TAXONOMIC REVISION OF THE SPECIES OF *Scaphoideus* UHLER AND *Scaphotettix* MATSUMURA (HOMOPTERA : CICADELLIDAE) OF THE INDIAN SUBCONTINENT

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IN

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Affectionately Dedicated to

My Beloved Parents

Smt. Sarojini Devi

and

Sri. G. Shivarudrappa Patel

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
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CERTIFICATE

This is to certify that the thesis entitled "TAXONOMIC REVISION OF THE SPECIES OF Scaphoideus UHLER AND Scaphotettix MATSUMURA (HOMOPTERA:CICADELLIDAE) OF THE INDIAN SUBCONTINENT" submitted in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (AGRICULTURE) in AGRICULTURAL ENTOMOLOGY of the University of Agricultural Sciences, Bangalore, is a bonafide record of research work done by Mr.G.S. MOHAN during the period of his study in this University under my guidance and supervision, and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

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(G.S.MOHAN)

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INTRODUCTION

I. INTRODUCTION

The leafhoppers (Cicadellidae) constitute a very large group of homopteran insects distributed in all zoo-geographical regions of the world (De Long, 1971). They are exclusively phytophagous and occur on almost all types of plants. They cause both direct damage by sucking precious plant sap, injecting toxins and indirect damage by acting as vectors of phytopathogenic agents.

The most destructive aspect of the leafhoppers having a significant impact on the economy of agricultural production, is their role as vectors of mycoplasma and virus diseases. Rice yellow dwarf, little leaf of brinjal, potato purple toproll, sesamum phyllody and sandal spike caused by mycoplasma like organisms (MLO), rice tungro, bajra streak and ragi mosaic caused by phytopathogenic viruses are some of the examples of diseases they transmit in India. However, vectors are not known for many MLO and virus diseases and except for a few species of leafhoppers, the systematics, biology, ecology and their role as vectors of plant pathogens is largely unknown.

Revisionary studies of vector species are of great importance as specific vectors are involved for each disease agent. The taxonomy of the Deltocephalinae

to which the genera Scaphoideus Uhler, Scaphotettix Matsumura, Scaphoidophytes Kirkaldy, Hussa Distant, Osbornellus Ball belong is not very well worked out especially in India (Viraktamath, 1982). Nielson (1979) rightly pointed out that "it is superfluous to state that the subfamily Deltocephalinae needs world wide revision .....".

The genus Scaphoideus has a world wide distribution, however, revisionary studies of the included species are available only for the new world (Barnett, 1977). The species of this genus are well known vectors of MLO diseases like "Flavescence doree" of grapes, elm phloem necrosis and western X-disease of peach in the United States of America. They are also quite abundant in the rice growing areas of the Oriental Region (Kitbamroong and Freytag, 1978).

Nineteen species of Scaphoideus, one species each of Hussa and Bolanus Distant are known to occur in the Indian subcontent (Distant, 1908, 1918). However, there are growing evidences that many of these species are erroneously placed in the genus and that some of them belong to the Nearctic genus Osbornellus. Similarly,

their role as vectors of plant diseases cannot be ruled out unless intensive studies involving these species for transmission of MLO and virus diseases show otherwise. In view of the importance of the group as probable vectors of plant pathogens, this revisionary work was undertaken with the following objectives:

a) to revise the known species of the genus Scaphoideus and related genera viz., Scaphotettix and Hussa occurring in the Indian subcontinent

b) to describe the new taxa discovered during the course of study

c) to prepare a key for the identification of the genera and species included in this study.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

The cicadellidae constitute the largest family of Homoptera comprising more than 11,000 species, approximately 1500 genera and 35 subfamilies (Knight, 1983; Viraktamath, 1983). They occur in both temperate and tropical parts of the world. The fauna of the tropics and southern continents is still largely unknown.

The Deltocephalinae is the largest subfamily of leafhoppers containing the greatest number of economically important genera and species. This is also the subfamily which contains the greatest number of vector species. It is also considered phylogenetically the most advanced group of leafhoppers (Nielson, 1979). Metcalf (1967) catalogued 2937 species of Deltocephalinae described until December 31, 1959 and included them in 390 genera and 47 subgenera. The subfamily is known to occur in all zoo-geographical regions though the largest number (1,103 species) are known from the Nearctic region. Until the end of 1955 only 193 species were known from the oriental region (Metcalf, 1967) which reflects on the paucity of field collection made from this region.

Though Metcalf treated Deltocephalinae as a subfamily of his family Euscelidae, most of Metcalf's families are treated as subfamilies in recent years (Oman, 1971; Knight, 1983; Young, 1968).

Even the subfamily name Deltocephalinae is used by most workers instead of Euscelinae (Nielson, 1979; Knight, 1983; Viraktamath, 1983; Nast, 1972; Linnavuori, 1975, 1978).

Major revisionary studies in Deltocephalinae have been carried out in the Nearctic region (Barnett, 1975, 1977, 1979; Beirne, 1952, 1956; Blocker, 1967; Dorst, 1937; Green, 1971; Kramer, 1962, 1963, 1965, 1971a, 1971b, 1971c, 1971d; Oman, 1949; Nault and De Long, 1980), the Neotropical region (Kramer and De Long, 1968, 1969; Linnavuori, 1959; Linnavuori and De Long, 1979), the Palaearctic region (Dlabola, 1954, 1957, 1961, 1971, 1972, 1974, 1981; Dubovsky, 1966; Emeljanov, 1962, 1964, 1966; Le Quesne, 1964; Ribaut, 1952; Vilbaste, 1958, 1968, 1980; Mitjaev, 1967), the Afrotropical region (Ghauri, 1961, 1964, 1971, 1972, 1974, 1975, 1981; Theron, Linnavuori, 1975, 1978) and the Australian region (Evans, 1947, 1966; Knight, 1975).

The oriental Deltocephalinae have been dealt with by Distant (1908, 1918), Datta (1972, 1972a, 1972b, 1973a, 1973b), Ghauri (1963, 1966, 1971,1972), Malhotra and Sharma (1977), Melichar (1903), Pruthi (1930, 1934a, 1934b, 1936), Kitbamroong and Freytag (1978), Ishihara,(1953a, 1953b), Ramachandra Rao, (1967, 1973) and Viraktamath (1978, 1981).

The economically important genera of Deltocephalinae have been revised either on worldwide basis or on restricted zoo-geographical regions. The genera Cicadulina China (Ruppel, 1965), Circulifer Zachvatkin (Young and Frazier, 1954), Collodonus Ball (Neilson, 1957, 1966), Exitianus Ball (Ross, 1968), Nephotettix Matsumura (Ghauri, 1971), Hishimonus Ishihara (Knight, 1970a), Litura Knight, and Naevus Knight (Knight,1970b), Grammacephalus Haupt (Linnavuori, 1978; Viraktamath, 1981), Orosius Distant (Ghauri, 1966), Aconura Lethierry and Doratalina Melichar (Vilbaste, 1965) have been revised on world basis.

The New world species of Balclutha Kirkaldy (Blocker, 1967), Psammotettix Haupt (Green, 1971) Deltocephalus Burmeister (Kramer, 1971a, 1971b) Osbornellus Ball (Beirne, 1956; De Long 1916, 1948),

Scaphoideus Uhler (Barnett, 1975, 1977) have been revised. Kitbamroong and Freytag (1978) treated the species of Scaphoideus from Thailand.

The previous workers (for example Distant, 1908, 1918; and Melichar, 1903) described the genera and species based only on the external characters of head, thorax, wings and colouration. At present with these characters alone, it is difficult to recognise deltocephalinae taxa. Infact some of the deltocephalinae genera can be recognised based only on male genitalia (Knight, 1970b, 1973). Therefore, the poineering works of Distant (1908, 1918) and Melichar (1903) are in urgent need of revision based on the characters of male genitalia and other additional characters.

The Deltocephalinae are characterized by Beirne (1956), Evans (1947), Linnavuori (1960b), Metcalf (1967) and Oman (1949) as follows:

Medium sized, form variable but rarely extremely elongate and depressed. Head sometimes strongly produced, anterior margin carinate but never foliaceous; face not in a horizontal plane; lateral margin of gena seldom strongly sinuated below eye, never incised; clypellus not swollen; lateral frontal suture extending to ocelli

which are always present; distance between ocelli equal to or greater than distance between antennal pits; ocellocular area not forming a ledge above antennal pit. Lateral margins of pronotum usually relatively short and not strongly carinate. Intermediate tibiae with large setae. Either macropterous, brachypterous or subbrachypterous; forewings with one or more cross veins anterior to apical series of veins distinct basally. Sexual dimorphism sometimes evident.

Male valve triangular, articulated with pygofer in lateral basal angles; style with a curved apophysis and broad basal part; connective either Y-shaped or linear with branches, slender or parallel and sometimes fused with shaft. A number of species feed on grasses but some feed on shrubs and trees.

2.1. Tribal classification of Deltocephalinae

The opinion is divided among the various workers regarding tribal classification of Deltocephalinae. Oman (1949) recognised six tribes namely Cochlorhinini Oman (1943), Scaphytopiini Oman (1943), Acinopterini Oman (1943), Balcluthini Baker (1915), Deltocephalini Oman (1949) and Macrostelini Kirkaldy (1904, 1905), and included the genus Scaphoideus in the tribe Deltocephalini.

Evans (1947) recognised five tribes in his subfamily Euscelinae. They are Balcluthini, Euscelini Naude (1926), Macrostelini, Platymetopini Haupt (1935), and Xestocephalini Evans (1938). Wagner (1951) recognised three new tribes Fieberiellini, Goniagnathini and Tetartostylini. Ribaut (1952) added the tribe Synophropsini. Emeljanov (1962) included Deltocephalini, Fieberiellini, Goniagnathini, Grypotini Evans (1947), Macrostelini, Scaphytopiini and Tetartostylini as tribes of subfamily in the Palaearctic region and described four new tribes namely, Opsiini, Coryphaecini, Doraturini and Jassargini.

Metcalf (1967) recognised 19 tribes in his family Eucelidae. Acinopterini, Athysanini Van Duzee (1892), Balcluthini, Cicadulini, Van Duzee (1892), Cochlorhinini, Colladonini Bliven (1955), Deltocephalini, Eucelini, Fieberiellini, Goniagnathini, Grypotini Rabaut (1952), Macrostelini, Platymetopiini, Scaphoideini Oman (1943), Scaphytopiini, Synophropsini, Tetartostylini, Thamnotettixini Distant (1908) and Xestocephalini.

Hamilton (1975) redefined the subfamily Aphrodinae in which he included Deltocephalinae and Hecalinae and

recognised 9 tribes namely Hecalini, Deltocephalini, Krisnini, Selenocephalini, Paraboloponini, Aphrodini, Stirellini paradorydiini and Eupelecini he recognised 6 sub-tribes under the tribe Deltocephalini, namely, Cochlorhinina, Cicadulina, Platymetopiina, Deltocephalina, Macrostelina and Athysinina. He included the genus Scaphoideus in the subtribe Platymetopiina.

2.2. Host plants and economic importance of the genus Scaphoideus

At least two species of the genus Scaphoideus namely, Scaphoideus littoralis Ball (transmits "Flavescence doree" of grape) Scaphoideus luteolus van Duzee (transmits Western X-disease of peach) are reported to transmit plant pathogenic agents (Caudwell et al., 1970; Hart, 1978; Neilson, 1979, Schvester, 1969).

Barnett (1977) reviewed the host plants of the genus Scaphoideus, however the information on this aspect is very scanty. They have been collected on grape, (Vitis spp.), blue berry (Vaccinium sp.), witch hazel (Hamamelis virginiana), willow (Salix sp.), oak (Quercus sp.), spice bush (Lindera benzoin), cotton wood (Populus deltoides), cane (Arundinasia gigantea),

apple (Pyrus malus), osage orange (Madura pomifera), Japanese maple (Acer palmatum) Juniperus, Solidago: Crataegus and aster (Osborn, 1900; De Long, 1916, 1939, 1948). Scaphoideus atlantus Ball, S.crassus De Long and Mohr, S.luteolus Van Duzee, S.nigricans Osborn, S.sensibilis Ball and S.titanus Ball have been reared by Gibson (1973) on American elm (Ulmus americana L.) It appears that American elm serves as a laboratory host for a number of species of Scaphoideus occurring in America. Scaphoideus festivus Melichar and Scaphoideus sp. have been collected in sandal growing forests of southern India (Chatterjee, 1939). Vidano (1964, 1965), considered S.titanus as a pest of grapes.

2.3. Taxonomy of the genera

Metcalf (1967) included 32 genera and 265 species in the tribe Scaphoideini. However, many of them have been transferred to other tribes and subfamilies for example Dryadomorpha walker to Paraboloponinae;Caffretus Evans and Stymphalus Stal to Scaphytopiini etc. In this review only the information available on the genera Scaphoideus Uhler and Scaphotettix Matsumara are presented.

Uhler (1889) described the genus Scaphoideus for the inclusion of Jassus immistus Say, Scaphoideus jacundus, Scaphoideus intricatus, and Scaphoideus consors, the latter three being described by him as new species. Subsequently S.jacundus and S.consors have been transferred to Contura and Osbornellus, respectively. Unfortunately Say's type was destroyed and Uhler (1889) did not designate a type species for the genus Scaphoideus. Distant (1908) subsequently designated Scaphoideus immistus as the type species of the genus. Distant (1918) described the genus Bolanus with Bolanus baeticus Distant as the type species, which was subsequently suppressed as a synonym of Scaphoideus by Evans (1947). Ball (1932) recognised four groups of species in Scaphoideus and erected the genera Sanctanus (type-species Scaphoideus sanctanus Ball), Prescottia (type-species Scaphoideus lobatus van Duzee), Osbornellus (type-species Scaphoideus auronitens Provancher) and Portanus (type-species Scaphoideus stigmosus Uhler). Matsumura (1914) described the genus Scaphotettix for the inclusion of Scaphotettix viridis Matsumura from Formosa. This is the only known species included in the genus to date.

Distant (1918) described the genus Hussa with Hussa insignis Distant as the type species. Barnett (1975) synomized Hussa with Scaphoideus. De Long and Mohr (1936) designated a neotype for three subgenera of Scaphoideus namely, Lonenus, Angenus and Latenus. Scaphoideus intricatus was placed in Lonenus as the type, however no type-species were designated for the other two sub-genera. Hence, they are invalid (Oman, 1949; Barnett, 1975). De Long and Knull (1971) again proposed the above three subgeneric names and type species for each. However, Angenus is a synonym of Scaphoideus as both of them have the same type species.

