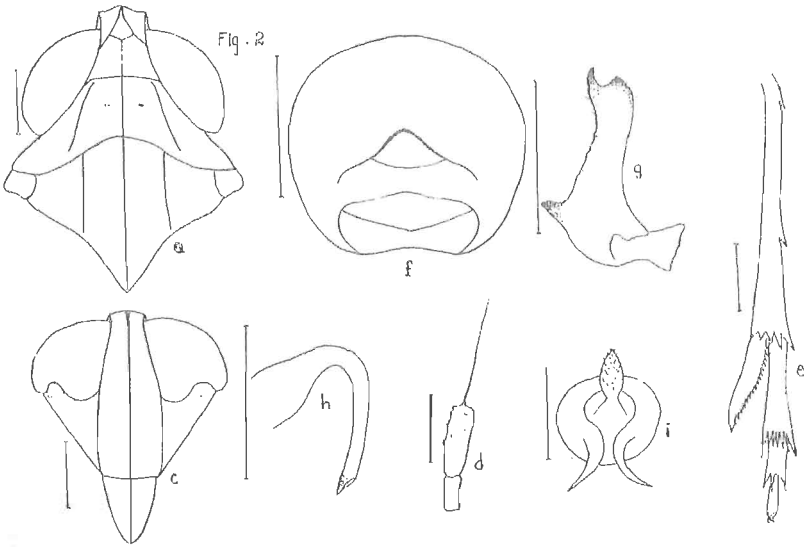


Fig. 2



combined, calcar foliaceous, thin with a row of 12-17 teeth on hind margin, shorter than basitarsus.

Male genetalia: Pygofer longer than broad, posterior opening more or less circular, anal angle produced into a blunt cone, turned inwards; diaphragm narrow with a dorso-median bluntly conical armature; aedeagus tubular, hook-like, narrowed apically, gonopore posterior to tip, rows of minute teeth dorsally and laterally in the apical half; genital styles short, subrectangular, laterally compressed, inner angle slightly swollen, apex truncate; anal segment, narrow, apical margin transverse, latero-apical angles strongly produced ventrad in a pair of moderately long spinose processes; anal style short, oblong.

Measurements: Length - 2.80; Head - 0.58; Pronotum - 0.62; Antenna - 0.11+0.21; Hind tarsus - 0.23+0.20; Calcar - 0.20; Tegmen - 2.20.

Material examined: Holotype male "Inside lamp dome, Coimbatore, Nov.-Dec.'59, Coll. A.R. Agarwal". Paratype: 2 males (male genetalia on slides) labelled as the holotype.

Genus : Unkanodes Fennah

Fennah, 1956, Proc. Calif. Acad. Sci., 28(4) : 443.

Vertex longer than broad, width at base not exceeding width of an eye; forking of median frontal carina at extreme base; basal segment of antennae more than twice as long as

broad at apex; lateral pronotal carinae not meeting hind margin.

30. ? Unkanodes straminecus, sp. nov. (Plate XV, Fig. 2)

Colouration: Vertex, pro- and meso-nota stramineous, Y-shaped carina on vertex, pronotal carinae and median mesonotal carina creamy yellow, lateral carinae on vertex and mesonotum yellowish, sides of mesonotal disc suffused with yellow, lateral area of submedian carinae at apex of vertex and on frons piceous; clypeus, genae, antennae, legs and ventral side of body ochraceous; tegmina subhyaline with yellowish tint, venation ochraceous.

Form: Elongate forms. Head slightly narrower than pronotum; vertex elongate, narrow about 1.5 times longer than basal width, projecting in front of eyes, lateral margins shallowly concave, apex rounded, slightly narrower than base; Y-shaped carina feeble, submedian carinae not uniting at apex, but closely following side by side upto middle of eyes on the frons, basal compartment as broad at hind margin as the median length; frons elongate, lateral margins slightly diverging, about three times as long as maximum width at apex, base narrower than apex, tricarinate, lateral carinae elevated; clypeus subtriangular, tricarinate; antennae short, terete, basal segment longer than broad, second segment about 2.5 times longer than first. Pronotum narrow, broader at base

than long in middle, posterior margin incised, tricarinate, lateral carinae straight, diverging latero-caudad, not attaining hind margin; mesonotum slightly smaller than vertex and pronotum combined, tricarinate; hind basitarsus longer than other two together, calcar foliaceous, shorter than basitarsus, 12-15 minute teeth on hind margin.

Male genetalia: Pygofer longer than broad, posterior opening a little broader dorso-ventrally than long, anal angle entire; diaphragm without any armature; aedeagus tubular, long, beak-like, basally swollen, tubular portion curved ventrad with oblique apex, gonopore posterior to tip, minute teeth opposite to gonopore; genital styles short, basal half broad with the inner angle produced to a spine, apical half narrow, turned latero-dorsad, inner apical angle produced to a finger like prolongation; anal segment short, ring-like, latero-apical angles produced ventrad in a pair of short spinose processes; anal style short, fusiform.

The antennal character seems to agree with the genus Unkanodes, but the carination do not fully agree with the key characters given by Fennah (1956); hence this is hesitantly placed under this genus.

Measurements: Length - 4.00; Head - 0.60; Pronotum - 0.75; Antenna - 0.10+0.25; Hind tarsus - 0.45+0.27; Calcar - 0.28; Tegmen - 3.60.

Material examined: Holotype male "Inside lamp dome, I.A.R.I., New Delhi, June'70; Coll. K.V. Mammen". Paratypes: 2 males (genetalia on slide) labelled as the holotype.

Genus : Sogatella Fennah

Fennah, 1963, Bull. ent. Res., 54 : 48.

Vertex longer than wide, usually rounding into frons subrectangularly or obtusely; submedian carinae meeting at extreme apex of vertex or extreme base of frons; lateral pronotal carinae not meeting hind margin; in male aedeagus usually tubular and simate.

The four species with the author may be separated on the basis of the following key:

1. A small button-like medio-ventral process on pygofer; genital styles basally swollen, frons and genae dark brown; apical half of tegmina usually fuscous ..... S. furcifera

-. Medio-ventral process of pygofer absent ..... 2.

2. Diaphragm with a pair of short, peg-like armature; genital styles not forking at apex; anal emargination of pygofer pointed and turned backwards; frons tawny; tegmina hyaline ..... S. rhodesi

-. Diaphragmal armature strong; genital styles forking at apex ..... 3.

3. Diaphragmal armature horse-shoe shaped; genae and mesopleura dark brown; tegmina hyaline ..... S. longifurcifera

-. Diaphragmal armature with a pair of peg-like vertical processes; genae stramineous, mesopleura light brown; tegmina hyaline with a fuscous band along posterior border ..... S. kolophon

31. Sogatella furcifera (Horvath) (Plate XVI, Fig. 1)

Fennah, 1963, Bull. ent. Res., 54 : 50.

= Delphax furcifera Horvath, 1899, Term. Fuzetex., 22 : 372.

= Liburnia furcifera Matsumura, 1900, Ent. Nachr., 26 : 262.

= Sogata distincta Distant, 1912, Ann. Mag. Nat. Hist., (8)9 : 191.

= Sogata pallescens Distant, 1912, Ibid. 192.

= Opiconsiva colorata Distant, 1917, Trans. Linn. Soc. London Zool., 17 : 301.

= O. baltesta Distant, 1917, Ibid. 302.

= O. gloriosa Distant, 1917, Ibid. 302.

= O. insularis Distant, 1917, Ibid. 303.

= O. derelicta Distant, 1917, Ibid. 303.

= Nesosydnus furcifera Muir, 1917, Proc. Hawaiian Ent. Soc., 3 : 328.

= Sogata furcifera Muir, 1923, Philippine Jour. Sci., 22 : 174.

Colouration: Disc of vertex, pro- and mesonota creamy yellow, lateral field of mesonotum, antero-lateral area of pronotum behind eyes, frons and genae dark brown, clypeus less deep; frontal carina and antennae ochraceous; legs except pro- and meso-coxae pallid, body ventrally brownish black; tegmina subhyaline, a deep brown macula at claval apex, apical half fuscous in anal area with venation deep brown.

Form: Macropterous and brachypterous form. Head narrower than pronotum; vertex elongate about 1.5 times longer than basal width, apex quadrate subrectangularly rounding into

PLATE XVI

Fig. 1 : *Sorsatella furcifera* (Horvath)

Fig. 2 : *Sorsatella rhodesi* (Muir) comb. nov.

PLATE XVI

Fig. 1

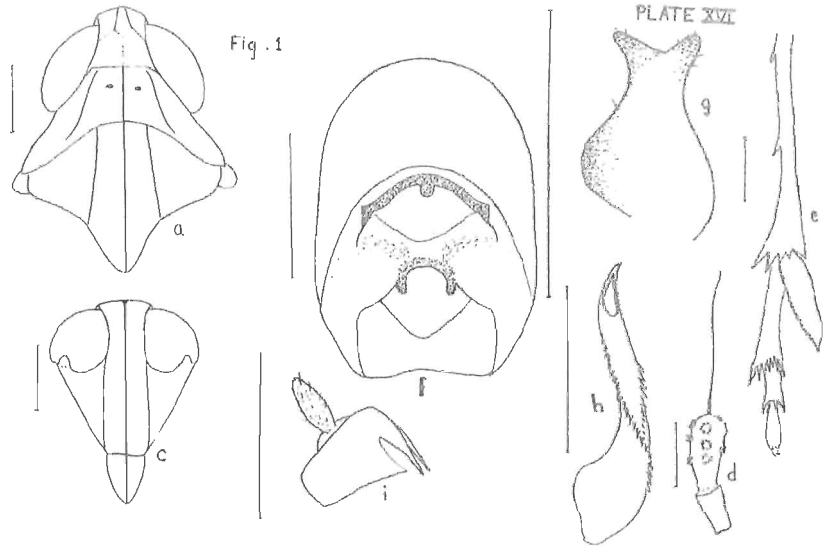
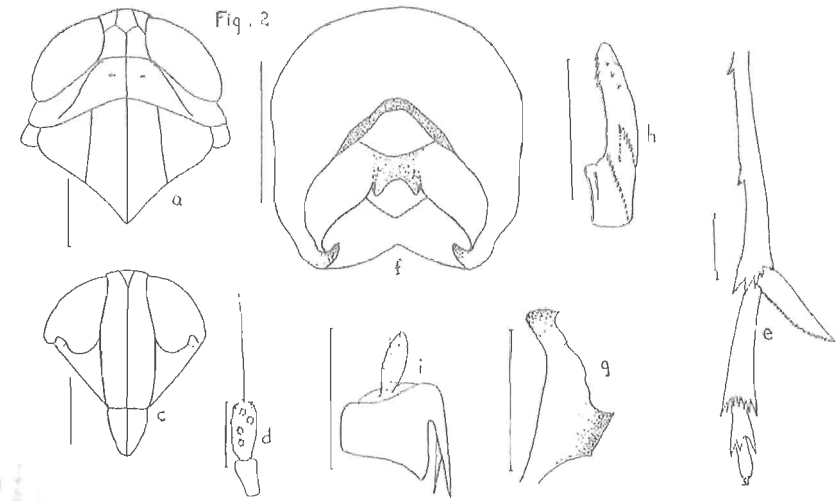


Fig. 2



frons, as wide at apex as base, slightly projecting in front of eyes, lateral margins subparallel; carination strong, X-shaped carina feebly developed, submedian carinae uniting at extreme apex of vertex, basal compartment of vertex wider at hind margin than median length; frons elongate, about 3 times longer than maximum width near the middle, lateral margins arcuate, tricarinate, median carina simple; clypeus triangular, tricarinate; antennae short, terete, basal segment longer than broad, second segment about 1.5 times longer than first, widened apically. Pronotum narrow, tricarinate, lateral carinae divergingly curved latero-caudad, not attaining the hind margin; mesonotum broader than long, slightly shorter than vertex and pronotum combined, tricarinate; hind basitarsus longer than other two together, calcar foliaceous, shorter than basitarsus, 25-30 minute teeth on hind margin.