Vilbaste (1968) described the genus Scaphoidella for the inclusion of his species Scaphoidella arboricola from Maritime Territory of USSR. Anufreiv (1977) added one more species (Scaphoidella stenopoea from China and USSR.

Melichar (1903) recorded Scaphoideus festivus Matsumura from Sri Lanka and described S.ornatus, S.morosus and S.elegantulus from Sri Lanka.

Distant (1908) transferred Eutettix punctulatus Melichar (1903) to the genus Scaphoideus. In addition he also added S.indicus (from Assam, Margherita,

Tenasserim and Myitta), S.consanguineus (from Calcutta), S.polymitus (from Tenasserim; Myitta), S.russus (from Tenessarim; Myitta), S.notatus (from Sri Lanka) and S.fletcheri (from Sri Lanka) from the Indian sub-continent. In 1918, Distant described seven more species from the Indian sub-continent. As mentioned earlier he also described Hussa insignis and Bolanus baeticus which are now placed in the genus Scaphoideus.

Kitbamroong and Freytag (1978) described 17 species of Scaphoideus from Thailand of which 14 were new to science. Kwon and Lee (1978) described new species Scaphoideus hongdoensis from Hongdo, Korea, Scaphoideus matsumurai described as a new species from Formosa by Freytag (1976).

Species of the genus Scaphoideus recorded from the Indian subcontinent

Genus Scaphoideus

Scaphoideus Uhler, 1889: 33. Type species: Jassus immistus Say, by subsequent designation

Hussa Distant 1918: 68. Type species: Hussa insignis Distant, original designation and by monotypy.

Bolanus Distant, 1918:89. Type species:Bolanus baeticus Dist. by original designation and by monotypy.

Lonenus De Long, 1939: 33. Type species: Lonenus intricatus by monotypy.

Scaphoideus assamensis Distant

Scaphoideus assamensis Distant, 1918: 67(n.sp.)

Locality: Assam

Scaphoideus baeticus (Distant)

Bolanus baeticus Distant, 1918: 89 (n.sp.)

Scaphoideus baeticus: Evans, 1947: generic transfer. Locality: Assam.

Scaphoideus brachycephalus Distant

Scaphoideus brachycephalus Distant, 1918: 66(n.sp.)

Locality: Kodaikanal

Scaphoideus consanguineus Distant

Scaphoideus consanguineus Distant, 1908: 375(n.sp.)

Locality: Calcutta

Scaphoideus elegantulus Melichar

Scaphoideus elegantulus Melichar, 1903: 193

Locality: Ceylon

Scaphoideus festivus Matsumura

Scaphoideus festivus Matsumura, 1902: 384 (n.sp.)

Freytag, 1976: 172.

Localities: Ceylon, India (Kodaikanal, Mysore, Coorg) Sumbaria (also occurs in Japan, Formosa, China, Korea, Manchuria).

Freytag (1976) stated that the true festivus occurs in Japan, Russia, China, and that, the records of this species from other countries south of northern part of China are probably in error and most such records should be referred to the closely related species S.ornatus Melichar (1903).

Scaphoideus fletcheri Distant

Scaphoideus fletcheri Distant, 1908: 377(n.sp.)

Locality: Ceylon.

Scaphoideus hieroglyphicus Distant

Scaphoideus hieroglyphicus Distant, 1918: 65(n.sp.)

Locality: Nandidurg

Scaphoideus indicus Distant

Scaphoideus indicus Distant, 1908: 374(n.sp.)

Locality: Assam, Tenasserium

Scaphoideus insignis (Distant)

Hussa insignis Distant, 1918: 68 (n.sp.)

Scaphoideus insignis : Barnett: 1975: 494 (generic transfer)

Locality: Tamil Nadu: Shambaganur

Scaphoideus morosus Melichar

Scaphoideus morosus Melichar:1903: 197 (n.sp.)

Distant 1908: 373 (redescribed)

Localities: Ceylon, India: Assam, W.Bengal

(also occurs in Formosa, Java, Philippines)

Scaphoideus notatus Distant

Scaphoideus notatus Distant, 1908: 377 (n.sp.)

Locality: Ceylon

Scaphoideus nutans Distant

Scaphoideus nutans Distant, 1918: 65(n.sp.)

Locality: Kodaikanal

Scaphoideus ornatus Melichar

Scaphoideus ornatus Melichar, 1903: 196 (n.sp.)

Distant: 1908: 373 (redescribed)

Locality: Ceylon

(Freytag (1976): states that this is distributed throughout the Oriental region)

Scaphoideus pallifrons Distant

Scaphoideus pallifrons Distant, 1981: 66(n.sp.)

Locality: Kodaikanal

Scaphoideus polymitus Distant

Scaphoideus polymitus Distant, 1908: 376(n.sp.)

Locality: Tenasserim

Scaphoideus punctulatus (Melichar)

Eutettix punctulatus Melichar, 1903b: 191(n.sp.)

Scaphoideus punctualatus: Distant, 1908 g.378 (generic transfer)

Locality: Ceylon

Scaphoideus redundans Distant

Scaphoideus redundans Distant, 1918b: 64 (n.sp.)

Locality: Kodaikanal, Niligiri Hills

Scaphoideus russus Distant

Scaphoideus russus Distant, 1908: 377(n.sp.)

Locality: Tenasserim

Scaphoideus stigmaticus Distant

Scaphoideus stigmaticus Distant, 1918: 67(n.sp.)

Locality: Himalayas

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The details of methods adopted during the course of this study are given below.

3.1.1. Sources of leafhopper material

Majority of the specimens used for the study were from the collections made under the project "Systematic and biological studies on Asiatic leafhoppers". These were sorted out and curated for further study. These specimens were collected from the states of Karnataka, Kerala, Tamil Nadu, Uttar Pradesh, West Bengal and Mizoram in India, A few specimens from Sri Lanka were also studied.

3.1.2. Types of species described by Melichar and Distant

Dr.P.H.Freytag, Department of Entomology, University of Kentucky, Lexington, Kentucky, U.S.A. studied the types of Bolanus baeticus Distant, Scaphoideus assamensis Distant, S.brachycephalus Distant, S.consanguineus Distant, S.fletcheri Distant, S.hieroglyphicus Distant, S.indicus Distant, S.notatus Distant, S.nutans Distant, S.pallifrons Distant, S.redundans Distant, S.russus Distant, S.stigmaticus Distant, S.elegantulus Melichar, S.morosus Melichar S.ornatus and S.punctulatus Melichar. He provided the photographes of various aspects of the type specimens of these specimens and male and female genital diagrams of

Map-I Localities from which the leafhoppers used in the study originated.

the following species for our study: male genital diagrams of elegantulus, morosus notatus, ornatus, punctulatus, redundans and russus; female genital diagrams of assamensis, consanguineus, indicus and stigmaticus. In addition he informed that the type specimen of Scaphoideus polymitus Distant is missing.

3.2. Processing of the material for study

3.2.1. Mounting and labelling

The leafhoppers were mounted singly on triangular card point on the right hand side of thorax by using Quickfix^{R} diluted in ethyl acetate so that it permitted both visible and physical access to the head, wing and abdomen. The data label with information regarding locality, date of collection and name of the collector was transfixed, separately to the respective specimens. Sexes of the leafhoppers were indicated on right hand side of the card point by code colouring with green and yellow for male and female, respectively.

3.2.2. Preparation of genitalia

The procedure advocated by Oman (1949) and Knight (1965) for the study of male genitalia was closely followed. The specimen was gently supported on a cork piece, on its

back and with the help of a fine bent needle the abdomen was detached from the thorax at the junction of the two. The abdomen was then transferred to a test tube containing a few milliliters of 10% potassium hydroxide this was heated slowly over a spirit lamp till the convection currents were observed in the solution. The abdomen was removed to a glass cavity dish containing water and the digested soft tissues were pressed out with the help of a pair of bent needles mounted on plastic handle. After repeated washing in water, the abdomen was transferred to glycerine in a glass cavity dish for further dissection (separation of genitalic parts from the genital capsule) and observations were made under stereoscopic microscope. After study the dissected parts were placed in the abdomen of the specimen and preserved in a drop of glycerine held in Arthropod microvial^{R}. The vial was stoppered with a neoprene cork and the latter was transfixed by the pin holding the rest of the specimen, with a slight downward inclination.

3.2.3. Preparation and study of wings

The wings were dry mounted on slide for the purpose of study and illustration. Fore and hind wings of one side (usually left) were removed on to a clean dry glass

slide. After spreading them properly, a glass cover slip with small quantity of adhesive smeared at the corners was placed on them and gently pressed. The slide was then allowed to dry. Each slide was labelled giving the details of the specimen from which the wings were removed. The drawings of the wings were made using a microslide projector.

3.3. Illustrations

The genitalic parts were illustrated using compound microscope fitted with a mirror type camera lucida. The parts of the male genitalia were held in the desired position on the cavity slide by means of a small quantity of bees wax firmly fixed to the bottom of the cavity slide before placing glycerine to avoid movements of the genital structures to be illustrated. However, the illustrations of male pygofer, male valve, male plate, style were prepared out of temporary slide mounts under a coverslip in glycerine. The illustrations of head, thorax and face were prepared using a camera lucida attached to a steroscopic microscope. The specimens used for illustration were labelled as "Illustrated - Mohan".

3.4. Measurements

Ten males and ten females were used for measurements. Where the number of specimens collected was less than ten, the available number of specimens were measured. The measurements of various parts were made with the help of a standardized ocular micrometer placed in one of the eye pieces of Olympus stereoscopic microscope. The parts measured and the ratios used are as follows:

Total length : distance between the anterior most point of vertex and the posterior tip of the folded forewings along the mid-dorsal line.

Length of vertex : distance between the anterior and the posterior margins of vertex along the mid dorsal line.

Length of pronotum : distance between the anterior and posterior margins of pronotum along the mid dorsal line.

Length of scutellum : distance between posterior margin of pronotum and caudal tip of scutellum along the mid-dorsal line.

Length of face : distance between the anterior margin of frons and the posterior margin of clypellus along the mid ventral line when the face was in horizontal position.

Length of forewing : distance between the articulatory point (with meso-thorax) of forewing and its apical tip.

Length of clavus : length along the claval suture.

Length of hind tibia : distance between the articulatory point of hind tibia with femur and the tip of tibial pecten.

Width of head including eyes : distance between the points where eyes projected most to the sides.

Width of vertex : distance between the inner margins of eyes where the width is minimum.

Width of pronotum : distance measured nearer to the posterior angles where the pronotum is broadest.

Width of forewing : distance measured in middle of forewing where it is maximum.

All the measurements are expressed in millimetre.

Fig.1 : Descriptive terminology of leafhoppers - external morphology

a total length
b length of fore wing
c length of clavus
d length of hind tibia
e width of fore wing

A : Head and thorax

f width of head including eyes
g width of vertex
h width of pronotum
i length of vertex
j length of pronotum
k length of scutellum

B : Profile of head and thorax

l vertex
m pronotum
n scutellum

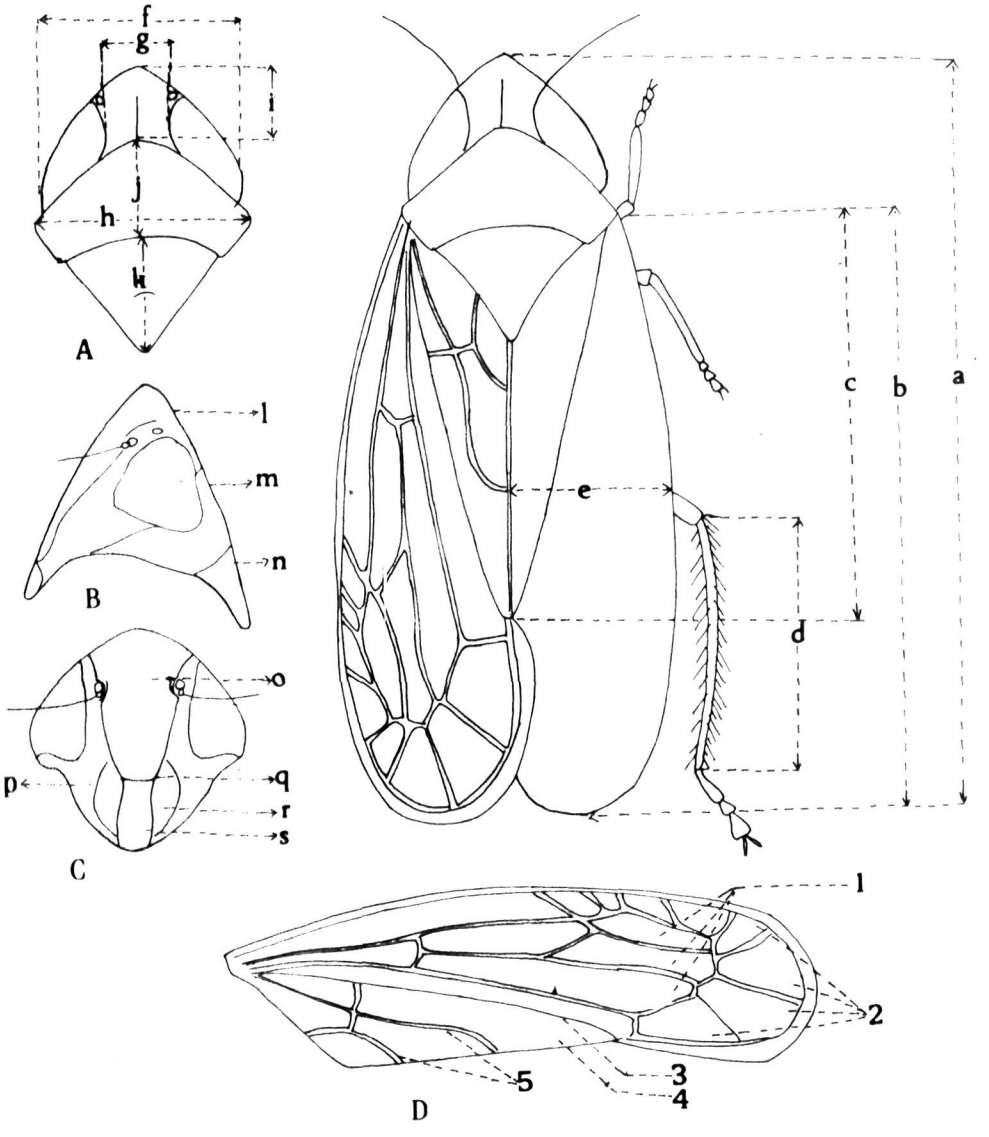
C : Face

o fronto clypeus
p gena
q transclypeal sulcus
r lorum
s clypellus

D : Fore wing

1 anteapical cells
2 apical cells
3 claval suture
4 clavus
5 claval veins

D' : Hind wing (not shown in the diagram)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3.4.1. Ratios

The different morphometric ratios used in the description of species are as follows:

A : Total length of leafhopper to width of head including eyes

B : Length of vertex to its width

C : Length of pronotum to its width

D : Length of forewing to its width

E : Length of face to width of head including eyes

3.5. Terminology

Terms used in the description of the morphology are those used by Oman (1949) and Young (1952). The various parts are illustrated in Figs.1 and 2.