Male genetalia: Pygofer moderately long, posterior opening slightly longer dorso-ventrally than broad, anal angle entire, a medio-ventral button-like projection; diaphragm narrow, dorsally a highly sclerotized horse-shoe shaped armature, the tips of which project out as finger tips, aedeagus moderately long, tubular, sinuate, broad at base, narrowed apically, genital orifice lateral to tip, two rows of teeth, one obliquely on left side, other on the ventral border; genital styles short, flattened, broad, with mesal margin swollen in basal half, distally furcate; anal segment

moderately short, collar-like, latero-apical angles produced ventrad in a pair of moderately long spinose processes; anal style short, oblong.

Measurements: Length - 3.30; Head - 0.65; Pronotum - 0.79; Antenna - 0.17+0.25; Hind tarsus - 0.51+0.37; Calcar - 0.42; Tegmen - 2.70.

Material examined: 17 ex. from Delhi; 3 ex. from Kerala; 1 ex. from Coimbatore; 7 ex. from Kalimpong.

32. Sogatella rhodesi (Muir) comb. nov. (Plate XVI, Fig. 2)

= Sogata rhodesi Muir, 1929, Ann. Mag. Nat. Hist., (10)4 : 208.

= Liburnia rhodesi Metcalf, 1943, General Catalogue Hemiptera, 4(3) : 368.

Colouration: Disc of vertex, pro- and meso-nota testaceous; frons, genae and clypeus tawny, carinae ochraceous; body ventrally deep brown; legs ochraceous and fuscescent; tegmina hyaline, venation brown.

Form: Short forms. General characters are same as in S. furcifera. Vertex not projecting in front of eyes, submedian carinae uniting at extreme base of frons; Y-shaped carina distinct; mesonotum slightly longer than vertex and pronotum combined.

Male genetalia: Pygofer slightly longer than broad, posterior opening longer dorso-ventrally than broad, anal

emargination produced to a pointed tip, curved backwards; diaphragm with a pair of small peg-like dorsal processes, concave in between; aedeagus short, tubular, sinuate, broad at base, narrow apically, apex not acutely pointed, genital orifice lateral to tip, a row of 4-5 teeth ventrally at tip, two rows of teeth obliquely on left side; genital styles short, laterally compressed, basal half wider with inner angle produced, apical half narrow, curved laterad, apex truncate; anal segment short, apical margin transverse, latero-apical angles produced ventrad in a pair of moderately long spinose processes; anal style short, stumpy.

Measurements: Length - 3.00; Head - 0.66; Pronotum - 0.70; Antenna - 0.15+0.27; Hind tarsus - 0.48+0.30; Calcar - 0.32; Tegmen - 2.40.

Material examined: 8 ex. from Coimbatore.

33. Sogatella longifurcifera (Esaki and Ishihara) (Plate XVII, Fig. 1)

Fennah, 1963, Bull. ent. Res., 54 : 53.

= Delphacodes longifurcifera Esaki and Ishihara, 1947, Mushi., 17 : 41.

Colouration: Disc of vertex, pro- and meso-nota yellowish white, carination creamy yellow, lateral fields of mesonotum with subtriangular tawny band having orange yellow border, slightly enfumed in the antero-lateral area of pronotum behind eyes; frons and clypeus stramineous, genae dark brown;

PLATE XVII

Fig. 1 : Sogatella longifurcifera (Esaki & Ishihara)

Fig. 2 : Sogatella kolophon (Kirkaldy)

Fig. 1

PLATE XVII

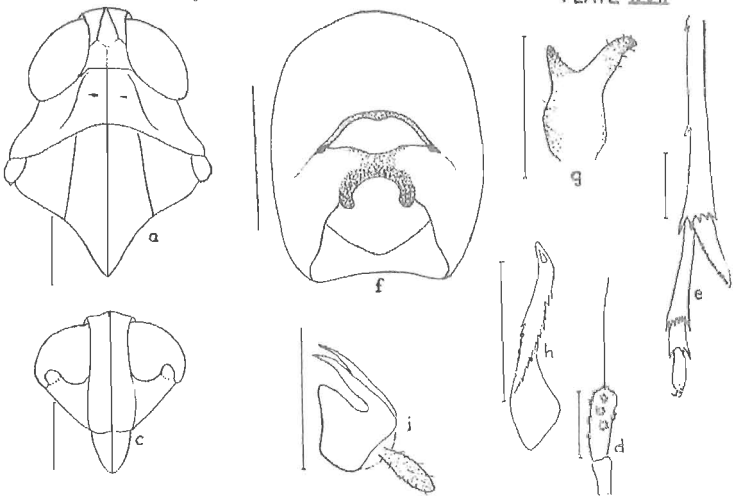
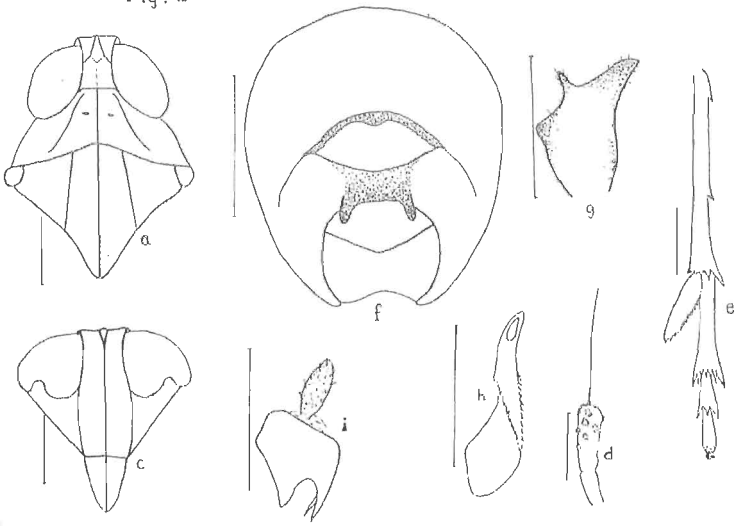


Fig. 2



antennae creamy white; mesopleura dark brown; legs pallid; tegmina hyaline, venation light brown.

Form: General characters same as in S. furcifera.

Male genetalia: Pygofer longer than broad, posterior opening slightly longer dorso-ventrally than broad, a slight medio-ventral swelling present; dorsal margin of diaphragm deeply concave with a highly sclerotized horse-shoe shaped armature, the tips of which project out as finger tips, aedeagus similar to that of S. furcifera; genital styles short, broad, inner basal angle tumid, apex forked into two diverging processes; anal segment short, collar-like, latero-apical angles strongly produced ventrad in a moderately long spinose processes; anal style short, oblong.

Measurements: Length - 3.30; Head - 0.54; Pronotum - 0.67; Antenna - 0.12+0.24; Hind tarsus - 0.43+0.32; Calcar - 0.27; Tegmen - 2.60.

Material examined: 18 ex. from Delhi; 5 ex. from NPC; 2 ex. from Coimbatore.

34. Sokatella kolophon (Kirkaldy) (Plate XVII, Fig. 2)

Fennah, 1963, Bull. ent. Res., 54 : 58.

= Delphax kolophon Kirkaldy, 1907, Bull. Hawaiian Sugar Pl. Assoc., 3 : 157.

= Liburnia furcifera var. kolophon Metcalf, 1943, General Catalogue Hemiptera, 4(3) : 361.

Colouration: Disc of vertex, pro- and meso-nota yellowish white, lateral fields of pronotum orange brown; frons, clypeus and genae stramineous; antennae and legs ochraceous; pro- and meso-coxae, and mesopleura light brown; tegmina hyaline, a fuscous band along posterior border, more deep at apical half, venation light brown.

Form: General characters are same as in S. furcifera; submedian carinae meeting at the base of frons.

Male genetalia: Closely similar to S. longifurcifera. Dorsal margin of the diaphragm with a pair of vertical processes.

Measurements: Length - 3.10; Head - 0.49; Pronotum - 0.63; Antenna - 0.11+0.21; Hind tarsus - 0.41+0.32; Calcar - 0.26; Tegmen - 2.60.

Material examined: 5 ex. from Delhi; 2 ex. from Kerala.

Genus : Chloriona Fieber

Fieber, 1866, Verh. Zool. Bot. Ges. Wien., 16 : 519.

Vertex longer than broad; frons, longer than broad, forking of median carina near level of middle of eyes; lateral pronotal carinae not reaching posterior margin; basal segment of antenna relatively shorter.

The three species before the author can be separated on the basis of the following key:

1. Diaphragm with a dorso-median armature; aedeagus laterally compressed, with longitudinal striations in dorsal half basally; anal styles short ..... C. paludum

-. Diaphragm without dorso-median armature ..... 2.

2. Aedeagus subcylindrical with truncate apex, without teeth in apical half; anal spines moderate ..... C. kirkaldyi

-. Aedeagus tubular with bluntly rounded apex; 2-3 longitudinal rows of teeth in apical half; anal styles long and narrow ..... C. albonigra, sp. nov.

35. Chloriona paludum (Kirkaldy) comb. nov. (Plate XVIII, Fig.1)

= Kelesia paludum Kirkaldy, 1910, Fauna Hawaiiensis Suppl.: 579.

= Sogata paludum Muir and Giffard, 1924, Bull. Hawaiian Sugar Pl. Assoc., 15 : 13.

= Liburnia paludum Metcalf, 1943, General Catalogue Hemiptera, 4(3) : 367.

Colouration: Vertex, genae, clypeus, antennae and legs tawny; pronotum stramineous; mesonotum frons, pro- and meso-coxae, mesopleura and body underneath chocolate brown; tegmina hyaline with slight yellowish tint, venation ochraceous, a long brown macula at claval apex.