Aedeagus : The sclerotized intromittant organ carrying ejaculatory duct in the male.

Anteapical cells(Sub-apical cell) : Cells of the wings which occur before apical cells.

Apical cells : Cells of the wings present in the apical area.

Apophysis of style : Terminal finger-like process of style.

Atrium : Broad basal opening of the gonoduct.

Connective : Scleroized basal part of adeagal shaft with stem and arms bears paraphyses.

Clavus : The triangular anal portion of the forewing.

Clypellus (anteclypeus) : More or less rectangular sclerite located just before the mouth parts emerging out of the head.

Coronal sulcus : A longitudinal sulcus along the midline of the vertex between the compound eyes.

Dorsal apodeme : Apodeme formed possibly by the modification of atrial rim and directed distally to which the muscles of the tenth segment are connected.

Dorsal connective : Sclerotized elongate paired structure articulating between tenth segment and dorsal apodeme.

Face : The entire cephalic aspect of head.

Frontoclypeus : Area of the face dorsad of the clypellus, laterally limitted by lateral fascial sulci.

Genae : Outer most sclerite below the eyes on the face.

Gonopore : Terminal opening of the gonoduct which runs through the shaft.

Intermediate sclerite : A plate-like sclerite interposed between aedeagus and connective, either fused or articulated with connective and aedeagus.

Lorum (Mandibular plate) : Present on either side of the clypellus, usually delimited on the outside by an arc-shaped sulcus.

Ocelli : Simple eyes on the anterior margin of vertex near compound eyes.

Paraphyses : A pair of elongate, sclerotized structures either articulated or fused with caudal apex of connective and usually placed ventrad of aedeagus.

Phallobase (Socle) : Body of the aedeagus which bears the dorsal apodeme and the shaft.

Preapical lobe : Any lobe-like prolongation before the tip of the organ concerned, here used for style.

Pronotum : Dorsal sclerite of the prothorax which is usually large and shield - like.

Pygofer (Pygophore) : Combined tergum and the pleura of the ninth abdominal segment which houses the genital organs in both sexes.

Pygofer process : Appendage arising on any part of the pygofer.

Scutellum : Triangular plate that follows the pronotum.

Shaft : Part of the aedeagus that carries the gonopore and through which the terminal part of the ejaculatory duct traverse.

Style : A pair of appendages on either side of the connective used as claspers during copulation.

Male plate (sub-genital plate) : A pair of lobe-like appendages which extend caudelly beneath the pygofer and form the floor of the pygofer cavity.

Male valve : The sternum of the ninth segment found in males.

Vertex : The entire dorsal surface of head excluding eyes.

Fig.2 : Descriptive terminology of leafhoppers-genitalia

E Pygofer

E′ Dorsal connective (not shown in the diagram)

F Male valve

G Male plate

H Style

I Apophysis of style

J Connective

J′ Intermediate sclerite

K Connective and paraphyses, dorsal view

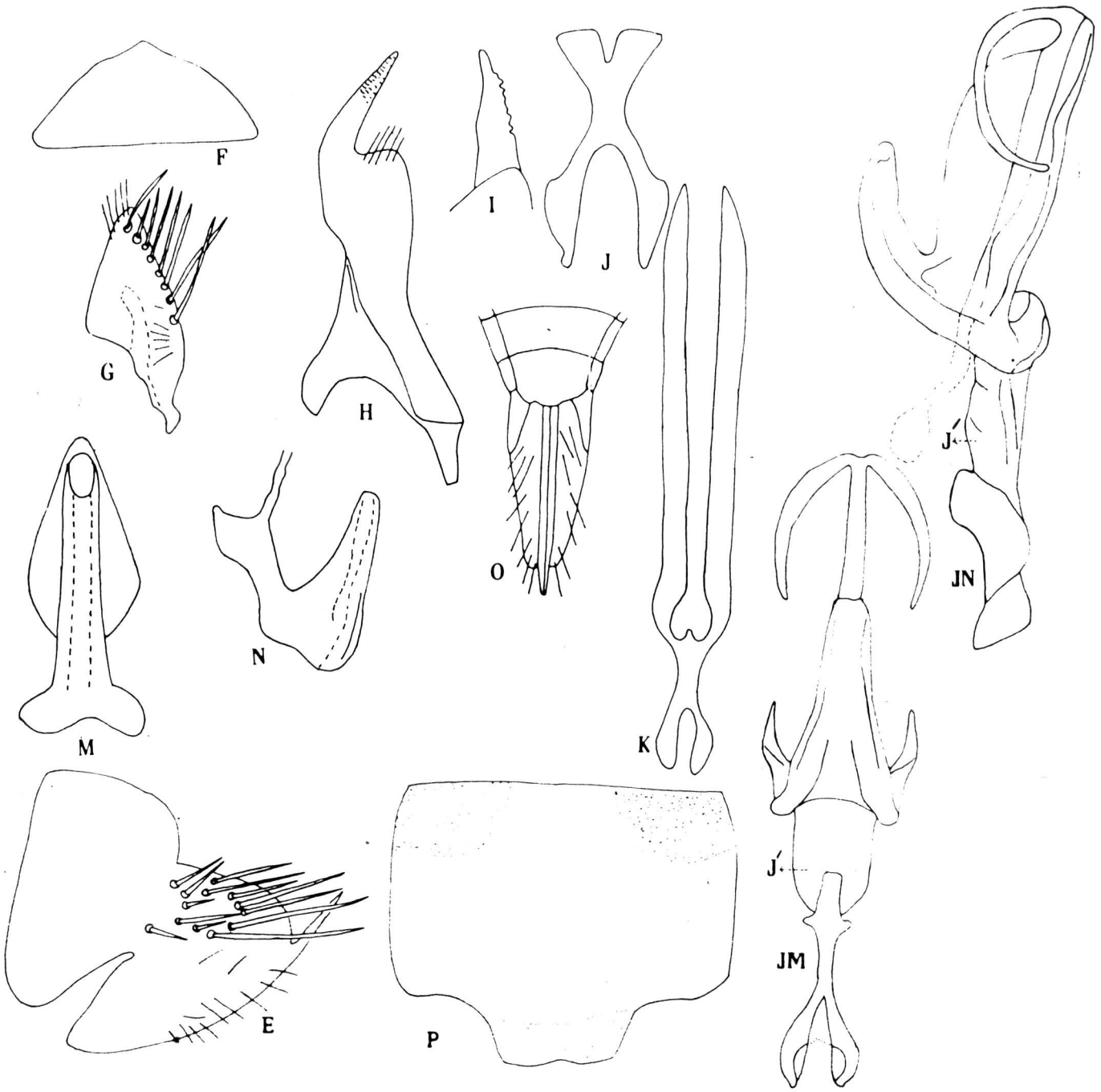
L Connective and paraphyses, Lateral view (not shown in the diagram)

M Aedeagus dorsal view

N Aedeagus lateral view

O Female ovipositor

P Female seventh sternum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3.6. Citation of collectors names

While citing names of the collectors of the specimens examined, the following abbreviations are used:

ARV : Mr.A.R.V.Kumar, Department of Entomology, University of Agricultural Sciences, GKVK, Bangalore, Karnataka.

BM : Dr.B.Mallik, Regional Research Station, Mudigere, Karnataka

CAV : Dr.C.A.Viraktamath, Department of Entomology, UAS, Bangalore.

CSW : Mr. C.S.Wesley, Department of Entomology, UAS, Bangalore.

HSK : Mr.H.S.Krishnamurthy, Field Officer, Syndicate Bank, Munirabad.

HVA : Mr.H.V.Ananth Murthy, Field Officer, Bank of India, Raichur.

KDG : Dr.K.D.Ghorpade, 123, Brigade Road, P.O. Box No.2654, Bangalore-25

SV : Mr. S.Viraktamath, Agricultural Engineering Institute, UAS, Raichur.

3.7. Type depositories

The holotypes of the new taxa described here will be deposited in the insect collections of the Department

of Entomology, University of Agricultural Sciences, G.K.V.K. Bangalore (UAS). The paratypes (wherever possible) will be deposited in the National Pusa Collection, Indian Agricultural Research Institute, New Delhi (IARI), British Museum (Natural History), London (BMNH), the United States National Museum of Natural History, Washington, D.C. (USNM).

RESULTS

IV. RESULTS

The present revisionary study revealed the presence of 21 species belonging to three genera, of which one genus and fifteen species are new to science. In addition new distribution records of the species are also established. The results of the study are presented here.

4.1. The three genera recognised are Scaphotettix Matsumura, Scaphodhara gen. nov. and Scaphoideus Uhler. These can be distinguished by the following key.

1. Claval veins either approximated or connected by a cross vein; meso-thoracic femora with stout long setae of varying length; ratio of width of frontoclypeus between antennal pit to width of frontoclypeus at apex varies from 0.90 to 1.25; connective without paraphyses or intervening sclerite between aedeagus and connective (Fig.4 D, N,M).. .. .. .. Scaphotettix Matsumura

- Claval veins neither approximated nor connected by a cross vein at their mid length; mesothoracic femora with stout short setae of uniform length (except in Scaphoideus curvatus); ratio between width of frantoclypeus between antennal pit to

width of frantoclypeus at apex varies from 1.32 to 1.68; connective either with paraphyses or with an intervening sclerite between connective and aedeagus (Fig.10M, 11M, ...) ... 2

2. An interveining sclerite between aedeagus and connective present (Fig.10M, 11M); paraphyses absent.. .. .. Scaphodhara gen.nov.

- No interveining sclerite between aedeagus and connective; paraphyses of connective well developed (Fig.13K).. .. Scaphoideus Uhler

4.2.1. Genus Scaphotettix Matsumura

Head, pronotum and scutellum with transverse sanguineous or orange bands; vertex with one or two marginal and submarginal inverted V-shaped chocolate brown markings. Forewing with a number of transparent spots surrounded by fuscous area with dark brown veins.

Head including eyes either as wide as or narrower than pronotum, longer medially than next to eyes, either acutely angled or obtusely rounded. Pronotum 0.39 times as long as its width. Frantoclypeus widened dorsally. Clypellus broader apically. Vertex 0.72 times as long as its width. Claval veins either confluent in the middle or approximated medially and connected by a

cross vein; a cross vein between outer claval vein and claval suture; anteapical cells three, inner anteapical cell open behind, outer anteapical cell smallest, about 1/2 to 2/3 as long as median anteapical cell; only one reflexed vein connecting basal outer angle of outer anteapical cell and costal margin. Fore femora compressed with a series of short stout spines on ventral margin in addition to 10-15 hair-like setae on meso-apical area. Middle femora compressed with a row of some short and some long stout spines along mesal margin.

Pygofer with caudal lobe either with or without attenuated process, with tufts of long setae or with scattered setae. Male plate triangular with rounded apex having an oblique row of stout setae. Style slender, elongate or robust with well developed preapical lobe, apophysis of style short or elongate with pointed apex, its ventral margin serrated. Connective Y-shaped with stem shorter or longer than arms, neither with paraphyses nor with an intervening sclerite between aedeagus and connective. Aedeagal shaft slender, elongate or stouter, wider near base, with a pair of apical tooth or spine-like processes. Gonopore apical or subapical.

.2.2. Key to species of Scaphotettix (males)

/ Scaphotettix indicus (Distant), S.hieroglyphicus (Distant) and S.consanguineus (Distant) are known only from females and hence are not included in the key /.

1. Claval veins fused (Fig.5D). Aedeagus with apical pair of appendages strongly recurved and directed ventrally (Fig.5M) .. ..S.keralicus sp.nov.

- Claval veins either approximated or connected by cross vein (Fig.3D,4D). Aedeagal processes variable, but not strongly recurved and directed ventrally 2

2. Aedeagus without processes (Fig.4 MJN); pygofer without caudal attenuated process .. .. .. S.freytagi sp.nov.

- Aedeagus with processes; pygofer with a caudal attenuated process (Figs.3 EM, 6 EM, 7 EM, 8 EM) 3

3. Aedeagus with a pair of apical and a pair of subapical processes (Fig.7M); caudal lobe of pygofer gradually narrowed to an attenuated process (Fig.7E); dorsal margin with a short caudally directed process (Fig.7E) .. .. S.quadrifidus sp.nov

- Aedeagus with only a pair of apical processes (Figs.3M,6M,8M); caudal lobe of pygofer abruptly narrowed and produced into a spine-like process from the caudo ventral margin (Figs.3E,6E,8E) 4

4. Aedeagal process with crenulate margin; stem of connective more than 1.5 times as long as its arms (Fig.8 J, M) .. .. S.redundans Distant

- Aedeagal process smooth margined or almost with a single denticle at mid length of process (Fig.3M); stem of connective half as long as its arms(Fig.6J) 5

5. Aedeagal shaft slender evenly curved (Fig.3 N); apical process of aedeagus in caudal aspect L-shaped with median tooth (Fig.3 MN).. .. S.agumbensis sp.nov.

- Aedeagal shaft stouter, wider near base than at apex, aedeagal process evenly curved ventrally in caudal view (Fig.6 JM JN).. .. S.malnadicus sp.nov.

4.2.3. Scaphotettix agumbensis sp.nov.(Fig.3, Plate.1a)

Vertex ochraceous with a marginal and submarginal piceous bands, area between these orange, a transverse sanguineous spot broadened in the middle and narrowed towards eyes on disk, margined with piceous anteriorly.

Face ochraceous anterior margin whitish with a ventral ill-defined brownish margin. Pronotum with an anterior marginal and a posterior sub-marginal sanguineous transverse bands. Scutellum with pale sanguineous anterior band not reaching lateral margins, posterior half ochraceous, lateral margin piceous. Colour of forewing similar to that of Scaphotettix malnadicus. Fore tibia, apex of middle femur, basal, apical and two median spots on the middle tibia, first and second tarsomeres and series of spots at base of hind tibia, apex of hind tibia, hind basitarsus, entire second tarsomere and basal 1/3 of third tarsomere, piceous.