Form: Small forms. Head narrower than pronotum; vertex elongate, narrow, longer than wide; slightly projecting in front of eyes, lateral margins subparallel, apex broadly rounded, as wide at apex as base; carination strong, Y-shaped

carina feeble, submedian carinae meeting at extreme apex above the level of middle of eyes, basal compartment of vertex wider in hind margin than median length; frons elongate, narrow, about 2.5 times longer than maximum width, lateral margins arcuate, as wide at apex as base, tricarinate; clypeus triangular, tricarinate; antennae short, terete, basal segment longer than wide, second segment about twice as long as first. Pronotum narrow, posterior border deeply incised, tricarinate, lateral carinae divergingly curved latero-caudad, not attaining posterior margin; mesonotum as long as or slightly longer than vertex and pronotum combined, tricarinate; hind basitarsus longer than other two together, calcar foliaceous, acuminate, shorter than basitarsus, 17-24 minute teeth on hind margin.

Male genetalia: Posterior opening of pygofer a little broad dorso-ventrally than long, anal emargination large; diaphragm with a dorso-median conical armature with rows of minute teeth; aedeagus small, laterally compressed, basal half dorsally produced with longitudinal striations as if composed of laminae; apex obliquely cut with gonopore at tip; genital styles short, flat, fairly broad, basal inner angle produced, medially narrow, slightly twisted, widened towards apex, apex shallowly concave with inner angle produced; anal segment narrow, ring-like, latero-apical angles produced ventrad in a pair of short, spinose processes; anal style short.

PLATE XVIII

Fig. 1 : Chloriona paludum (Kirkaldy), comb. nov.

Fig. 2 : Chloriona kirkaldyi (Muir), comb. nov.

Fig. 1

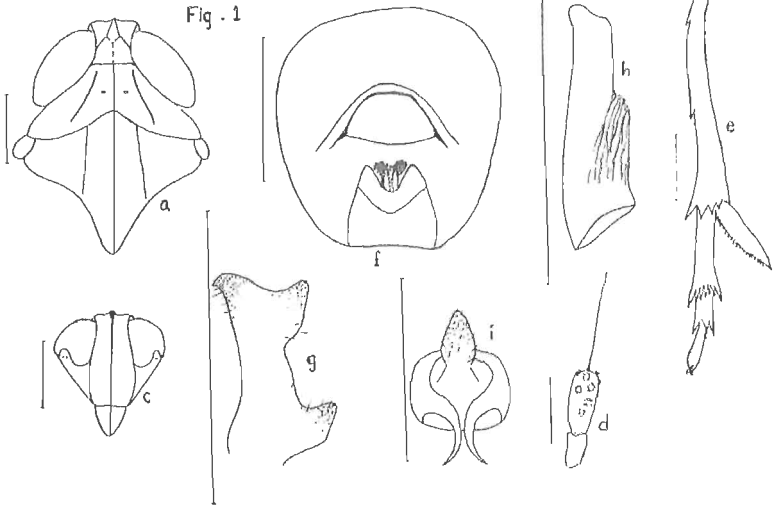
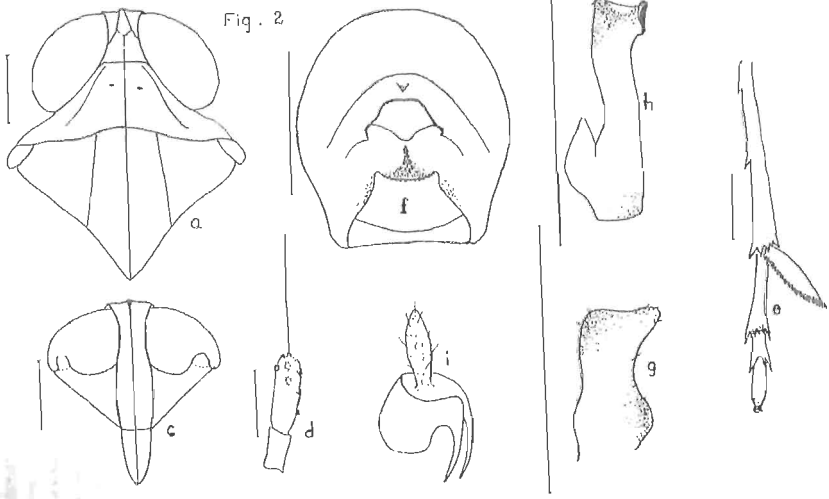


Fig. 2



Measurements: Length - 2.70; Head - 0.55; Pronotum - 0.60; Antenna - 0.11+0.22; Hind tarsus - 0.35+0.28; Calcar - 0.28; Tegmen - 2.20.

Material examined: 30 ex. from Delhi; 20 ex. from Kerala.

36. Chloriona kirkaldyi (Muir) comb. nov. (Plate XVIII, Fig. 2)

= Delphax puella Kirkaldy, 1907, Bull. Hawaiian Sugar Pl. Assoc., 3 : 160.

= Kelesia kirkaldyi Muir, 1917, Proc. Hawaiian Ent. Soc., 3 : 329.

= Sogata kirkaldyi Muir, 1927, Fulgoroidea of Samoa, 12.

= Liburnia kirkaldyi Metcalf, 1943, General Catalogue Homoptera, 4(3) : 363.

= Coronacella kirkaldyi Fennah, 1956, Ins. Micron., 6(3) : 126.

Colouration: Vertex, pronotum anteriorly and mesonotum brownish black, posterior half of pronotum and apex of scutellum creamy white; carination of vertex creamy white; frons and genae brownish black, clypeus less deep, lateral carinae of frons and carination on vertex creamy white; antennae tawny, basal segment more deep; body ventrally deep brown; legs ochraceous except fore and middle coxae with brown streaks; tegmina hyaline, long black macula at claval apex, venation ochraceous.

Form: General characters more or less same as in C. paludum; vertex not projecting in front of eyes; frons

relatively longer, lateral carinae slightly, arcuate, sinuate, elevated; calcar with 12-17 minute teeth.

Male genitalia: Pygofer short, posterior opening a little longer dorso-ventrally than wide, dorso-laterally invaginated, a small triangular median protuberance below the ventral border, anal angle entire; diaphragm broad, dorsal margin slightly convex, highly sclerotized medially with a row of minute teeth-like projections; aedeagus short, tubular, slightly incrassate at apex, gonopore at tip with 3-4 minute teeth dorsally, base with a dorsal enlargement with a conical tip and one or two longitudinal striations, genital styles short, broad, laterally compressed, inner basal angle slightly tumid, inner margin concave, apex obliquely truncate with inner angle produced conically; anal segment short, ring-like, apical margin transverse, latero-apical angles strongly produced ventrad in a pair of short, narrow spinose processes; anal style short, oblong.

Measurements: Length - 2.80; Head - 0.56; Pronotum - 0.66; Antenna - 0.12+0.22; Hind tarsus - 0.37+0.31; Calcar - 0.25; Tegmen - 2.20.

Material examined: 1 ex. from Delhi; 12 ex. from Coimbatore; 4 ex. from Kerala.

37. Chloriona albonigra, sp. nov. (Plate XIX, Fig. 1)

Colouration: Vertex, anterior border of pronotum and mesonotum piceous, rest of pronotum pallescent, tip of

scutellum creamy white; frons and genae piceous, apex of frons, clypeus, antennae and posterior border of genae creamy white; body ventrally dark brown; tegmina hyaline, a large transverse macula at the level of claval apex across the tegmina, venation light brown, brownish macula at claval apex.

Form: Small forms. General characters same as in C. paludum; vertex not projecting in front of eyes; length of calcar as long as or slightly shorter than basitarsus.

Male genetalia: Pygofer short, as long as wide, posterior opening a little longer dorso-ventrally than broad, a medio-ventral invagination and the lateral margins slightly inflected, anal angle entire; diaphragm broad, dorsal border highly sclerotized with corrugated margin; aedeagus short, tubular, basal half broad, narrowed apically ending in a blunt tip, gonopore lateral to tip, 2-3 longitudinal rows of teeth in apical half and 2-3 teeth opposite to gonopore; genital styles short, laterally compressed, inner basal angle tumid, medially narrow, apex slightly broadened with a fold at inner angle, outer angle pointed; anal segment short, ring-like, apical margin transverse, latero-apical angles produced ventrad in a pair of long, narrow spinous processes; anal style short, stumpy.

Measurements: Length - 2.50; Head - 0.55; Pronotum - 0.63; Antenna - 0.14+0.26; Hind tarsus - 0.40+0.36; Calcar - 0.36; Tegmen - 2.20.

Material examined: Holotype male "Inside lamp dome, I.A.R.I., New Delhi, May'70, Ramdas Menon Coll.", allotype with same data as holotype; paratypes: 2 ex. labelled as the holotype.

Genus : Delphacodes Fieber

Fieber, 1866, Verh. Zool. Bot. Ges. Wien., 16 : 524.

Small forms. Vertex short, base a little short of twice the width of an eye in the same line; lateral pronotal carinae curved behind eyes, not reaching posterior margin.

The two species before the author may be separated on the basis of the following key:

-. Body testaceous; dorsal armature of diaphragm composed of a pair of fingerlike processes; aedeagus tubular; genital styles long ..... D. propinqua

-. Body croceous; diaphragmal armature broadly bifid; aedeagus sickle shaped with a ventral projection at base; genital styles short ..... D. albovittata

38. Delphacodes propinqua Fieber (Plate XIX, Fig. 2)

Muir, 1917, Proc. Hawaiian Ent. Soc., 3 : 335.

= Delphax propinqua Fieber, 1866, Verh. Zool. Bot. Ges. Wien., 16 : 525.

= Liburnia propinqua Fieber, 1872, Kat. Europaischen Cicad. 5.

= Megamelus terminalis Crawford, 1914, Mon. Delphacidae, 632.

PLATE XIX

Fig. 1 : Chloriona albonigra, sp. nov.

Fig. 2 : Delphacodes propinqua Fieber

Fig. 1

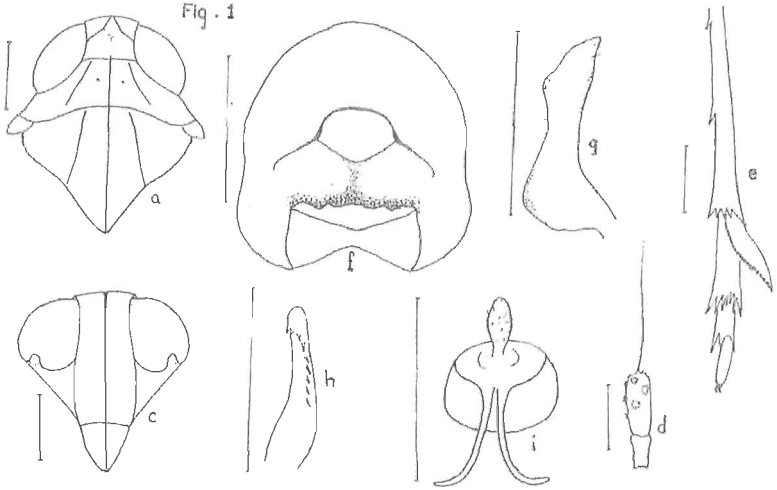
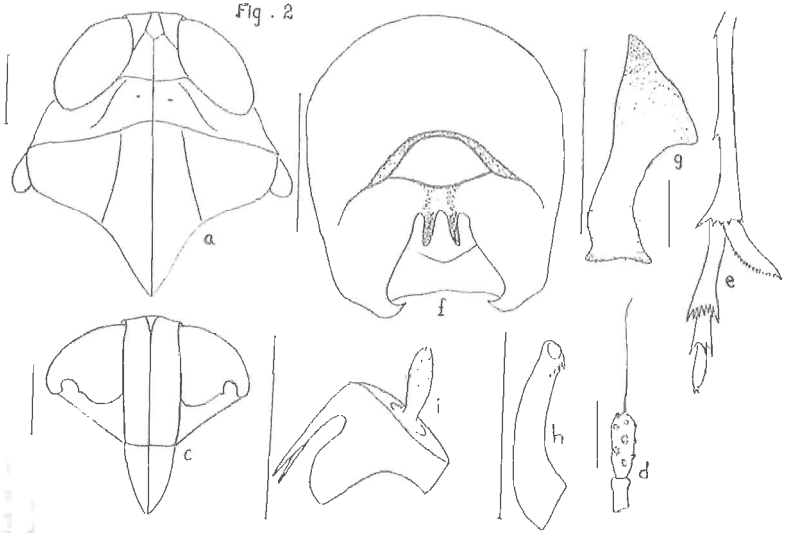


Fig. 2



Colouration: Vertex, pro- and meso-nota testaceous, carination creamy white; frons and median cell in between submedian carinae chocolate brown; genae and clypeus yellowish brown; antennae ochraceous; body ventrally yellowish brown; legs pallid; tegmina hyaline, venation ochraceous in basal half and brown in apical half.

Colour variation usually noticed.

Form: Head as broad as or slightly narrower than pronotum; vertex, narrow, elongate, about 1.5 times longer than basal width, lateral margins shallowly concave, apex quadrate, as wide as base; carination strong, Y-shaped carina feeble, submedian carinae not uniting at apex, basal compartment wider at hind margin than median length; frons elongate, narrow, about 3 times longer than maximum width, lateral margins subparallel, tricarinate, median carina forking at extreme base; clypeus triangular, tricarinate; antennae short, terete, basal segment short, longer than broad, second segment about twice as long as first. Pronotum narrow, incised posteriorly, broader at base than long in middle, tricarinate, lateral carinae divergingly curved latero-caudad, not meeting posterior margin; mesonotum longer than vertex and pronotum combined, tricarinate; hind basitarsus longer than the other two together; calcar foliaceous, shorter than basitarsus, 19-21 minute teeth on hind margin.

Male genetalia: Pygofer longer than broad, posterior opening a little longer dorso-ventrally than broad, anal

emargination produced to a narrow, pointed tip, curved dorsad and turned inwards; dorsal margin of diaphragm produced into a pair of black finger-shaped processes; aedeagus tubular, laterally compressed, slightly arcuate, broad at base, apex blunt, gonopore lateral to tip, a row of 3-5 minute teeth dorsal to gonopore, genital styles long, flat, base conical with inner angle bulged out, medially narrow, apex truncate, with inner angle pointed inwards; anal segment short, ring-like, apical margin transverse, latero-apical angles produced ventrad in a pair of moderately long spinose processes; anal style short, stumpy.

Measurements: Length - 3.00; Head - 0.65; Pronotum - 0.78; Antenna - 0.12+0.24; Hind tarsus - 0.37+0.31; Calcar - 0.28; Tegmen - 2.30.

Material examined: 20 ex. from Delhi; 9 ex. from Coimbatore; 2 ex. from Kerala; 2 ex. from Kalimpong.

39. Delphacodes albovittata Matsumura (Plate XX, Fig. 1)

Matsumura and Ishihara, 1945, Mushi, 16 : 61.

= Dicranotropis albovittata Matsumura, 1900, Ent. Nachr., 26 : 269.

Colouration: Disc of vertex, pro- and meso-nota croceous, a creamy streak, narrowed anteriorly, running all along the median carina from scutellum to vertex; lateral pronotal carinae creamy white, lateral mesonotal carinae pale yellow; frons, clypeus, genae and antennae croceous,

carination creamy white; body ventrally castaneous; legs ochraceous with brown streaks on coxae; tegmina subhyaline, fuscous along veins in apical half.

Form: General characters same as in P. propinqua.

Male genetalia: Pygofer longer than broad, posterior opening longer dorso-ventrally than broad, anal angle entire, ventral margin V-shaped; diaphragm dorsally with a broad, apically bifid median armature covered with minute teeth; aedeagus sickle-shaped with a ventral thumb-like projection at base, basal half broad, then curved like the blade of a sickle with a bluntly pointed apex, gonopore just behind tip ventrally, one or two minute teeth opposite to gonopore; genital styles short, laterally compressed, slightly narrow in middle, apical half diverging laterad, inner angle produced to a blunt, short, beak; anal segment narrow, ring-like, apical margin transverse, latero-apical angles produced ventrad in a pair of moderately long spinose processes; anal style short, oblong.

Measurements: Length - 2.90; Head - 0.56; Pronotum - 0.59; Antenna - 0.15+0.28; Hind tarsus - 0.44+0.29; Calcar - 0.27; Tegmen - 2.40.

Material examined: 7 ex. from Delhi; 2 ex. from Coimbatore; 2 ex. from Tiruvella.

Genus : Perigrimus Kirkaldy

Kirkaldy, 1904, Entomologist, 37 : 176.

Head narrower than pronotum, vertex short, broad; forking of median frontal carina in basal third of frons; lateral pronotal carinae not meeting posterior margin; aedeagus very long and slender.

40. Perigrimus maidis (Ashmead) (Plate XX, Fig. 2)

Kirkaldy, 1904, Entomologist, 37 : 176.

= Delphax maidis Ashmead, 1890, Psyche, 5 : 323.

= Dicranotropis maidis Van Duzee, 1897, Bull. Buffalo Soc. Nat. Sci., 5 : 240.

= Pundaluoya simplicia Distant, 1906, Fauna British India, 3 : 468.

Colouration: Vertex, disc of pro- and meso-nota stramineous, lateral area of mesonotum brownish ochraceous, carination flavescent; frons, genae, clypeus, meso- and meta-pleura, coxae and femora of legs brownish fuscous; antennae yellowish brown with fuscous annulation at apex; tibiae and tarsi flavus; tegmina hyaline with yellowish tint, fuscous along veins in apical half.

Form: Stout built forms. Head narrower than pronotum; vertex more or less square, lateral margins shallowly concave, apex emarginate, slightly projecting in front of eyes; carination strong, Y-shaped carina distinct, submedian carinae not uniting at apex, basal compartment wider in hind margin than

PLATE XX

Fig. 1 : *Delphacodes albovittata* Matsumura

Fig. 2 : *Perigrinus maidis* Ashmead

PLATE XX

Fig. 1

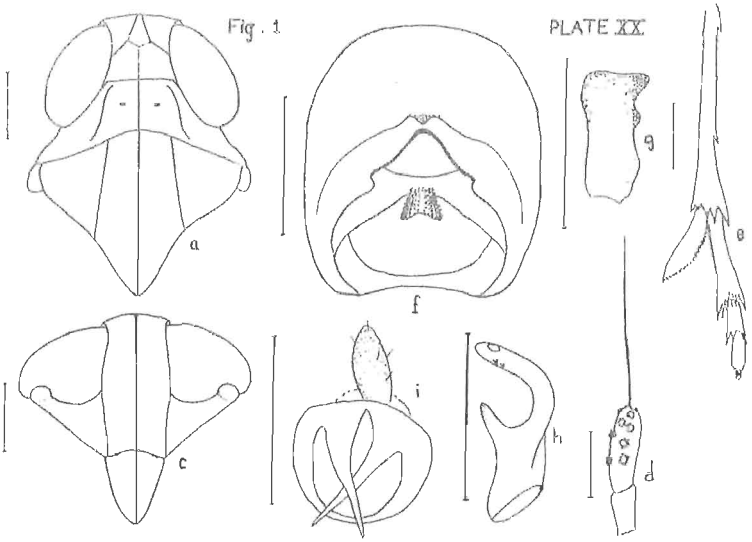
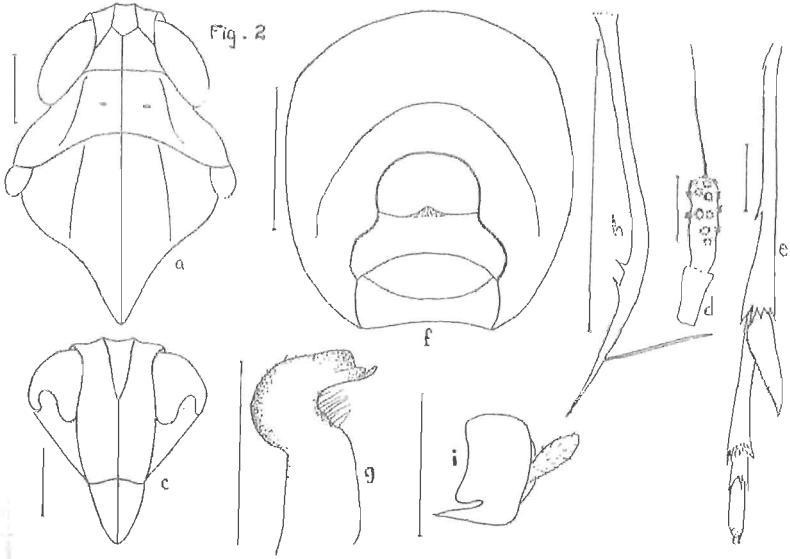


Fig. 2



median length; frons elongate, about 2.5 times longer than maximum width, lateral margins slightly arcuate, tricarinate, forking of median carina one-third from base, ridged, lateral carinae elevated; clypeus subtriangular, tricarinate; antennae moderately long, terete, basal segment short, longer than broad, second segment about twice as long as first. Pronotum broad, posterior margin incised, tricarinate, lateral carinae straight, diverging posteriorly, not meeting hind margin; mesonotum longer than vertex and pronotum combined, tricarinate; hind basitarsus distinctly longer than other two together, calcar foliaceous, shorter than basitarsus, 19-25 minute teeth on hind margin.

Male genetalia: Pygofer slightly broader than long, posterior opening a little longer dorso-ventrally than broad, anal angle entire, diaphragm without armature; aedeagus long, very narrow with a slight bend dorsally, apex narrowly pointed, two small spines ventral to the bend and a long thread-like appendage ventrally behind apex; genital styles stout, hooked at apex, laterally compressed, basal half broad, horizontal, apical half hooked directed dorsad, apex with 2-3 narrow lobes, inner one longer; anal segment short, apical margin transverse, latero-apical angles produced ventrad in a pair of short spinose processes; anal style short, stumpy.

Measurments: Length - 5.30; Head - 0.63; Pronotum - 0.80; Antenna - 0.20+0.34; Hind tarsus - 0.50+0.36; Calcar - 0.32; Tegmen - 4.30.