Head bluntly conical, slightly narrower than pronotum. Vertex broader between eyes than its median length. Pronotum 1.8 times as wide as its median length, longer than scutellum. Claval veins approximated in the middle, outer anteapical cell 3/4 as long as the median anteapical cell.

Male genitalia: Ventro-caudal angle of male pygofer produced into a spine-like process directed caudo-dorsally, caudodorsal margin convex. Tenth segment large and well sclerotized. Valve triangular. Male plate rather

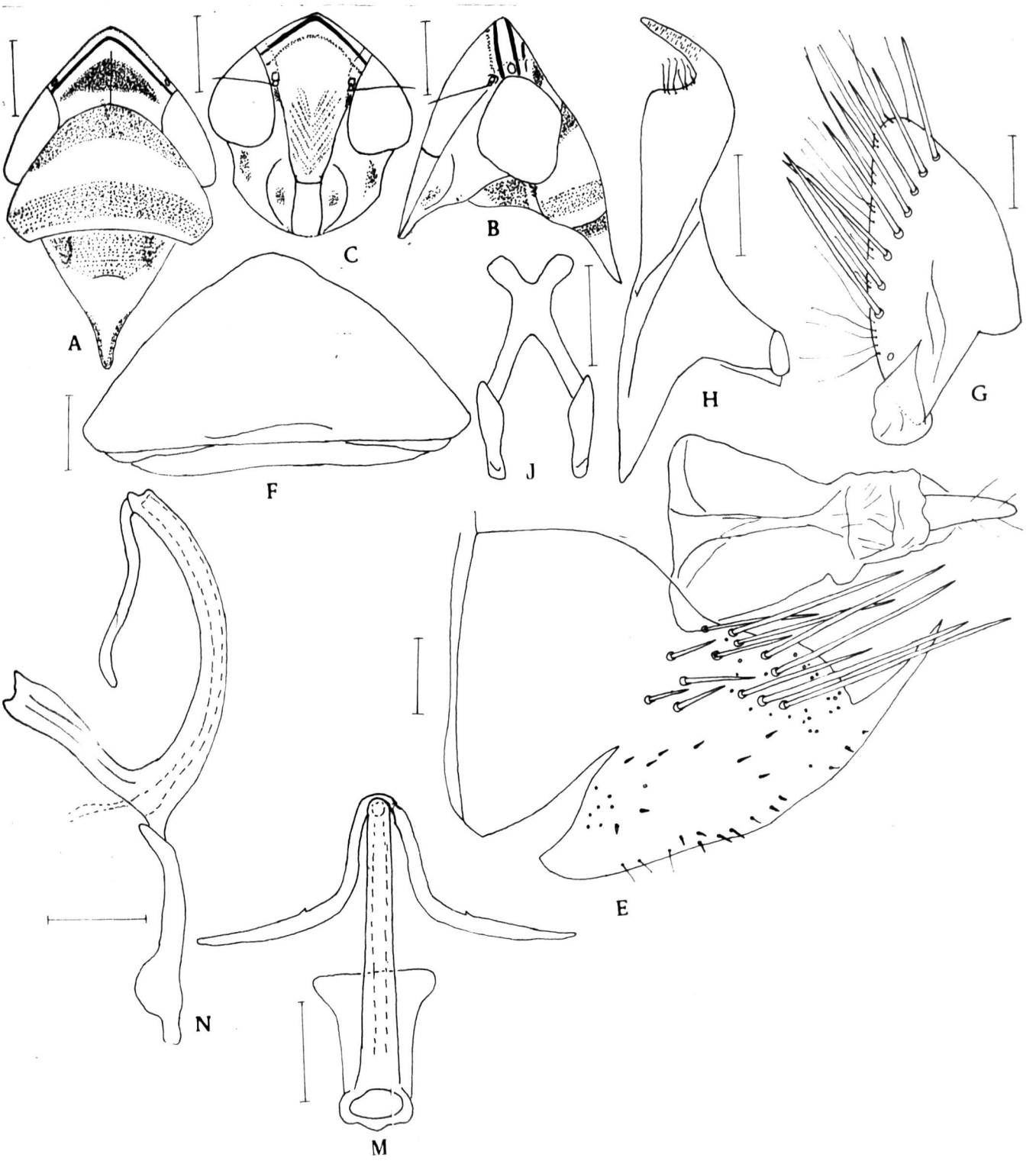
triangular with rounded apex, having oblique row of stout setae and numerous marginal hair-like setae. Style slender elongate with well developed pre-apical lobe, apophysis short, slender, strongly curved laterally, its surface pustulate. Connective X-shaped with caudal arms short, anterior arms slender, elongated three times as long as caudal arms. Aedeagus with well developed thin plate-like dorsal apodeme which is about half as long as shaft; shaft caudo-dorsally smoothly curved, of uniform width and with a pair of apical processes; each process in its basal 1/3 directed anteriorly and then obruptly laterally with a median short tooth. Gonopore subapical.

Morphometric ratios: Male:A: 3.93, B:0.87; C:0.53; E:1.02.

Measurements (in mm): Male-total length: 5.0; length of vertex: 0.5; length of pronotum: 0.7; length of scutellum:0.6; length of face:1.3; width of head including eyes: 1.27; width of vertex:0.57; width of pronotum:1.3.

Specimen examined: Holotype ♂ INDIA: Karnataka, Agumbe, 23.xi.1982 (H.V.A.Murthy Coll.)(UAS).

Fig.3. Scaphotettix agumbensis sp.nov.(♂)
Scale refers to 0.1 mm except in ABC where it is equal to 0.5 mm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Remarks: This species is closely related to S.malnadicus in having X-shaped connective and characters of style, adeagus and pygofer. However, this species has more slender and elongate style with a shorter apophysis. The adeagal shaft is also slender and elongate with differently shaped process. Dorsal apodeme is well developed. One of the style and one process of the adeagus are damaged.

4.2.4. Scaphotettix freytagi sp.nov.(Fig.4, Plate.1b)

Scaphoideus festivus sensu Ishihara, 1961.

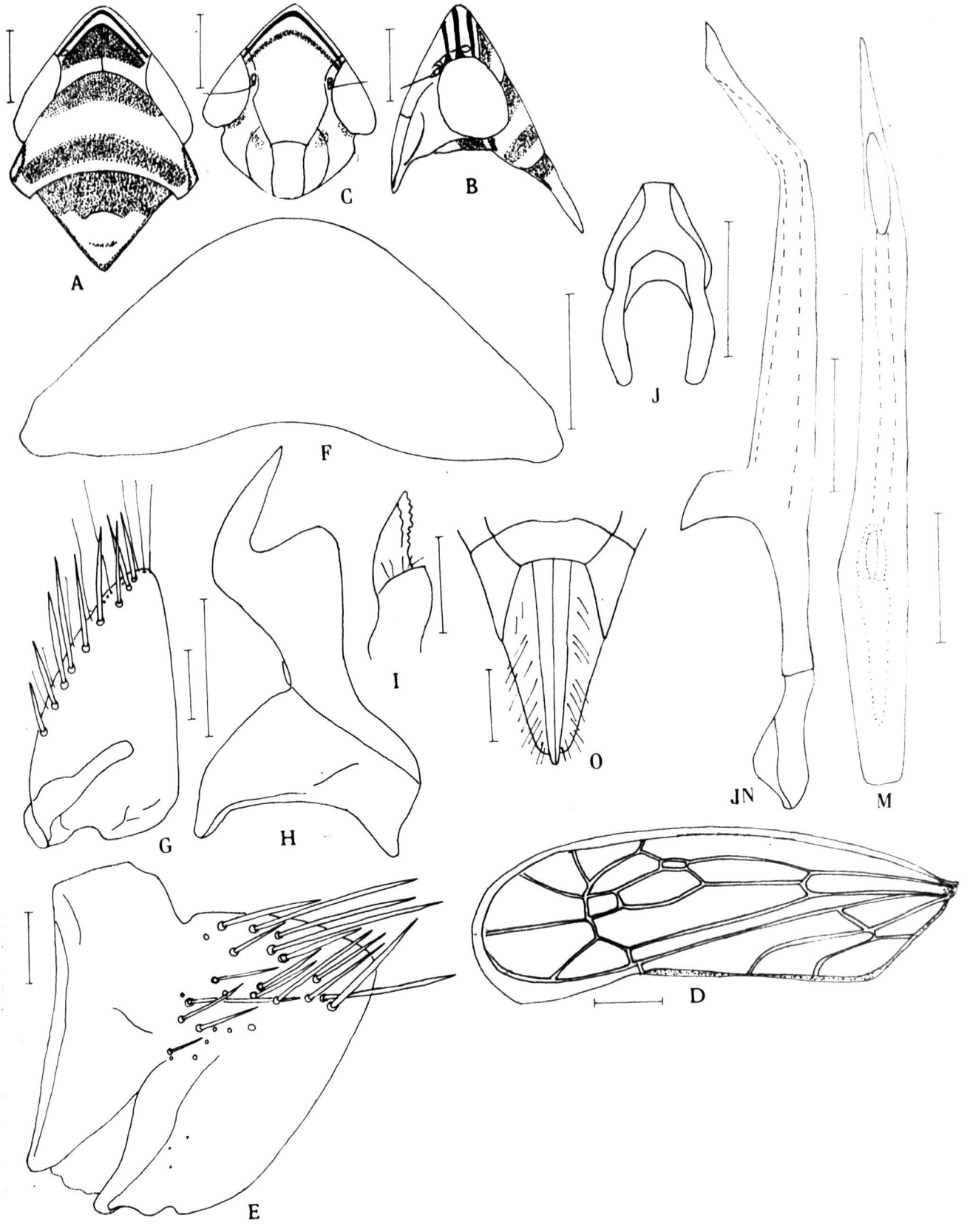
Head ochraceous with three arcuate black lines of which two are on anterior margin of the vertex and one below it; a transverse sanguineous line across eyes anteriorly margined by the second dorsal black line. Face with a faint dorsal fuscous arcuate line. Pronotum and scutellum ochraceous, a transverse fascia along anterior margin of pronotum and sub-marginal fascia on the disk reddish-orange; a sub-marginal stripe on the extreme lateral area of pronotum fuscous; dorsal half of episternum and dorsal 3/4 of mesoepimeron dark fuscous. Anterior half of scutellum sanguineous, lateral margin and narrow apical margin, dark fuscous. Legs ochraceous

colouration of legs similar to that in Scaphotettix quadrifidus. Forewings dark fuscous with hyaline areas surrounded by dark fuscous, venation darker.

Vertex conically produced in front, median sulcus reaching 4/5 of the length, median length shorter than width between eyes. Pronotum slightly more than twice as wide as long but slightly shorter than scutellum. Claval veins separate but connected by a cross vein; outer anteapical cell half as long as median apical cell; median apical cell wider in the middle.

Male genitalia: Caudal margin of pygofer obtusely rounded without a tuft of long setae but caudal half with a number of scattered long setae. Tergum of the pygofer well sclerotized. Valve with a rounded caudal margin. Male plate obtusely rounded at apex, with a marginal row of stout setae in caudal 3/4 in addition to long hair-like setae. Style robust with well developed preapical lobe, apophysis short, straight, laterally directed, with a pointed apex, its ventral margin serrate. Connective Y-shaped with short stout stem half as long as arm. Aedeagus elongate tubular, preatrium 1/4 as long as total length, dorsal apodeme short and stout, shaft narrowed

Fig.4. Scaphotettix freytagi sp.nov. (♂♀)
Scale refers to 0.1 mm except in ABCD & O
where it is equal to 0.5 mm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caudally, at its apical 1/3 curved dorsally; apex compressed blade-like. Gonopore sub-apical.

Female genitalia: Seventh sternum three times as long as the sixth, caudal margin medially concave.

Morphometric ratios: A:♂ 3.55, ♀ 3.46; B:♂ 0.73, ♀ 0.69; C:♂ 0.45, ♀ 0.50; D:♂ 3.15, ♀ 3.12; E:♂ 0.93, ♀ 0.90.

Measurements (in mm): total length: ♂ 4.05, ♀ 4.4; length of vertex: ♂ 0.38, ♀ 0.41; length of pronotum:♂ 0.52, ♀ 0.62; length of scutellum: ♂ 0.57, ♀ 0.67; length of face; ♂ 1.07, ♀ 1.15; length of forewing: ♂ 3.15, ♀ 3.5; length of clavus: ♂ 2.15, ♀ 2.3; length of hind tibia:♂ 1.0, ♀ 2.2; width of head including eyes: ♂ 1.14, ♀ 1.27; width of vertex: ♂ 0.52, ♀ 0.59; width of pronotum: ♂ 1.14, ♀ 1.23; width of forewing:♂ 1.0, ♀ 1.12.

Specimens examined

Holotype ♂, INDIA:Uttar Pradesh: Dehra Dun, 28.iv.1975 (CAV.Coll.)(UAS).

Paratypes: 2 ♂, 5 ♀, data as in holotype; 2 ♂, 4 ♀ INDIA: W.Bengal: 10 km N of Siliguri, 1.xi.1981 (CAV Coll.277):1 ♀, INDIA: W.Bengal:Calcutta, 11.xi.1981

(CAV Coll.284). 1 ♀ INDIA: Kerala:Walayar forest, 26.x.1975 (CAV Coll.). 1 ♂, INDIA: Karnataka, Bannerghatta (24 km S. of Bangalore), 9.viii.1979 (CAV) (IARI, BMNH, UAS, USNM).

Remarks: This species differs from other species by not having Aedeagal processes and pygofer without caudal attenuated process. Ishihara (1961) misidentified this species as Scaphoideus festivus, which is very evident from male genital diagrams provided by him.

4.2.5. Scaphotettix keralicus, sp.nov.(Fig.5, Plate.1C,1D)

Similar to that of Scaphotettix quadrifidus with following differences.

In male, face has a sub-marginal dark brown,curved transverse band on the dorsal aspect and a few medially interrupted bands at the basal half of the frons; antenna pits, a spot below each eye, lateral margin and discal spot to lora brownish. Claval veins sanquineous, the first cross vein between radial sector and median sanguineous. Female colouration is much brighter and darker than in the females of Scaphotettix quadrifidus. The apical half of the face including part of genae, entire lorum, clypellus and apical 1/3 of frons dark brown;a transverse fascia accross middle of frontoclypeus and middle of gena ochraceous.