Material examined: 10 ex. from Coimbatore, 3 ex. from Kerala.

Genus : Euidella Puton

Puton, 1886, Cat. Hemip. Faune Palearctique 2 Ed. : 72.

Vertex slightly longer than broad, a little produced in front of eyes; frontal carina forking one-third from base; lateral pronotal carinae not meeting hind margin; legs fairly long and slender; hind basitarsus distinctly longer than other two combined.

The two species with the author may be separated on the basis of the following key:

-. Pygofer without medio-ventral process; aedeagus flattened with two long flagellar appendages; genital styles long, L-shaped; anal spines short, narrow ..... E. flagellata, sp. nov.

-. Pygofer with a small triangular medio-ventral process; aedeagus tubular with a short flagellum and 2-3 spines; genital styles short, anal spines conical, stumpy ..... E. delhiensis, sp. nov.

41. Euidella flagellata, sp. nov. (Plate XXI, Fig. 1)

Colouration: Vertex and pronotum straminecus, mesonotum tawny, carination flavescent; frons, clypeus, genae and antennae ochraceous; body ventrally and legs ochraceous; tegmina hyaline with yellowish tint, a fuscous band in apical half above median line; smoky along the veins.

Form: Head slightly narrower than pronotum; vertex broad, about 1.2 times as long as basal width, lateral margin shallowly concave, apex broadly rounded, slightly narrower than base, slightly projecting in front of eyes; carination strong, X-shaped carina feeble, submedian carinae not uniting at apex, basal compartment of vertex wider at hind margin than long in middle; frons elongate, about 3 times longer than maximum width in middle, lateral margins subparallel, tricarinate, forking of median carina above level of ocelli, lateral carinae elevated; clypeus subtriangular, tricarinate; antennae long, terete, basal segment short, longer than broad, second segment about twice as long as first. Pronotum narrow, incised posteriorly, tricarinate, lateral carinae straight, diverging latero-caudad not meeting hind margin; mesonotum longer than vertex and pronotum combined, tricarinate; hind basitarsus distinctly longer than other two together, calcar foliaceous, shorter than basitarsus, 24-26 minute black teeth on hind margin.

Male genetalia: Pygofer longer than broad, posterior opening a little longer dorso-ventrally than broad with a medio-ventral invagination, anal angle slightly produced; ventral margin of diaphragm concave, dorsal margin folded ventrally forming a median arch-shaped thickening; aedeagus long, laterally compressed, divergingly curved ventrad, apex humped with a dorsally pointed tip bearing two flagellar appendages, one long, broad, medially twisted with a pointed tip,

PLATE XXI

Fig. 1 : *Euidella flagellata*, sp. nov.

Fig. 2 : *Euidella delhiensis*, sp. nov.

PLATE XXI

Fig. 1

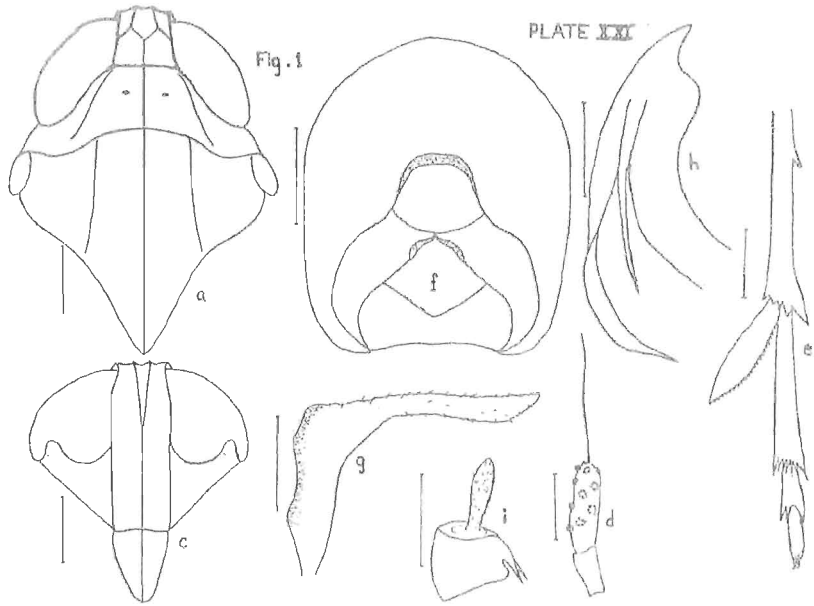
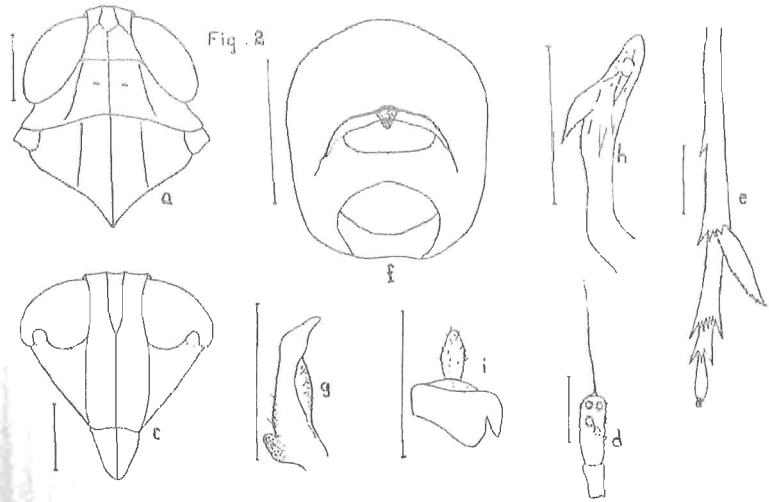


Fig. 2



other short, narrow and pointed; genital styles long, L-shaped, basal third broad, horizontal, then bent dorsad, narrow with a bluntly pointed tip, reaching the base of anal segment; anal segment short, ring-like, apical margin transverse, latero-apical angles produced ventrad in a pair of short pointed spines; anal style small, fusiform.

Measurements: Length - 4.10; Head - 0.80; Pronotum - 0.88; Antenna - 0.13+0.26; Hind tarsus - 0.57+0.38; Calcar - 0.39; Tegmen - 3.50.

Material examined: Holotype male "Inside lamp dome, Coimbatore, Nov.-Dec.'59; Coll. R.A. Agarwal"; allotype female labelled as the holotype; Paratypes: 3 ex. from Coimbatore; 2 ex. from Delhi.

42. Euidella delhiensis, sp. nov. (Plate XXI, Fig. 2)

Colouration: Vertex, pro- and meso-nota ochraceous, carination straminceous; frons, clypeus, genae, antennae, body ventrally and legs ochraceous; tegmina hyaline, venation in apical half deep brown.

Form: General characters more or less same as E. flagellata except its small size.

Male genetalia: Pygofer slightly longer than broad, posterior opening a little longer dorso-ventrally than broad, a small, triangular medio-ventral protuberance, anal angle

entire; diaphragm without any armature; aedeagus cylindrical, diverging, curved ventrad, apex bluntly conical, gonopore lateral to tip, a dorsal flagellum just behind apex directed backwards, 2-3 narrow, long spines laterally; genital styles short, sword-shaped, slightly twisted in middle, basally broad with inner angle projecting into a cone, narrowed towards apex turned laterad; anal segment short, ring-like, apical margin transverse, latero-apical angles produced ventrad into a pair of short, conical, stumpy processes with rough surface; anal style short.

Measurements: Length - 3.00; Head - 0.50; Pronotum - 0.61; Antenna - 0.11+0.21; Hind tarsus - 0.41+0.30; Calcar - 0.25; Tegmen - 2.60.

Material examined: Holotype male "Inside lamp dome, I.A.R.I., New Delhi, June'70; Coll. K.V. Mammen"; (male genetalia on slide); paratypes: 2 males, labelled as the holotype.

Genus : Dicranotropis Fieber

Fieber, 1866, Verh. Zool. Bot. Ges. Wien., 16 : 521.

Vertex slightly longer than wide; median frontal carina forking one-third from base, lateral pronotal carinae not meeting hind margin; pygofer usually with a medio-ventral process.

The four species before the author may be separated on the basis of the following key:

1. Pygofer with a medio-ventral prolongation ..... 2.

-. Pygofer without medio-ventral prolongation, but with two distinct lobes, aedeagus tubular, basal half deflexed, apex with two thread-like appendages; *body ochraceous* ..... *Dicranotropis sp.* (1)

2. Aedeagus tubular with 3-4 spine-like processes; body stramineous .... D. cornata

-. Aedeagus not tubular ..... 3.

3. Medio-ventral process of pygofer conical with two minute processes at apex, aedeagus laterally compressed, apex broadly conical with two ventral processes; body testaceous ..... D. fuscifrons

-. Medio-ventral process of pygofer conical but simply pointed; aedeagus short, ventrally grooved, ending in two curved spines; body flavo-testaceous ..... *Dicranotropis* sp. (2)

43. Dicranotropis cornata Muir (Plate XXII, Fig. 1)

Muir, 1917, Proc. Hawaiian Ent. Soc., 3 : 317.

Colouration: Vertex, pro- and meso-nota stramineous, carination creamy white; frons, clypeus, genae and antennae ochraceous; body ventrally and legs ochraceous; tegmina hyaline, venation in apical half brown.

Form: Head slightly narrower than pronotum; vertex short, slightly longer than basal width, lateral margins shallowly concave, apex quadrate, narrower than base; carination strong, Y-shaped carina distinct, submedian carinae not uniting at apex, basal compartment wider in hind margin than

median length; frons elongate, broad, about twice as long as maximum width in middle, lateral margins subparallel, base narrower than apex, tricarinate, forking of median carina above the level of ocelli; clypeus subtriangular, tricarinate; antennae moderately long, cylindrical, basal segment short, longer than broad, second segment about twice longer than first. Pronotum narrow, wider at base than median length, posterior margin incised, tricarinate, lateral carinae divergingly curved latero-caudad, not attaining hind margin; mesonotum as long as vertex and pronotum combined, tricarinate; hind basitarsus slightly longer than other two together, calcar foliaceous, slightly shorter than basitarsus, 33-34 minute teeth on hind margin.

Male genetalia: Pygofer longer than broad, swollen, posterior opening shorter dorso-ventrally than broad with a medio-ventral prolongation, latero-ventral margins slightly produced, a shield-like internal plate dorsal to the prolongation; diaphragm without armature; aedeagus moderate, tubular, apical half bent ventrad, ending in a conically blunt apex, an elongated spine at the median bending and 2-3 short spines laterally, all directed cephalad; genital styles long, basally narrow, inner angle tumid, curved dorsad, apical half narrow, slightly twisted, directed laterad with a pointed tip; anal segment small, ring-like, apical margin transverse, latero-apical angles produced ventrad in a pair of short, narrow spinose processes; anal style short, stumpy.

PLATE XXII

Fig. 1 : Dicranotropis cornata Muir

Fig. 2 : Dicranotropis fuscifrons Muir

PLATE XXII

Fig. 1

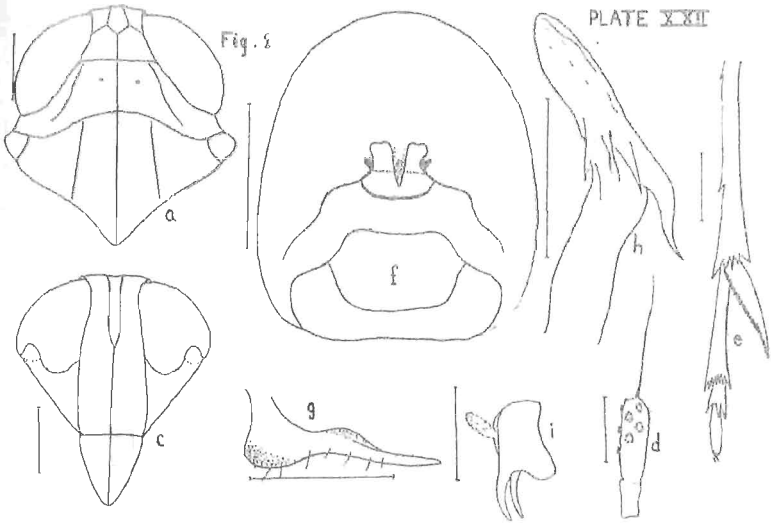
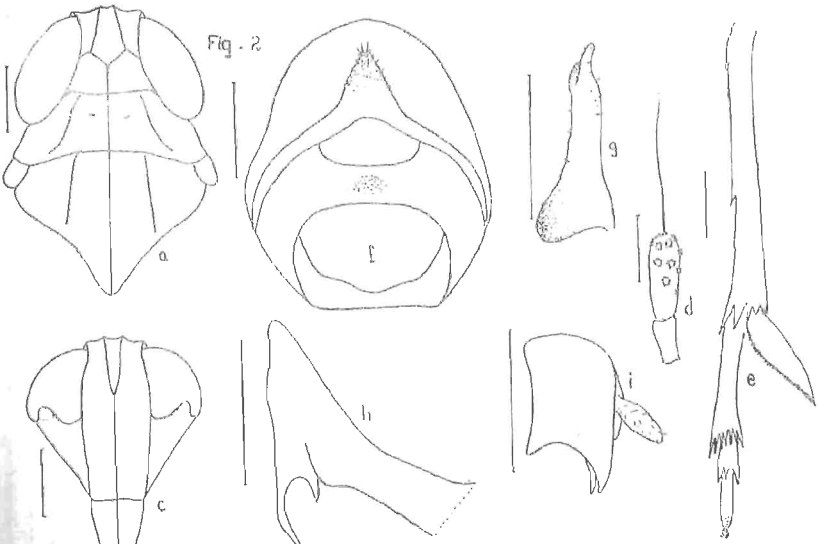


Fig. 2



Measurements: Length - 3.00; Head - 0.68; Pronotum - 0.71; Antenna - 0.14+0.30; Hind tarsus - 0.45+0.30; Calcar - 0.30; Tegmen - 2.70.

Material examined: 1 ex. from I.A.R.I., New Delhi, (male genetalia on slide).

44. Dicranotropis fuscifrons Muir (Plate XXII, Fig. 2)

Muir, 1917, Proc. Hawaiian Ent. Soc., 3 : 317.

= Perkinsiella fuscifrons Muir, 1911, Bull. Hawaiian Sugar Pl. Assoc., 8 : 11.

Colouration: Vertex, pro- and meso-nota testaceous; frons, clypeus and genae tawny; antennae and legs ochraceous; body ventrally deep brown; tegmina hyaline, fuscous suffusion along apical half.

Form: General characters more or less same as in D. cognata; calcar as long as basitarsus, 28-30 minute teeth on hind margin.

Male genetalia: Pygofer longer than broad, posterior opening broader dorso-ventrally than long, a medio-ventral conical prolongation with rough surface ending in a pair of narrow pointed spines turned ventrad (in the postero-ventral view, in the figure, shown directed upwards), anal angle entire; diaphragm without any armature; aedeagus moderate, laterally compressed, basal half tubular, apical half flattened, apex conical, inner apical angle produced ventrad to a long finger shaped structure with a small peg-like outgrowth from the inside

border; genital styles short, laterally compressed, basally broad with inner angle tumid, apical half narrow, slightly twisted ending in a pointed tip; anal segment small, apical margin transverse, latero-apical angles produced ventrad in a pair of short, spiny processes; anal style short, stumpy.

Measurements: Length - 3.50; Head - 0.82; Pronotum - 0.85; Antenna - 0.14+0.25; Hind tarsus - 0.48+0.32; Calcar - 0.44; Tegmen - 3.00.

Material examined: 3 ex. from I.A.R.I., New Delhi.

46. Dicranotropis sp. (1) (Plate XXIII, Fig. 1)

Colouration: Vertex, pro- and meso-nota ochraceous; frons, clypeus, genae, antennae, legs and body ventrally deep ochraceous; tegmina hyaline, fuscous along veins in apical half.

Form: General characters more or less same as in D. cornata.

Male genetalia: Pygofer longer than broad, posterior opening a little wider dorso-ventrally than long, two small lobes with a median invagination in between on the ventral border medially, anal angle not produced; diaphragm broad, with a median wedge dorsally; aedeagus elongate, tubular, basal half cylindrical, with a weak bend medially, apical half deflexed, directed cephalad, apex narrow produced into two narrow thread-like appendages; genital styles short, basal half broad, narrow

in middle, widened apically, inner angle slightly produced, outer angle produced and curved laterad; anal segment small, ring-like, latero-apical angles produced ventrad in a pair of narrow spinous processes; anal style short, stumpy.

Measurements: Length - 3.50; Head - 0.32; Pronotum - 0.88; Antenna - 0.14+0.26; Hind tarsus - 0.48+0.33; Calcar - 0.35; Tegmen - 2.90.

Material examined: One male "Inside lamp dome, I.A.R.I., New Delhi, Sept.'59; R. Menon, Coll."; (male genetalia on slide).

46. Dicranotropis sp. (2) (Plate XXIII, Fig. 2)

Colouration: Vertex, pro- and meso-nota flavo-testaceous, carination pale creamy; frons, clypeus, genae, antennae, legs and body ventrally ochraceous; tegmina hyaline, venation ochraceous.

Form: General characters more or less same as in D. cornuta. Vertex relatively a little longer than base.

Male genetalia: Pygofer longer than broad, posterior opening a little longer dorso-ventrally than broad, ventral border with a black, median prolongation, latero-ventral margins inflexed, anal angle entire; diaphragm without armature; aedeagus short, ventrally grooved, basally broad, narrowed towards apex, ending in a pair of short curved spines,

the base supported ventrally by a decurved rod-like appendage; genital styles short, flat, dorsal half broad, narrow in middle, slightly twisted laterad, apex broader, turned inwards, a minute tooth lateral to tip; anal segment short, ring-like; apical margin transverse, latero-apical angles produced ventrad in a pair of short spinose processes; anal style short oblong.

Measurements: Length - 2.80; Head - 0.55; Pronotum - 0.60; Antenna - 0.11+0.23; Hind tarsus - 0.41+0.32; Calcar - 0.28; Tegmen - 2.20.

Material examined: One male "Inside lamp dome, I.A.R.I., New Delhi; Aug.'69; Coll. K.V. Mammen"; (male genetalia on slide).

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PLATE XXIII

Fig. 1 : Dicranotropis sp. (1)

Fig. 2 : Dicranotropis sp. (2)

Fig. 1

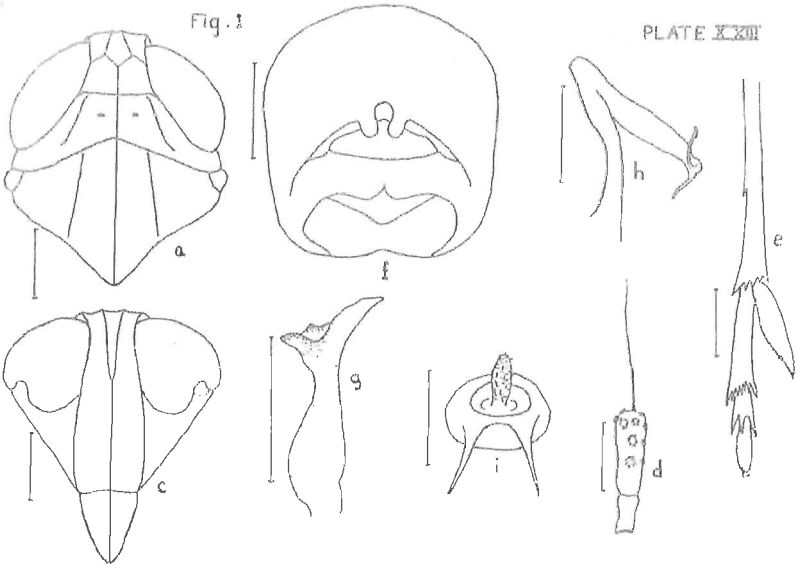
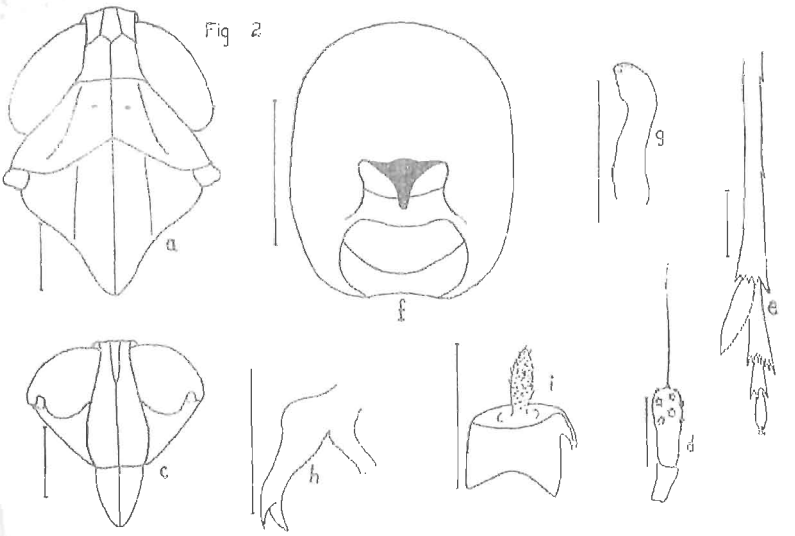


Fig 2



DISCUSSION

The main purpose of the present investigations, as already indicated in the introduction, has been two-fold: firstly, to make an assessment of the faunistics and zoogeography of the Indian Delphacidae and secondly, to probe into the soundness of the taxonomy of the family presently in vogue on the basis of a more sophisticated tool as a study of the male genitalia.