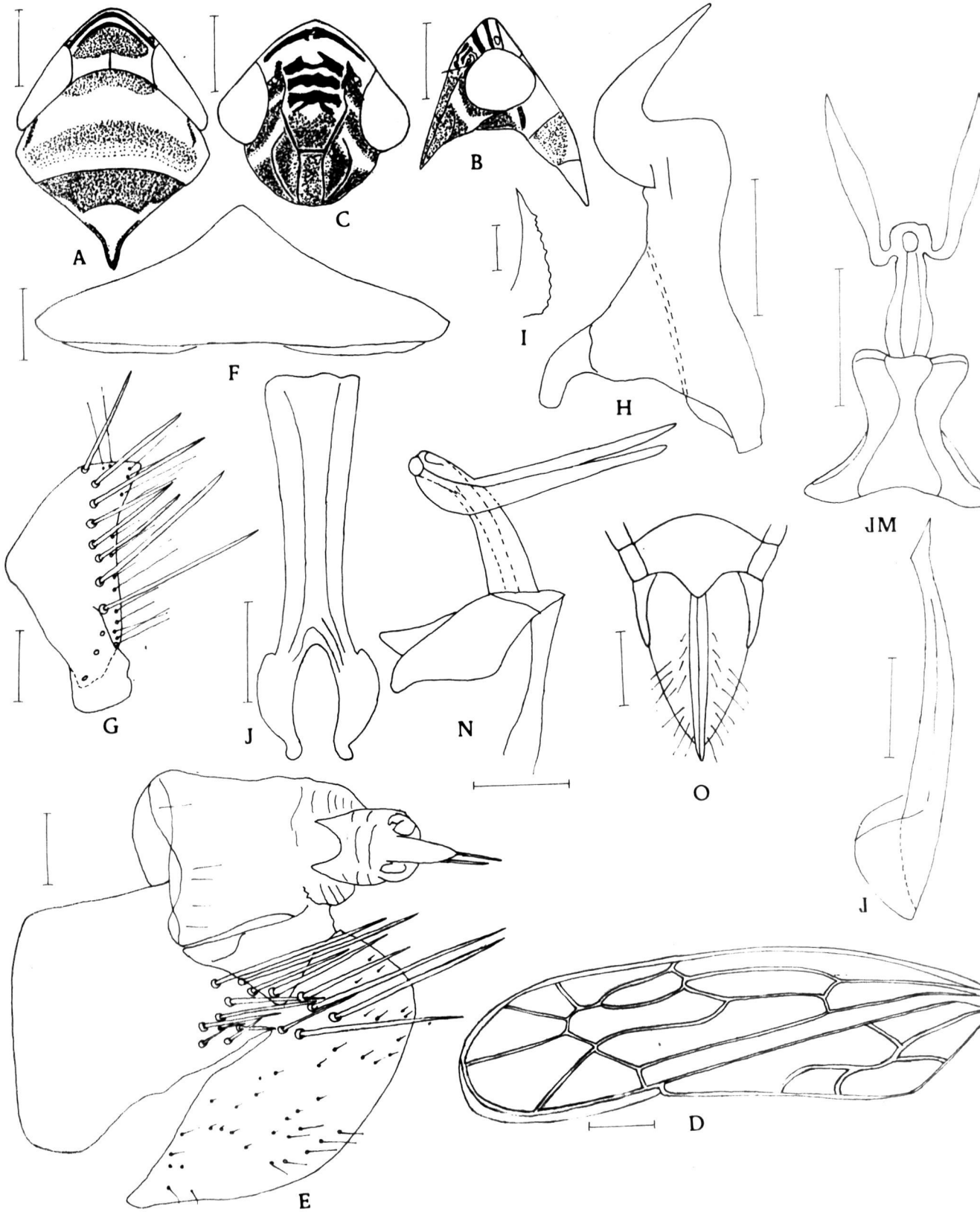
Vertex more acutely angled than in Scaphotettix quadrifidus. Claval veins fused in the middle, a cross vein from the inner claval vein reaches the claval suture.

Male genitalia: Pygofer with a rounded caudal margin without any process. Male plate triangular with obtuse apex covered with marginal hair-like setae and a row of sub-marginal stout elongate setae. Valve triangular. Style stout prominent with well developed pre-apical lobe, apophysis curved with its ventral margin serrate. Connective Y-shaped, stem twice as long as arms. Aedeagus some what L-shaped with well developed dorsal apodeme which is bifid distally; shaft straight, directed caudo-dorsally with an apical gonopore; a pair of long distally attenuated strongly recurved processes directed ventrally and then caudally arise at the apex of the shaft.

Female genitalia: The female seventh sternum thrice as long as median length of sixth sternum; its Hind margin conically produced in the middle.

Morphometric ratios: A : ♂ 3.80; ♀ 3.70; B: ♂ 0.75, ♀ 0.75; C: ♂ 0.50, ♀ 0.51; D: ♂ 3.27, ♀ 3.41; E: ♂ 0.8 , ♀ 0.88.

Fig.5. Scaphotettix keralicus sp.nov. (♂♀)
Scale refers to 0.1 mm except in ABCD & O where it is equal to 0.5 mm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Measurements (in mm): total length: ♂ 4.5, ♀ 5.0; length of vertex: ♂ 0.40, ♀ 0.45; length of pronotum: ♂ 0.62; ♀ 0.68; length of scutellum: ♂ 0.59, ♀ 0.68; length of face: ♂ 1.02, ♀ 1.20; length of forewing: ♂ 3.5, ♀ 4.0; length of clavus : ♂ 2.3, ♀ 2.6; length of hind tibia: ♂ 2.0, ♀ 2.6; width of head including eyes: ♂ 1.17, ♀ 1.35; width of vertex: ♂ 0.53, ♀ 0.60; width of pronotum: ♂ 1.22, ♀ 1.33; width of forewing: ♂ 1.07, ♀ 1.17.

Specimen examined

Holotype ♂, INDIA: Kerala: Thekkadi, 26.iii.1977 (CAV.Coll.No.65)(UAS).

Paratypes: 2 ♂, 2 ♀ , data as in holotype; 4 ♂, 4 ♀, data as in holotype but collected on 27.iii.1977; 1 ♂, 3 ♀ data as in holotype (SV Coll.); 2 ♂ , 4 ♀ data as in holotype but collected on 27.iii.1977; 5 ♂, 4 ♀ , data as in holotype (BM Coll.); INDIA: Karnataka; 1 ♂ Jog Falls 17.xi.1976 (BM), 1 ♂, 1 ♀, 8.v.1976(BM), 1 ♀ 9.v.1976 (BM); 1 ♀, 10.xi.1976 (CAV); Mudigere, 1 ♀, 7.x.1975 (CAV)(IARI, BMNH, UAS, USNM).

Remarks: See under Scaphotettix quadrifidus sp.nov.

Plates:

1 a : Scaphotettix agumbensis sp.nov. (♂)

1 b : Scaphotettix freytagi sp.nov. (♀)

1 c : Scaphotettix keralicus sp.nov.(♂)

1 d : Scaphotettix keralicus sp.nov.(♀)

Plate 1a

Plate 1b

Plate 1c

Plate 1d

4.2.6. Scaphotettix malnadicus sp.nov.(Fig.6, Plate 2a)

Anterior margin of vertex with a marginal and two sub-marginal piceous lines, the posterior sub-marginal line not reaching the inner margin of eyes, transverse stripe on the disk sanguineous. Face ochraceous with upper margin whitish with sub-marginal faint brownish band. Pronotum brownish with an anterior and a posterior sub-marginal transverse, sanguineous bands. Scutellum with basal angle brownish, area between them sanguineous, medially interrupted by an ochraceous line. Posterior half of scutellum yellowish white with lateral margins piceous. Fore wing pale brown with a prominant dark-brown markings surrounding a number of hyaline spots distributed on clavus and corium; apex of clavus, a spot at the inner claval vein and sub-marginal area of forewing narrowly dark brown. Colouration of legs same as in S.agumbensis.

Head bluntly conical, slightly narrower than pronotum. Vertex broader between eyes than its median length. Pronotum 1.8 times as wide as long, longer than the scutellum. Claval veins approximated in the middle, outer anteapical cell 3/4 as long as median anteapical cell.

Male genitalia: Caudo-ventral margin of pygofer with a caudally directed process, caudo-dorsal margin membranous ventral margin curved. Tenth segment large, sclerotized. Valve rather triangular. Male plate triangular with rounded caudal angle, with marginal hair-like setae more numerous at apex and with tufts of setae which become subapical near apex. Style with well developed pre-apical lobe, apophysis slender, strongly directed laterally with serrated ventral margin. Connective X-shaped, caudal arms very short, anterior arms slender elongate and 2.5 times as long as caudal arms. Adeagus with poorly developed dorsal apodeme, shaft slightly caudo-dorsally curved, broader at base, than at apex, with a pair of apical antero-ventrally curved processes. Gonopore sub-apical.

Morphometric ratios: Male: A: 3.76; B: 0.78; C :0.53; E 1.00.

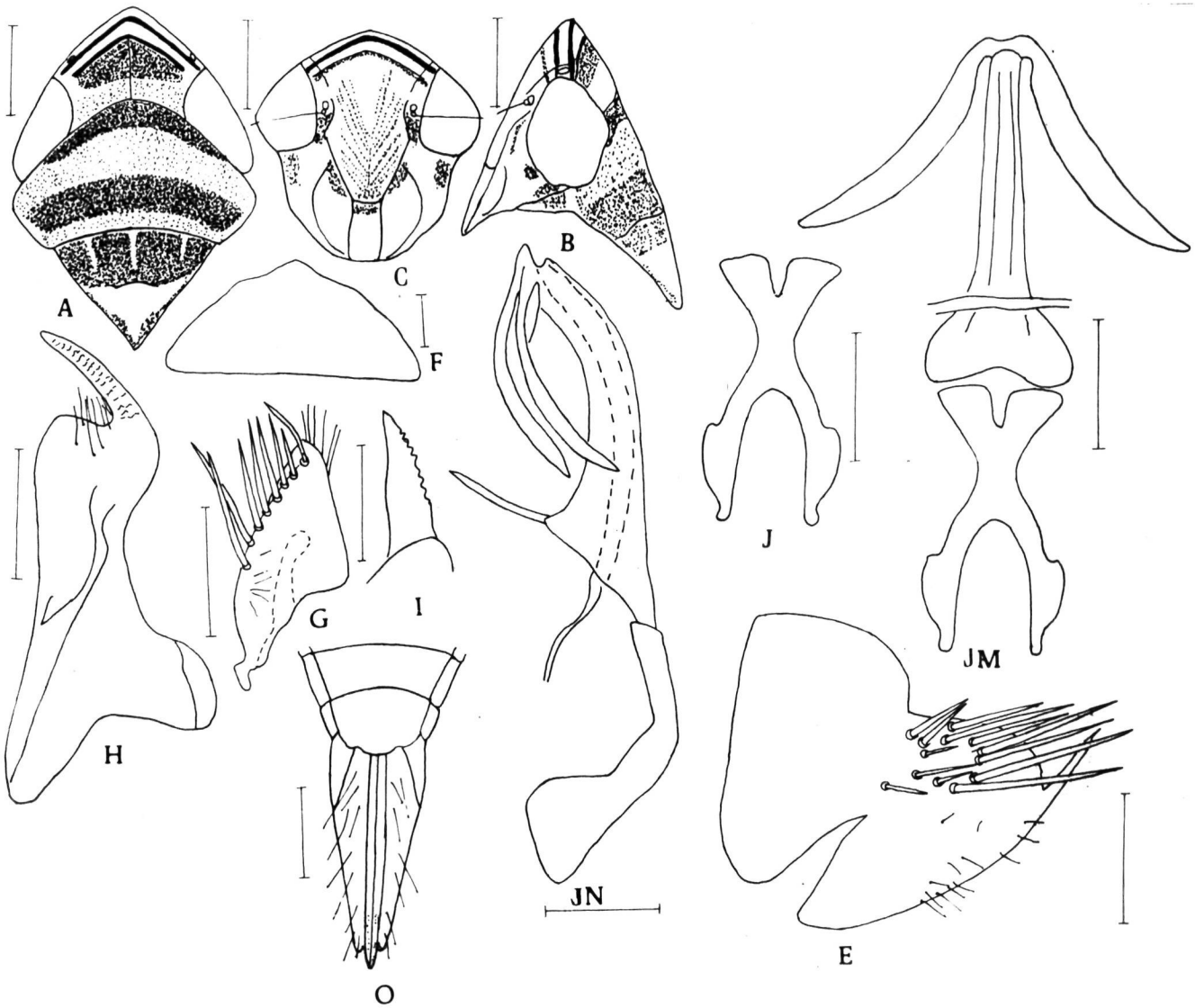
Measurements (in mm): Male: total length: 4.9; length of vertex: 0.47; length of pronotum: 0.7; length of scutellum: 0.62; length of face: 1.3; width of head including eyes: 1.3; width of vertex 0.6; width of pronotum: 1.32.

Specimen examined

Holotype ♂ INDIA: Karnataka: 35 km West of Jog Falls, 18.xi.1976 (CAV Coll.No.51) (UAS).

Fig.6. Scaphotettix malnadicus sp.nov. (♂♀)

Scale refers to 0.1 mm except in ABCD & O where it is equal to 0.5 mm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Remarks

This species is closely related to Scaphotettix agumbensis but differs in the structure of male genitalia as discussed under that species.

4.2.7. Scaphotettix quadrifidus sp.nov. (Fig.7,Plate.2b)

Vertex ochraceous with two submarginal bands posterior to and a marginal band ventrad of ocelli, dark brown; a transverse fascia across eyes sanguineous, anterior most margin of face pale ochraceous, margined by brown; dorsal half of frons brownish ochraceous, remaining part ochraceous in male; in female frons with a submarginal transverse brown fascia and a series of medially interrupted transverse fasciae, lateral frontal suture, antennal pits and area beneath compound eyes, brownish. Pronotum and scutellum ochraceous; pronotum with anterior marginal and a posterior sub-marginal transverse sanquineous fascia,apical half of scutellum yellowish. Legs pale ochraceous, bases of hind tibial spines brown, fore tibia striped with brown, middle tibia with three brown spots; basal and median tarsomere brown; apex of hind tibia, basitarsus and entire second tarsomere and basal half of 3rd tarsomere piceous. Claval veins sanquineous in some specimens and reddish brown in others. Forewing brownish

with a number of hyaline spots often surrounded by brown; apices of claval veins, recurved veins on the costal margin, a few spots on anteapical and apical cells and the veins, dark brown. In females the colouration is much darker.