1. Faunistics and zoogeography of Indian Delphacidae

When the author took up a study of the Indian Delphacidae only thirty species assigned to nineteen genera were on record from the limits of the Indian Republic. Of these, only twelve species were found represented in the National Pusa Collection. During the present investigations the author could make a study of forty six species, of which only fifteen are previous records. Nineteen species had to be described as new. Two species of Dicranotropis could not be specifically assigned since the author could not procure descriptions of all the recorded species of this genus for comparisons. Ten species known from outside the country are listed for the first time from within Indian limits. With the present contribution the number of Indian species is raised to sixty-one under thirty-one genera, of which five genera are described for the first time herein.

The zoogeographic distribution of the Indian delphacids, as far ascertained, shows a high degree of

endemism since over ninty per cent is constituted of oriental elements as should be expected, which necessarily includes the endemic forms. However, a fair percentage of the Indian fauna are cosmopolitan elements too. The important among these are Chloriona paludum, Delphacodes propinqua, Nilaparvata lugens, Peririmus maidis, Perkinsiella sinensis, Sardia rostrata, and Sogatella furcifera.

An important point noticed is the very rare occurance of the subfamily Asiracinae and the delphacine tribe Alohini in the Oriental delphacid fauna, including that of India. From this country the author has been able to secure so far only members of the Delphacini and Tropidocephalini. It is probable that the primitive Asiracinae and Alohini are highly restricted to definitive ecological pockets while the more highly evolved delphacines and tropidocephalines are much more extensive in distribution.

Some of the earlier records of Indian Delphacidae do not indicate the exact localities, mentioning the distribution as merely 'India'. Some others have been recorded from States like Assam, Bengal, Maharashtra and Tamil Nadu without any further details of the areas of collection. In a lesser number of cases only the exact localities such as Darjeeling, Pusa, Chapra, Ajmer, Chikkaballapura, Ootacamund, Coonoor, Kodaikanal, etc. are given. The present collections secured by the author has been from Delhi, Gauhati (Assam), Coimbatore (Tamil Nadu), Darjeeling and Kalimpong (West Bengal),

Ajmer (Rajasthan), and some parts of Kerala. It is obvious from the foregoing that no extensive surveys over the entire country has been possible and the records so far made are from isolated pockets over the country. Thus judging from the facts that the time and means at the disposal of the author has necessitated procurement of material from only an infinitesimal area scattered over the country and that itself could bring to light so many species, the vastness of the Indian delphacid fauna and the necessity of making more elaborate surveys are made quite evident.

2. Notes on generic limitations

In the assignment of the different species secured by the author under distinct genera difficult problems were encountered with. A good deal of diversities of opinion yet prevail in literature with regard to the scope and limitations of various generic categories. For example, Distant (1906 and 1916) and Metcalf (1943) have placed several species under the genera Delphacodes and Liburnia, which have been considered under a varying number of different genera by both earlier and later workers. In a taxonomic classification the generic limitations should be objective and not subjective. To define such limitations the first prerequisite is an assessment of the detailed morphological structures of the typical species of each genus and investigations on others that may be alligned with each of them. In many cases details of such typical species are yet to be deduced. In recent years

the male genitalic armatures have proved to be of great interest in this connection and it has been with this in view that the author has been suggested to probe into the male genitalia of the Indian species by his guide. The studies conducted by the author has revealed interesting genetalic variations in otherwise easily confused species. The author feels that such superficial resemblances have been responsible for the transfer of Phyllodimus pulchellus to his new genus Cemus by Fennah (1964). One of the dire necessities apparent to the author in the course of the present work, is the establishment of the specific identities on the basis of a good series of material apparently looking alike, and then only go to the question of its specific nomenclature by comparisons with the holotypes of each. It has been found that even in the same locality sympatric species recognisable mainly on the basis of genitalic structures and not on general morphological characters may occur together and therefore very diligent work is needed.

While the limitations of material and time available have necessarily prevented the author from making a study of the group as a whole, certain very useful informations could be gathered. These have necessitated certain nomenclatural changes with regard to some of the known Indian species as mentioned below.

Kelisia paludum, K. kirkaldyi, Sogata pusana, and S. rhodesi have been referred to the genus Liburnia by

Metcalf (1943). The author has felt that Kelisia paludum should be transferred to Chloriona on the basis of morphological as well as genitalic characters. Fennah (1956) has transferred Kelisia kirkaldyi to Coronacella, but the characters presented by the material of this species with the author present much more of relationships with K. paludum than with bella Metcalf, the type species of Coronacella. Hence both these species are referred to Chloriona in the present work. Sogata pusana seems to tally well with Matutinus opulentus, the type species of Matutinus, and so this is transferred to that genus. Likewise, Sogata rhodesi is more allied to Sogatella furcifera, and so this is considered as a Sogatella. Sogata distincta and S. pallescens have been considered on the basis of colour markings by Fennah as subspecies of Sogatella furcifera, but on account of the high variational ranges of colouration observed in material of this species within the same area of collection the author is unable to accept the subspecific distinctions of Fennah at least for the present.

Fennah (1964) while erecting the genus Cemus, assigned Phyllodimus pulchellus to that genus. In Cemus the fore femora and tibiae are not dilated as evinced by the type species, C. laeviculus Fennah. The author has, however, found that the material of Phyllodimus pulchellus before him, while agreeing fully with the genitalic details available for that species, presents the fore femora and tibiae somewhat

foliaceously dilated. Hence there may be either a certain amount of variation in the amount of flattening of these parts within the species or there may be a complex of two distinct but sympatric species mixed up. Till further studies are made the author prefers to consider pulchellus only under Phyllodinus.

Delphacodes albovittata seems to have recently been transferred by Fennah (1965) to a new genus Terthron. The author has so far failed to secure the basis of this transfer even from Fennah himself and so he is unaware of the scope and limitations of his Terthron. A careful study of material of this species with the author in comparison with that of Delphacodes propinqua, however, do not bring out valid characters for the segregation of these species under two distinct genera. Hence the author has retained both under Delphacodes.

A careful study of material available with the author determined as Eocurysa flavocapitata through the Commonwealth Institute of Entomology, London, prompts the author to feel that a complex of two species may be involved under this name. While the general characters of these seem to tally well, genitalic differences are apparent. The anal segment of the material in hand is provided with two distinct pairs of spines, whereas in E. flavocapitata only a single pair of such spines have been depicted (Muir, 1913). The author has, therefore,

considered the material in hand as comprising a distinct species to which the name S. bispinosa, sp. nov. is proposed herein.

The male genitalia of all species of Sogatella studied by the author and that by Caldwell (1950), Fennah (1963) and others show a great uniformity in the genital armatures, especially the aedeagus which is distinctly sinuate, while the frontal carinae may show a certain amount of variation in the level of its basal bifurcation. Matutinus is characterised by a dorso-median armature on the diaphragm, a straight aedeagus, and the angulated vertex-face in profile not parallel to the anterior eye margin.

Caldwell (1950) considered a medio-ventral long pygoferal process with a bifid tip as characteristic of Phrytonyxa, and the same kind of pygofer is presented by P. indica, sp. nov. described herein.

The male genitalia of Stenocranus aimorensis Joseph, studied by Joseph himself as well as the author, and in other species studied by Vilbaste (1968) the aedeagus is long and narrow with a curved tip and from its base arises a curved structure with a swollen cylindrical base which has a hole through which the aedeagal periandrum projects. The female genitalia of this genus is also characteristic. In S. aimorensis, however, the median frontal carina is double and closely apposed to each other, a character by which it differs from all other species of the genus. The author feels

that this character should not be emphasised to segregate this under a different genus.

In the genus Perkinsiella the medio-ventral process of the pygofer may be short and wide, produced into two triangular lobes, or a pair of long acute spines; the aedeagus is more or less cylindrical with flagella or spines. The antennal structure in the genus is, however, quite characteristic. Paraperkinsiella, gen. nov. clearly differs from this genus in the antennal character particularly; the male genitalic difference, if any, is yet unknown.

The genus Dicranotropis is also characterised by a medio-ventral pygoferal process, except in such species where this may be bilobate. In other genera like Chloriona, Phyllodinus, and Liburniellana, gen. nov. too a great uniformity is observable in the male genitalic set-up of the species under each genus.

In the Tropidocephalini too the genitalic armatures are quite distinctive, the aedeagus being always associated with a penis guide and the anal spines totally absent. In the species of Purohita, it seems the aedeagal structure is what mainly contributes towards specific segregations. The genus Tropidocephala also show a good amount of genitalic similarity, and the species may be segregated on the nature and number of spines on the genital styles and pygofer. In Paratropidocephala, gen. nov., the antennal basal segment is characteristically longer; the male genitalic differentiation, if any, are yet not available.

It may be emphasised that with the limited number of species studied, no generalisation can yet be possible in defining generic limitations. However, the foregoing discussion on the genitalic armatures tend to show that segregation of genera on purely general morphological characters have contributed to heterogenity under the different genera.

3. Notes on the higher classification of delphacids

From the phylogenetic view-point the Cixiidae has been considered as the forerunner of the Delphacidae by most evolutionary taxonomists. From the Cixiidae the delphacids seem to have arisen through the acquisition of a large mobile spur from specialisation of one of the terminal hind tibial spurs, a more generalized male genitalia and the characteristic venation. From male genitalic studies Kershaw and Muir (1922) concluded that in the Fulgoroidea three aedeagal subtypes are available of which the delphacoid subtype is the highly evolved and the tettigometroid the most primitive and the flattoid subtype in between the two.

Judging from the cixiid ancestry of the Delphacidae and the development of the delphicid tibial spur as a specialisation of one of the hind tibial spurs in that family, it is possible to interpret the more solid spur, as evinced in the subfamily Asiracinae and the tribe Alohini, as the more primitive among delphacids. However, the author has been unable to make studies on the genitalia of these groups and

so the antiquity of these groups cannot be presently established on that basis. The tribes Delphacini and Tropidocephalini do possess much flattened tibial end-spur concave on the inner face which may be taken as a definite advance over that occuring in the above mentioned groups. In the Tropidocephalini the spur is devoid of teeth along the inner margin, whereas these are present in the Delphacini. Further comparative studies on these two tribes have brought out the following differences: (i) in the Delphacini R_1, Rs and M_1 of the tegmina usually arise from a common stalk before branching whereas in the Tropidocephalini the vein R_1 is distinctly separated; (ii) in the hindwings of Delphacini, veins M and Cu_1 run parallel to each other until they are connected by a cross vein, but in the Tropidocephalini these veins are amalgamated after a short distance from the base; (iii) again in the hindwings the second anal vein is divided into three branches in the Delphacini whereas in the Tropidocephalini it is forked only once; (iv) in the Delphacini there are one or two pairs of anal spines which are absent in the Tropidocephalini; and (v) in the Tropidocephalini the aedeagus is always associated with a penis-guide usually on the left side which is wanting in the Delphacini. Judging from the absence of teeth on the hind tibial spur, the lesser amount of fusion between the longitudinal veins of the forewings, and the absence of anal spines, the Tropidocephalini appear to present

a more primitive organisation, while there is an evident advance with regard to the hind wing venation and the development of a penis-guide in this tribe over the Delphacini.