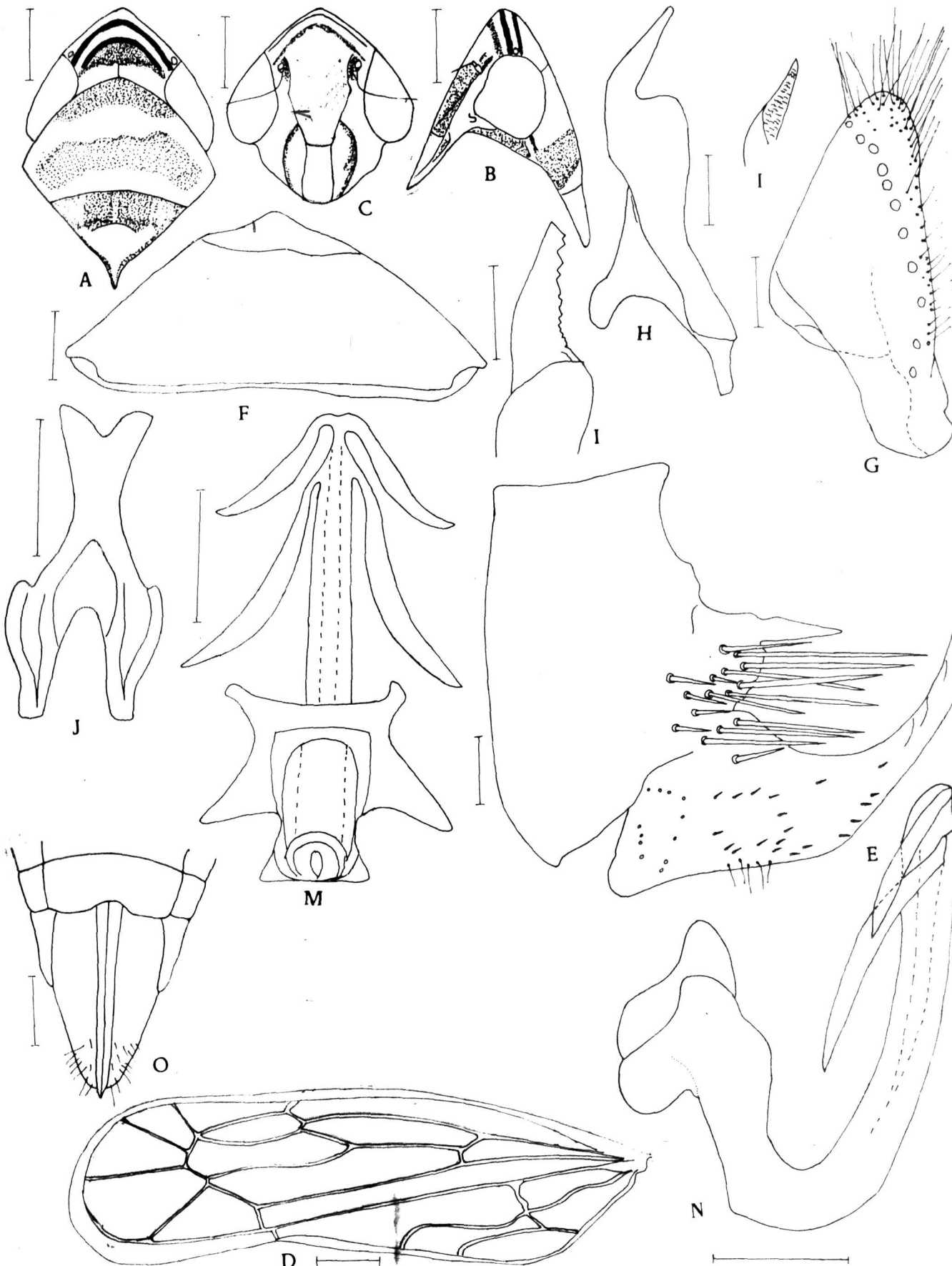
Head is shorter than pronotum (20:30). Pronotum longer than scutellum and wider than long (55:30).

Male genitalia: Pygofer caudally attenuated, produced into a dorsally curved process, caudo-dorsal margin with a short finger-like process, dorsum of pygofer well sclerotized. Valve broadly triangular. Apex of male plate obtusely rounded with long hair-like setae, and with an oblique row of stout sub-marginal spines. Style with well developed preapical lobe, apophysis short, finger-like, directed caudo-laterally with its lower margin transversely rugose. Connective Y-shaped, stem short, bifid and with a dorsal pair of hemispherical apodemes. Aedeagus rather J-shaped with well developed dorsal apodeme which has four distinct lobes; shaft rather of uniform width with a pair of apical and a pair of subapical laterally divergent processes. Gonopore apical.

Female genitalia: Seventh sternum twice as long as sixth, its caudal margin medially concavely curved.

Fig.7. Scaphotettix quadrifidus sp.nov. (♂♀)

Scale refers to 0.1 mm except in ABCD & O where it is equal to 0.5 mm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Morphometric ratios: A: ♂ 3.8, ♀ 3.6; B: ♂ 0.75, ♀ 0.62; C: ♂ 9.54, ♀ 0.51, D: ♂ 3.30, ♀ 3.40; E: ♂ 0.9, ♀ 0.76.

Measurements (in mm): total length: ♂ 5.31, ♀ 5.7; length of vertex: ♂ 0.48, ♀ 0.47; length of pronotum: ♂ 0.75, ♀ 0.81; length of scutellum: ♂ 0.68, ♀ 0.77; length of face: ♂ 1.26, ♀ 1.19; length of forewing: ♂ 4.2, ♀ 4.5; length of clavus: ♂ 2.76, ♀ 3.0; length of hind tibia: ♂ 2.46, ♀ 2.5; width of head including eyes: ♂ 1.37, ♀ 1.55; width of vertex ♂ 0.64, ♀ 0.75; width of pronotum: ♂ 1.38, ♀ 1.58; width of forewing: ♂ 1.27, ♀ 1.32.

Specimens examined: Holotype ♂ INDIA: Kerala: Thekkadi, 26.iii.1977 (CAV. Coll.No.65) (UAS).

Paratype: 3 ♂, 6 ♀, data as in holotype; 1 ♂, data as in holotype but collected on 27.iii.1977; 2 ♂, 3 ♀, data as in holotype (SV Coll.No.5); 2 ♂, data as in holotype (BM, Coll No.37). (BMNH, IARI, UAS, USNM).

Remarks: This species externally resembles *Scaphotettix keralicus* but differ in being longer, claval veins being separate and in the structure of male and female genitalia.

Plates:

2 a : Scaphotettix malnadicus sp.nov.(♂)

2 b : Scaphotettix quadrifidus sp.nov.(♂)

2 c : Scaphotettix redundans Distant (♂)

Plate 2a

Plate 2b

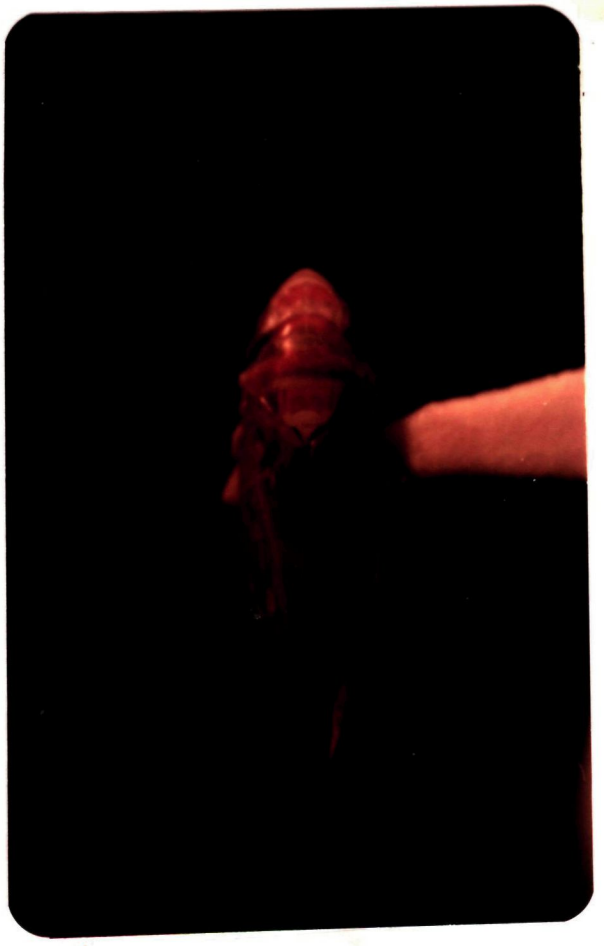


Plate 2c

4.2.8. Scaphotettix redundans (Distant) Comb.nov.
(Fig.8, Plate.2C)

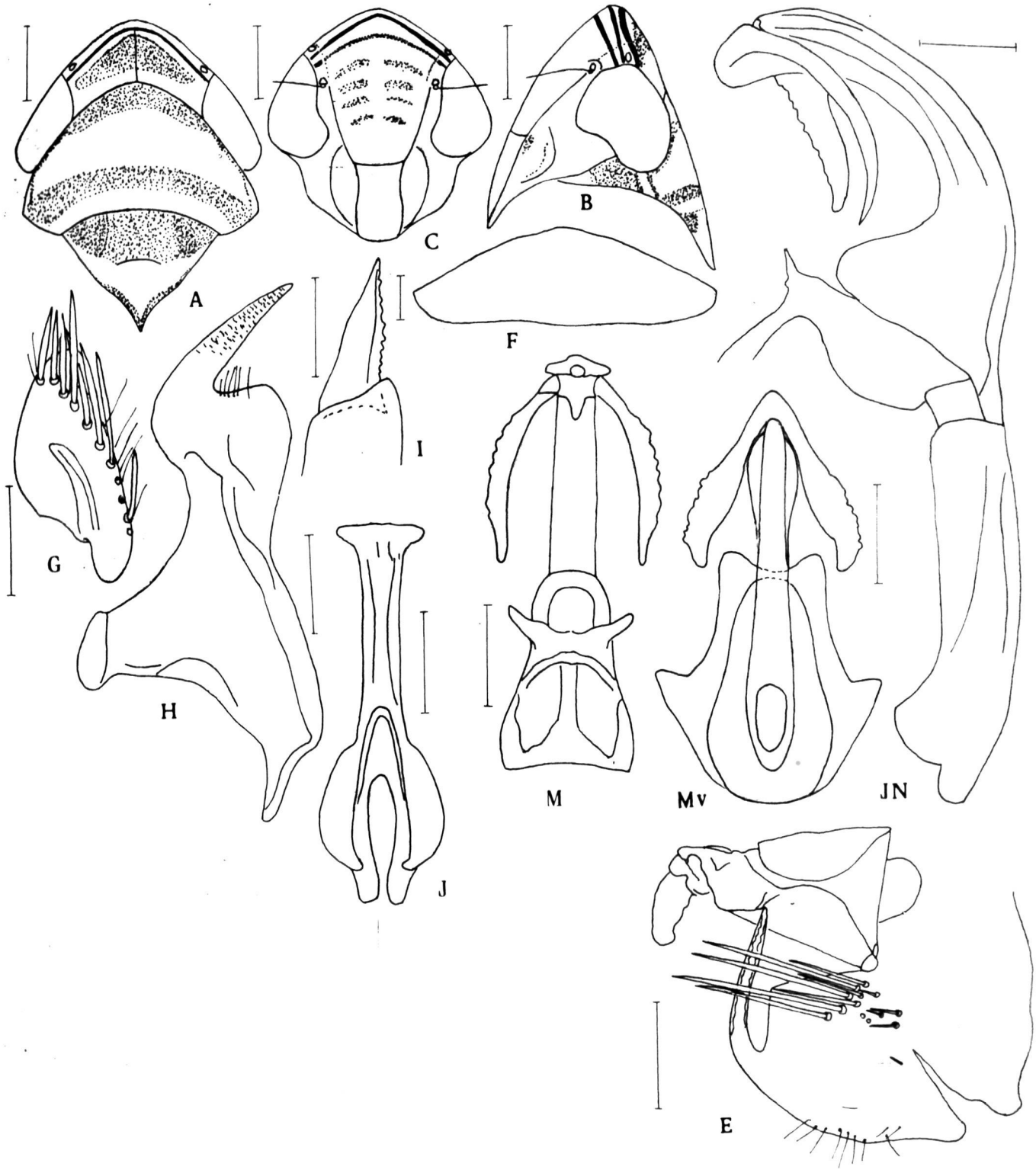
Scaphoideus redundans Distant, 1918

Colouration as described by Distant (1918) with following additions. Outer claval vein slightly incurved but not touching inner claval vein; apices of claval vein dark brown much broadly so in case of inner claval vein, clavus with three large whitish hyaline spots, the veins marked with dark brown. Two recurved veins on costal margin, vein dilimiting outer apical cell and the apical sub-marginal band broadly dark brown. The apices of hind basitarus and entire middle tarsal segment and basal area of third tarsal segment dark brown, the lateral margin of the pronotum with a fuscous line. Proepimeron fuscous.

Head obtusely rounded in front. Vertex much broader than its length.

Male genitalia: Pygofer with a ventral, dorsally produced process which is longer than the height of pygofer. Tenth segment well sclerotized. Darso-caudal area of pygofer membranous without any process. Valve broadly triangular. Male plate with obtusely rounded apex, and marginal stout setae which obliquely traverse the width of plate before the apex and with marginal and

Fig.8. Scaphotettix redundans Distant (♂)
Scale refers to 0.1 mm except in ABC where it is equal to 0.5 mm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apical long hair-like setae. Style with well developed preapical lobe, apophysis strongly laterally directed, distinctly acutely pointed, ventral margin finely serrated. Connective Y-shaped, stem of connective twice as long as the arm, caudally broad. Aedeagus with fairly well developed but short-dorsal apodeme; shaft curved caudo-dorsally and in lateral aspect slightly broader at apex than at base, with a pair of sub-apical latero-anteriolly directed blade-like processes with crenulate margin. Gonopore subapical.

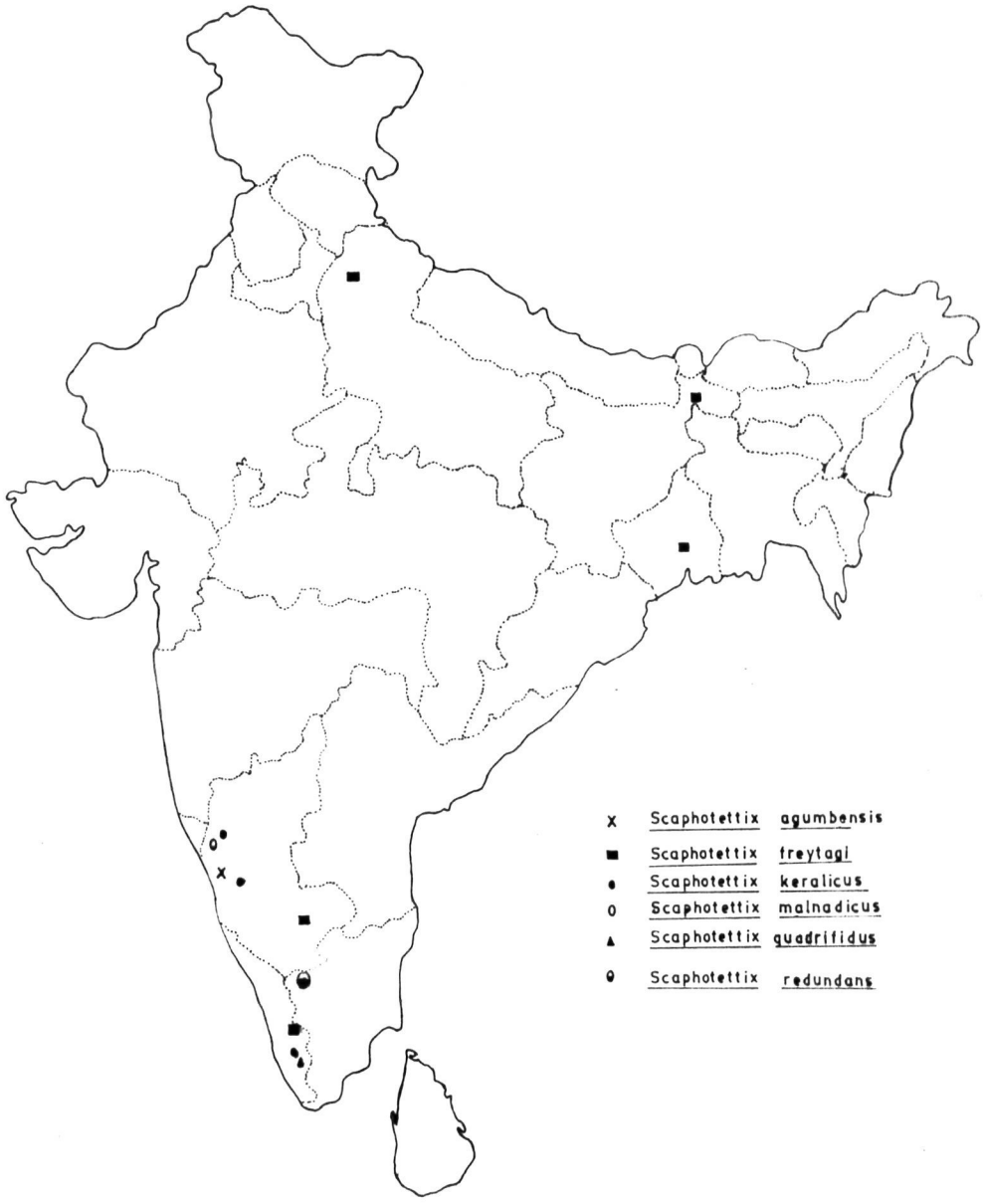
Morphometric ratios: Male: A: 4.0, B:0.6, C:0.5, D:3.84, E:0.8.

Measurements (in mm): Male: total length: 5.8, length of vertex: 0.42, length of pronotum: 0.75, length of scutellum:0.7, length of face: 1.2, length of fore-wing:4.8, length of clavus: 3.1, length of hind tibia: 2.6, width of head including eyes: 1.45, width of vertex: 0.7, width of pronotum:1.5, width of forewing:1.25.

Specimen examined

1 ♂, INDIA: Tamil Nadu: Naduvattam, 6.vi.1977 (CAV. Coll.)(UAS).

Map-II Distribution of species of Scaphotettix Matsumura.


x Scaphotettix agumbensis
■ Scaphotettix freytagi
• Scaphotettix keralicus
0 Scaphotettix malnadicus
▲ Scaphotettix quadrifidus
ϕ Scaphotettix redundans

Remarks: S.redundans is related to S.quadrifidus, S.agumbensis and S.malnadicus in having a ventral process to pygofer. It differs from these species in having crenulate margin to the aedeagal process.

4.3. Scaphodhara gen.nov.

Type-Species: Scaphodhara biloba sp.nov.

Colouration similar to some species of Scaphoideus. Head, pronotum, scutellum and folded forewings traversed by a median broad ivory or yellowish white stripe flanked by lateral brown area.

Head including eyes narrower than pronotum. Vertex with acutely pointed anterior margin, 1.19 times as long as its width between eyes. Face longer than wide, the ratio between the width of frantoclypeus between bases of antennae to width of frontoclypeus at apex varies from 1: 1.48 to 1: 1.68. Pronotum 0.46 times as long as its width, shorter than scutellum. Fore wing similar to that in Scaphoideus. Fore femora without short stout setae but with 9-11 hair-like setae on meso-apical area, middle femora with short stout setae of uniform length.

Pygofer longer than its height, caudally rounded or bluntly pointed with tufts of long and scattered setae. Male plate as in Scaphoideus. Style with well developed

preapical lobe, apophysis short, curved laterally either sharply pointed or bluntly pointed apically. Connective Y-shaped in its anterior part, an intermediate sclerite between aedeagus and connective with which it is either fused or articulated. Aedeagus fused with intermediate sclerite, often compressed and with a pair of apical processes. Dorsal connective either poorly or well developed. Ovipositor extending beyond pygoter in female.

4.3.1. Key to species of Scaphodhara (males)

1. Male plate bilobed (Fig.9G); aedeagal shaft strongly curved appearing C-shaped (Fig.9 N); apophysis of style stout with a rounded apex (Fig.9 HI) .. .. S.biloba sp.nov.

- Male plate with a single lobe (Figs.10G, 11G, 12G); aedeagal shaft, straight not curved; apophysis of style slender, curved laterally and with an acute apex (Figs.10 HI, 11 HI, 12 HI) 2

2. Aedeagus compressed; its processes at least half as long as shaft (Fig.10 JM, 12 JM) .. 3

- Aedeagus rather cylindrical, elongate, its processes short, about 1/4 as long as shaft, shaft lamellatly expanded (Fig.10 MJN) .. .. S.neela sp.nov.

3. Intermediate sclrite between aedeagus and connective with a pair of horn-like processes (Fig.10 JJ'M); caudal lobe of pygofer rounded (Fig.10 E) .. .. S.meppadica sp.nov.

- Intermediate sclerite between aedeagus and connective without horn-like processes (Fig.12 JJ'M), caudal lobe of pygofer acutely angled (Fig.12 E). .. S.periyari sp.nov.

4.3.2. Scaphodhara biloba sp.nov. (Fig.9 Plate.3a,3b)

A broad ivory stripe traversing vertex, pronotum, scutellum and continued on folded forewings and laterally margined by dark brown. A pair of narrow orange stripes on vertex, pronotum and scutellum on the yellow stripe, one on either side of median line. A spot at apex of vertex, two adjacent slightly transverse spots to it partially visible from above, an oblique spot arising from each ocellus, anterior inner margin of eyes dark chocolate brown. Face ochraceous, area above a line across antennal base with two complete and two to three incomplete transverse dark chocolate brown fasciae; a transverse brown faciae across lower angle of compound eyes. A spot on gena adjacent to lorum light brown. Lateral aspect of pronotum with two long brown stripes, extreme lateral margins and area between the brown stripes ochraceous.

The basal triangles of scutellum brown and in line with brown inner stripe of pronotum, extreme lateral margin of scutellum pale ochraceous, outwardly margined by brown. A ventral spot to epimeron and a large spot on meso-episternum brown. Anterior area of forewing hyaline. Venation brown, a dark brown spot on the cross vein between outer and median apical cell. Medial area of median anteapical cell brown longitudinally. Legs ochraceous, hind tibia spotted with brown at basis of spines and apex.

Colouration of female similar to that in male but face darker, upper fascia on face black. The transverse fascia across lower margin of compound eyes complete and piceous; apical half of frantoclypeus piceous; lower area of lorum and gena piceous. Apices of hind basitarsus, entire middle tarsus and base of third tarsomere piceous.

Vertex depressed medially, slightly broader between eyes than its median length, anteriorly acutely angled, coronal sulcus reaching 3/4 of its length. Vertex, pronotum and scutellum polished. Pronotum slightly more than twice as wide as long, longer than vertex but shorter than scutellum. Claval veins connected by a cross vein, outer claval vein connected with claval suture. Outer

anteapical cell 3/4 as long as median anteapical cell, two recurved veins connect outer anteapical cell with costal margin.

Male genitalia: Pygofer longer than its height caudo-dorsal area rounded with sub-marginal tufts of long setae in addition to scattered setae on ventral half. Tength segment posteriorly sclerotized, tergum of pygofer well sclerotized. Valve triangular, male plate with bilobed apex. Style stout and short with well developed preapical lobe, apophysis well developed pustulated, half as long as its total length. Connective Y-shaped stem poorly developed 3/4 as long as arm, attached to aedeagus almost at mid length. Aedeagus broadly U-shaped with strongly developed broad wing-like dorsal apodeme, which is slightly longer than shaft, shaft directed caudally, of uniform width in lateral aspect and with a pair of antero-ventrally curved subapical processes; each process lamellately expanded in middle and with acute pointed apex. Gonopore elongate and on ventral margin.

Female genitalia: Seventh sternum slightly longer than sixth sternum and its caudal margin medially produced into a bilobed some what W-shaped process.

Fig.9. Scaphodhara biloba sp.nov. (♂♀)
Scale refers to 0.1 mm except in ABCD & O where it is equal to 0.5 mm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Morphometric ratios: A: ♂ 4.19, ♀ 4.53, B: ♂ 0.89, ♀ 0.97, G: ♂ 0.45, ♀ 0.45; D : ♂ 3.70, ♀ 3.73; E: ♂ 0.96, ♀ 0.83.

Measurements (in mm): total length: ♂ 5.5, ♀ 6.8; length of vertex: ♂ 0.5, ♀ 0.65; length of pronotum: ♂ 0.63, ♀ 0.75; length of scutellum: ♂ 0.75, ♀ 0.89; length of face: ♂ 1.26, ♀ 1.25; length of wing: ♂ 4.7, ♀ 5.6; length of clavus: ♂ 3.05, ♀ 3.7; length of hind tibia: ♂ 2.7, ♀ 3.1; width of head including eyes: ♂ 1.31, ♀ 1.5; width of vertex: ♂ 0.56, ♀ 0.67; width of pronotum: ♂ 1.37, ♀ 1.66; width of forewing: ♂ 1.27, ♀ 1.50.

Specimens examined: Holotype ♂ INDIA: Karnataka: Ag.Coll. Dharwad, 10.viii.1972 (CAV)(UAS). Paratypes: 2 ♂, ? ♀: INDIA, Karnataka: Belgaum, 30.vii.1973 (CAV)(IARI, UAS, BMNH).

Remarks: Scaphodhara biloba sp.nov. is unique in Scaphodhara in having bilobed apex of male plate and slender, strongly recurved aedeagal shaft.

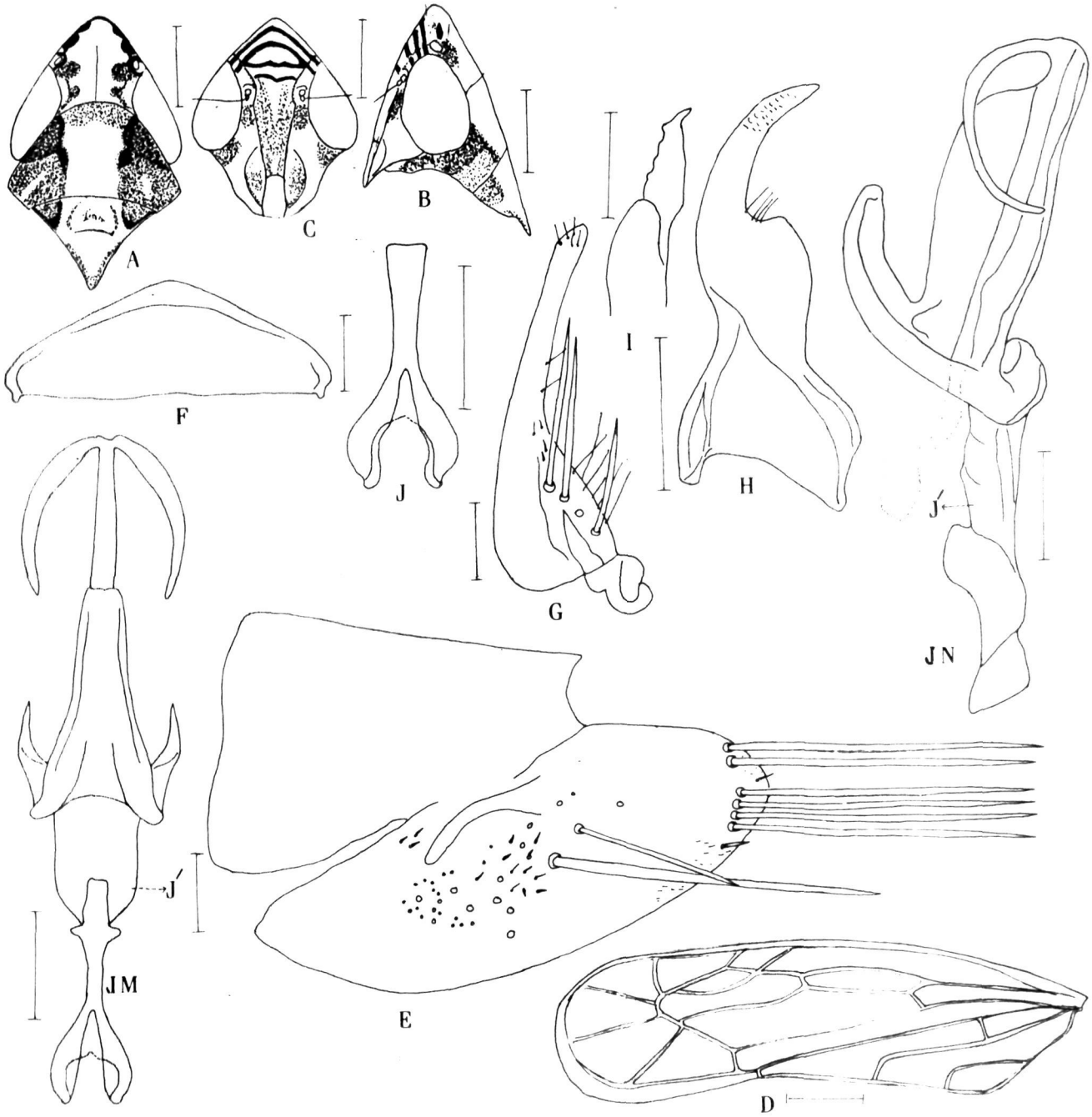
4.3.3. Scaphodhara meppadica sp.nov.(Fig.10, Plate.3C)

Vertex, median stripe on pronotum and suctellum creamy white, an oblique spot on either side of median line near apex of vertex on anterior margin fuscous;

an irregular spot behind each ocellus reddish brown with anterior and lateral fuscous markings. Face above with four transverse bands and a transverse spot below each antennal base piceous. Lateral area of pronotum yellowish brown with inner margin darker. Basal triangles of scutellum fuscous, with inner darker margin, an oblique fascia on pro-episternum, meso and meta thoracic pleura fuscous. Clavus with hyaline inner margin, claval cell between veins brownish with a median dark brown patch, corium with a brown patch on inner anteapical cell, third apical cell and on costal area at basal 1/3; oblique fascia to the costa dark brown, rest of the venation brown. Three spots on middle tibia, first and second tarsomere of middle leg, bases of hind tibial spines on outer margin, apex of first tarsomere and second tarsomere except apex piceous.