Metcalf (1913) while describing the venation of the Fulgoroidea illustrated the wing venation of Stenocranus lautus (Delphacini) showing the amalgamation of M and Cu_1 in hind-wings, without mentioning anything about it in the description. In no other species of Stenocranus is found such a fusion. This makes the author feel that Metcalf may have mistaken a species of Tropidocephala as Stenocranus, or there may have been some misprint.

Muir (1913) mentioned the presence of penis-guide as a character of the genus Tropidocephala, but in the descriptions and figures of the species studied by him, he did not mention anything about this organ, but he described a single anal spine. A detailed examination of the male genitalia of the species of Tropidocephalini has convinced the author that the so-called 'single anal spine' of Muir does not arise from the latero-apical angle of the anal segment, but from within that segment and unconnected with it which is closely adpressed to the aedeagus. The penis-guide may be functioning as an accessory apparatus during copulation.

While the higher classification presently in vogue is the primary division into two subfamilies Asiracinae and Delphacinae and the segregation of three tribes under the

latter, viz., Alohini, Tropidocephalini, and Delphacini, as enunciated by Muir, Wagner (1962) proposed a classification of the family into nine subfamilies on the basis of a taximetric approach which has met with very little of acceptance so far. It is worthy to note that Wagner had not considered much of genetalic details in his classificatory scheme.

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SUMMARY

The results of the studies carried out by the author for just over a period of two and a half years on the Indian Delphacidae are presented in this thesis under two main parts with a general introduction to the subject matter of the entire work.

The first part gives a brief review of our present knowledge of the family in general and also with special reference to the Indian fauna. A review of the morphology and bionomics, together with the role of delphacids as vectors of plant virus diseases and their natural enemies are also presented here, since data from such sources have recently been found to be of immense importance in taxonomic interpretations.

The second part is covered by the author's own studies. These are presented under four chapters, viz., Materials and Methods, External morphology of delphacids with special reference to those of taxonomic importance, the Taxonomy and descriptions of the Indian fauna studied by the author, and a discussion.

Under the materials and methods it is pointed out that when the author started the present studies the National Pusa Collection (NPC) was extremely poor in delphacids, comprising only twelve species under ten genera. So, most of the materials studied by the author had to be procured through his own efforts. Light collections, particularly those which were observed to have accumulated within electric lamp shades,

proved a veritably rich source. Such collections were received from different parts of the country through the help of the author's guide and others, besides his own collections. Net-catches were also made in various areas of grassland wherever possible. Special methods of tag-mounting of the specimens, dry mounting of the detached wings, and slide-preparations of various parts including the male genitalia were resorted to for the study of the morphological details for taxonomic interpretations.

A consolidated account of the general morphological features of delphacids having been found wanting in the available literature, such a one has been drawn up and presented. The terminology used for the various parts have been detailed here for easy understanding while scanning through the descriptions of the various taxa given in telegraphic language. Certain heretofore unrecorded differences between the two different tribes, Tropidocephalini and Delphacini, particularly with reference to the venational characters of wings and male genetalia, have also been ascertained and incorporated.

The detailed descriptions of forty six Indian delphacids with supporting illustrations and their taxonomy are presented in regular order. Among these only fifteen are old records from the country and ten are reported from India for the first time. The identities of two species assigned to the genus Dicranotropis could not be finalised for want of adequate literature. Nineteen species have been found to be new and out

of these eight could not be assigned to any of the so far recorded genera. For these five new genera had to be proposed and these have been named, Upacharella, Liburniellana, Thiruvella, Paraperkinsiella, and Paratropidocephala. The new species erected are Perkinsiella andamanensis, Paraperkinsiella coimbatorensis, Eocurysa bispinosa, Euidella flagellata, E. delhiensis, Coronacella curvipenis, Megamelodes delhiensis, Phrvetopysa indica, Chloriona alboniura, Matutinus indicus, M. malabaricus, Upacharella indica, Liburniellana bengalella, L. malabarica, L. travencorensis, Unkanodes straminecus, Thiruvella longicornis, Paratropidocephala viridula, and P. striata. A careful study of the species known as Kelisia paludum, Coronacella kirkaldyi, Sokata musana, and S. rhodesi revealed that they have not been assigned to their proper genera and new combinations for them are proposed. Wherever more than a single species is ascribed under any genus a key has been provided for their ready separation.

The discussion is presented under three headings, viz., Faunistics and zoogeography of the Indian Delphacidae, Notes on generic limitations, and Notes on the higher classification of the family. Under the first the occurrence in India of certain cosmopolitan species besides endemic elements and the very scanty survey so far made to ascertain the Indian delphacid fauna together with the desirability of more extensive work on this line have been brought out. The confused state with regard to the generic limitations and the necessity

of probing further into genitalic details for settling these on a sound basis are discussed and brought out with reference to the assignment of the Indian species under different genera as presented herein. Likewise, the role of the genitalic armatures in the higher taxonomy of the family has also been indicated.

A key for the separation of the various genera studied by the author and a conspectus to the taxonomy of the species dealt with in the present contribution are presented in two appendices.

The references to literature includes only what have been considered quite relevant to the present work by the author on the Indian delphacids. The works extensively quoted in the review of literature is omitted in view of the excellent catalogue of the family by Metcalf (1943) wherein all these could be traced if needed.

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APPENDIX I

KEY TO THE INDIAN GENERA OF DELPHACIDAE

1. Hind tibial spur thick, flattened or concave on inner face, hind margin without teeth. Forewings with R_1 separate, not forming a common stalk with Rs and M_1; hindwings with M and Cu_1 fused together after a short distance from base, second anal vein divided into two branches. Anal segment devoid of spines (Tribe: TROPIDOCEPHALINI) ..... 2.

-. Hind tibial spur thin, laminate or foliaceous, usually deeply concave on inner face, hind margin with a row of distinct teeth. Forewings with R_1, Rs and M_1 usually arising from a common stalk; hindwings with M and Cu_1 not fused together, second anal vein divided into three branches. Anal segment with spines (Tribe: DELPHACINI) ..... 4.

2. Lateral carinae of frons and vertex deeply foliate. First segment of antennae much longer than second, flattened and foliaceous ..... Purohita

-. Lateral carinae of frons and vertex moderately developed; antennae short and terete ..... 3.

3. Antennae much shorter than face, first segment annular, second about twice the first ..... Tropidocephala

-. Antennae about length of face; first segment long, about two-third the length of second ..... Paratropidocephala

4. Both segments of antennae flattened ..... 5.

-. Both segments of antennae terete ..... 6.

5. Head distinctly narrower than pronotum. First antennal segment long, only slightly broadened distally. Forking of median frontal carina far below level of eyes ... Paraperkinsiella

-. Head as wide as pronotum. First antennal segment short, triangular broadening towards apex. Forking of median frontal carina near lower margin of eyes ..... Perkinsiella

6. Anterior and intermediate femora and tibiae compressed and foliaceous .....Phyllodimus

-. All leg segments simple, cylindrical ..... 7.

7. Carinations on head and thorax very faint; median longitudinal carina on face almost completely obliterated ..... Epacharella

-. Carinations of head and thorax quite distinct ..... 8.

8. Submedian carinae of vertex meeting far behind the apical margin and forming a small areolet at the middle ..... Liburniellana

-. Submedian carinae of vertex meeting at the apical margin or beyond, on the face ..... 9.

9. Submedian carinae of vertex meeting at the apical margin and continued on the face as a single median carina (in Stenocranus aimerensis, these do not really meet but run down as far as clypeus as two very closely aposed carinae) ..... 10.

-. Submedian carinae of vertex converging apically but meeting only on the face (i.e. median longitudinal carina of face furcate)..... 21.

10. Lateral pronotal carinae reaching upto hind margin ..... 11.

-. Lateral pronotal carinae not reaching the hind margin, usually distinctly curved laterad before fading off on the pronotum ..... 12.

11. Lateral pronotal carinae more divergent. Pygofer without a medio-ventral process ..... Megamelodes

-. Lateral pronotal carinae less divergent. Pygofer with a long medio-ventral process bifid apically ..... Phrictopyga

12. Vertex in profile angulately rounding into frons, not parallel to anterior margin of eyes ..... Matutinus

-. Vertex usually subrectangularly or obtusely rounding into frons, parallel to anterior margin of eyes ..... 13.

13. Hind basitarsus with one or more small lateral spines. First antennal segment longer than wide ..... Allaparvata

-. Hind basitarsus without any lateral spines ..... 14.

14. Basal segment of antennae short, as long as broad or only very slightly longer ..... 15.

-. Basal segment of antennae distinctly longer than broad ..... 17.

15. Vertex only slightly longer than broad, basal width more than twice the width of each eye in the same line ..... Eosarysa

-. Vertex very narrow, distinctly longer than broad ..... 16.

16. Second antennal segment not more than twice as long as basal segment; submedian carinae of vertex meeting together before apex; the basal compartment of vertex rectangularly very elongate ..... Sardia

-. Second antennal segment about three times as long as basal segment. (Male aedeagus passing through an accessory appendage; third valvulae of females very much broadened) ..... Stenocranus

17. Antennae distinctly long and slender; basal segment more than half as long as second; vertex distinctly longer projecting in front of eyes; calcar as long as basitarsus; anal spines long ..... Thiruvella

-. Antennae short; basal segment less than half as long as second; anal spines short ..... 18.

18. Head broad, nearly as broad as pronotum; pronotal carinae strongly elevated ..... Coronacella

-. Head narrower than pronotum ..... 19.

19. Basal compartment of vertex distinctly long; X-carina distinct; basal segment of antennae more than twice as long as broad at apex ..... Unkanodes

-. Basal compartment of vertex relatively short; X-carina obsolete; basal segment of antennae relatively shorter .....20.

20. Elongate forms. Aedeagus cylindrical, simuate and acute at apex ..... Sogatella (part)

-. Short forms. Aedeagus cylindrical, straight and truncately rounded at apex ..... Chloriona

21. Median frontal carina furcate at extreme base of face ..... 22.

-. Median frontal carina forked about one-third from base of face ..... 23.

22. Vertex longer than wide at base, projecting in front of eyes. Aedeagus cylindrical, simuate and acute at apex ..... Sogatella (part)

-. Vertex almost square. Aedeagus cylindrical, straight and truncately rounded at apex ..... Delphacodes

23. Vertex square. Hind tibial spur with numerous minute teeth. Aedeagus long, very narrow and whip-like ..... Perigrimus

-. Vertex slightly longer than wide ..... 24.

24. Hind basitarsus much longer than the other two segments together; legs fairly long and slender; fore femora considerably longer than coxae ..... Euidella

-. Hind basitarsus not longer than the other two together or only very slightly so. Fore femora only slightly longer than coxae..... Diranotronis

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APPENDIX II

CONSPECTUS OF DELPHACID SPECIES STUDIED BY THE AUTHOR

Family : DELPHACIDAE

Subfamily : DELPHACINAE