Vertex bluntly, conically, pointed; medially longer than width between eyes. Head narrower than pronotum. Pronotum slightly more than twice as wide as long and shorter than scutellum. Outer anteapical cell half as long as inner anteapical cell. Two or three oblique cross veins arising on outer anteapical cell and reaching costal margin.

Fig.10. Scaphodhara meppadica sp.nov. (♂)
Scale refers to 0.1 mm except in ABCD where it is equal to 0.5 mm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Male genitalia: Pygofer elongate with two tufts of sub-apical setae, caudal margin rounded. Valve triangular, obtusely rounded caudally. Male plate with apical 2/3 narrowed, of uniform width, basal 1/3 broad with an oblique row of four long setae. Style with well developed pre-apical lobe, apophysis about 1/3 as long as total length of style, with sub-apical tooth and its ventral margin serrated. Connective and aedeagus fused with an intervening median plate between them. Connective Y-shaped, stem longer than arms. Aedeagus with well developed slightly arcuate dorsal apodeme. Shaft directed caudally, strongly, compressed with an apical pair of strongly arcuate processes, directed anteriorly and ventrally. Gonopore apical on dorsal aspect.

Morphometric ratios: Male: A: 4.4, B: 1.45, C:0.45, D:3.86, E:1.04.

Measurements (in mm): Male: total length: 4.3, length of vertex: 0.51, length of pronotum: 0.47, length of scutellum: 0.56, length of face:1.00, length of forewing:3.4, length of clavus:2.1, length of hind-tibia: 2.0, width of head including eyes: 0.96, width of vertex: 0.35, width of pronotum:1.03, width of forewing: 0.88.

Plates:

3 a : Scaphodhara biloba sp.nov. (♂)

3 b : Scaphodhara biloba sp.nov. (♂)

3 c : Scaphodhara meppadica sp.nov.(♂)

Plate 3a

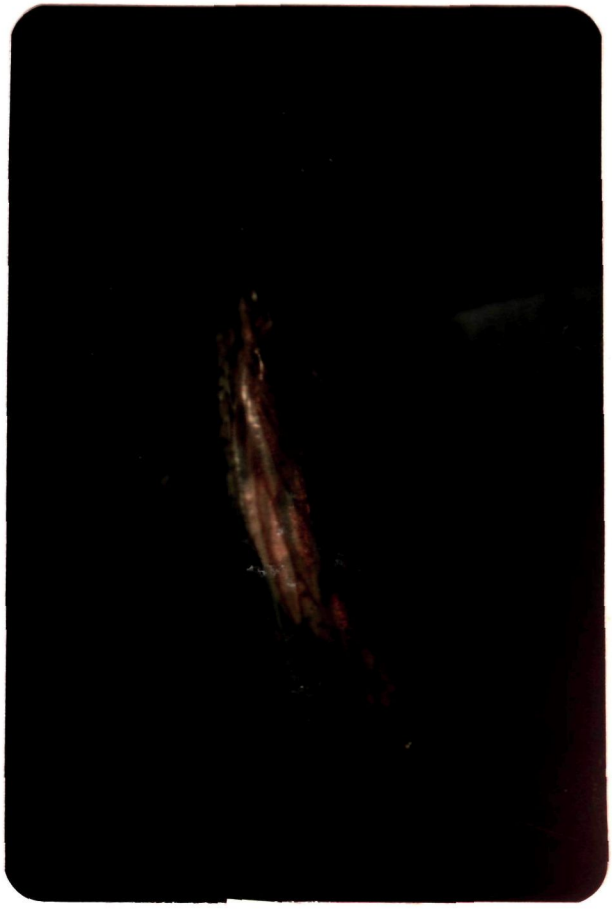

Plate 3b

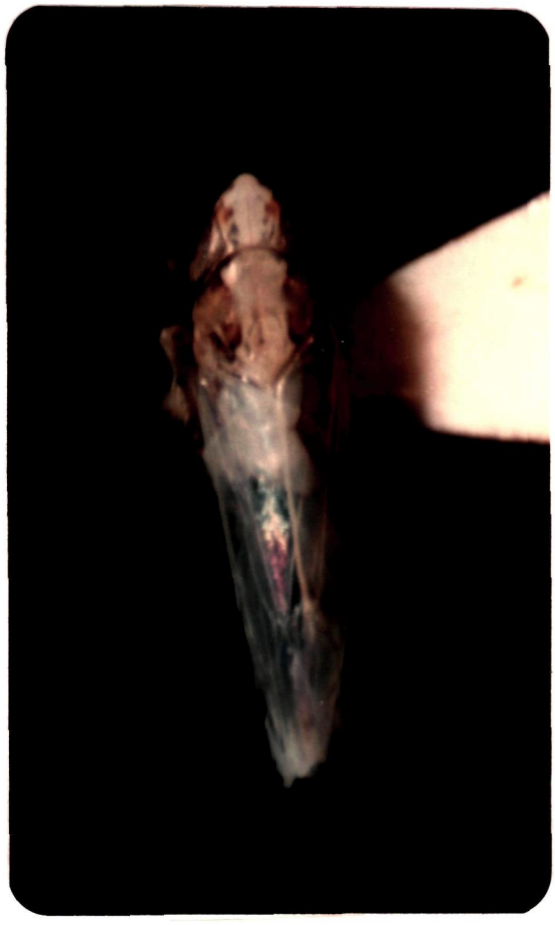

Plate 3c

Specimens examined

Holotype ♂, INDIA, Kerala, Meppadi, 690 m, 17.x.1975 (Ghorpade)(UAS).

Paratypes: 1 ♂ INDIA: Karnataka, Mudigere: 2.vi.1978 (CAV), 1 ♂ same data but collected by HSK; 1 ♂ Kerala: Thekkadi, 26.iii.1977 (CAV). (IARI, BMNH, UAS).

Remarks: This species is closely related to Scaphodhara petiyari. Both of them have similar ♂ genitalia. This species can be differentiated from periyari by the absence of median orange coloured fascia on vertex and thorax, simple dorsal connective and by the shorter process of aedeagal shaft.

4.3.4. Scaphodhara neela sp.nov.(Fig.11, Plate.4a)

Vertex and thorax with yellowish white median longitudinal stripe and laterally marked with brown. In male a median reddish orange line traverses from 1/3 apical distance of vertex to apex of scutellum; apex of vertex with a minute fuscous dot; a sinuate line on lateral margin widened as a spot at its apex on vertex, fuscous; a large round reddish brown spot confluent with posterior widened spot of this line.

Face with three arcuate dark fuscous bands above the bases of antennae. An oblique spot below base of antenna fuscous. Lateral brown spot on pronotum darker, in anterior half, mesally interrupted behind each eye, lateral most margins ochraceous, scutellum with basal triangles fuscous. An oblique stripe on proepisternum, mesothoracic and metathoracic pleura, three spots on middle tibae, second tarsal segment of middle leg, bases of spines of hind tibia, its apex, hind basitarsus and second tarsal segment except the apex, dark fuscous; wing hyaline, venation brown, a spot across apices of inner and outer claval veins, another spot in basal half of inner anteapical cell and a spot in median apical cell dark brown.

Head acute angled narrower than pronotum. Vertex 1.4 times as long as width between eyes, face longer than wide. Pronotum slightly more than twice as wide as long, shorter than scutellum. Outer anteapical cell 1/3 as long as median anteapical cell.

Male genitalia: Pygofer longer than its height with two sub-apical tufts of long setae; caudally bluntly rounded; valve broadly triangular, male plate broad, in basal 1/3 abruptly narrowed and prolonged caudally with four long stout setae in basal broad region and with

Fig.11. Scaphodhara neela sp.nov. (♂♀)
Scale refers to 0.1 mm except in
ABCD Dh & O where it is equal to
0.5 mm


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sparse marginal hair-like setae. Style broad at base, pre-apical lobe well developed, apophysis of style slightly laterally curved, obliquely truncate and rather foot-shaped, its surface with a short discontinuous transverse rugae. Connective Y-shaped, stem short as long as arms fused with median plate. Median plate triangular with two laterocaudally directed horn-like processes and medially fused with aedeagal shaft. Shaft elongate more or less of same width in lateral aspect, slightly sinuate, with a pair of apical ventrally directed processes.

Female genitalia: Seventh sternum twice as long as sixth its caudal margin broadly produced in the middle.

Morphometric ratios: A: ♂ 4.28, ♀ 4.49, B: ♂ 1.39, ♀ 1.52, C: ♂ 0.45, ♀ 0.50, D: ♂ 3.91, ♀ 3.47, E: ♂ 1.01, ♀ 1.02.

Measurements (in mm): total length: ♂ 4.5, ♀ 4.9; length of vertex: ♂ 0.53, ♀ 0.61; length of pronotum: ♂ 0.50, ♀ 0.57; length of scutellum: ♂ 0.60, ♀ 0.64; length of face: ♂ 1.07, ♀ 1.12; length of forewing: ♂ 3.8, ♀ 4.0; length of clavus: ♂ 2.5, ♀ 2.45; length of hind tibia: ♂ 2.2, ♀ 2.3; width of head including eyes: ♂ 1.05 ♀ 1.09; width of vertex: ♂ 0.38, 0 ♀.40; width of pronotum: ♂ 1.10, ♀ 1.14; width of forewing: ♂ 0.97, ♀ 1.15.

Plates:

4a : Scaphodhara neela sp.nov. (♂)

4b : Scaphodhara periyari sp.nov.(♂)

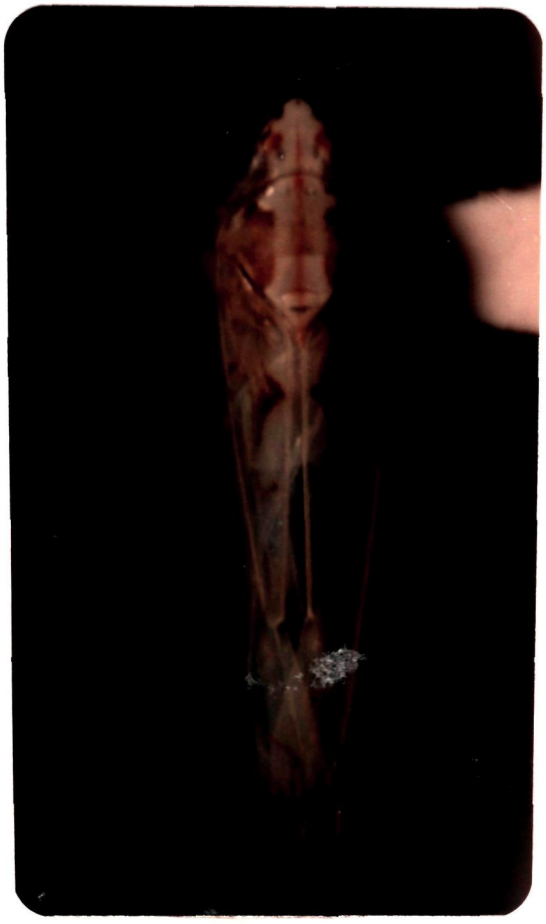

Plate 4a

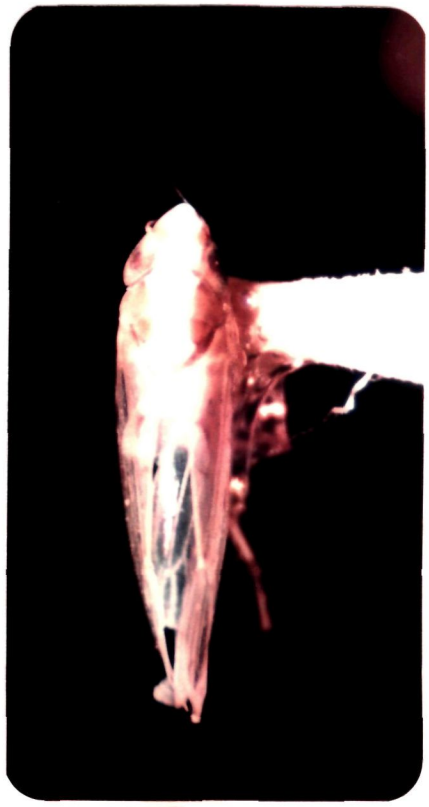

Plate 4b

Specimens examined: Holotype: ♂ INDIA: Kerala: 12.5 km N of Munnar, 1972 m, 23.ii.1977 (CAV)(UAS). Paratypes: 1 ♂ data as in holotype. INDIA: Kerala:2 ♀ Thekkadi 26 & 27.iii.1976 (CAV)(IARI,BMNH, UAS).

Remarks: Scaphodhara neela sp.nov. is unique among the species of Scaphodhara in having straight, elongate aedeagal shaft with short apical processes and the intermediate sclerite with a lateral horn-like process on either side.

4.3.5. Scaphodhara periyari sp.nov. (Fig.12, Plate.4b).

Colouration similar to that in Scaphodhara meppadica. Spots behind ocelli on vertex reddish. Lateral area of pronotum more uniformly brownish. Median sulcus and median line traversing the length of pronotum and scutellum orange.

Vertex medially longer than width between eyes (7:10). Pronotum slightly more than twice as wide as long. Scutellum longer than pronotum. Outer anteapical cell almost half as long as median anteapical cell.

Male genitalia: Pygofer longer than its height, caudal margin bluntly conical with sub-marginal tufts of long setae. Valve dome-shaped with caudal sclerotized

Fig.12. Scaphodhara periyari sp.nov. (♂)
Scale refers to 0.1 mm except in ABCD where it is equal to 0.5 mm


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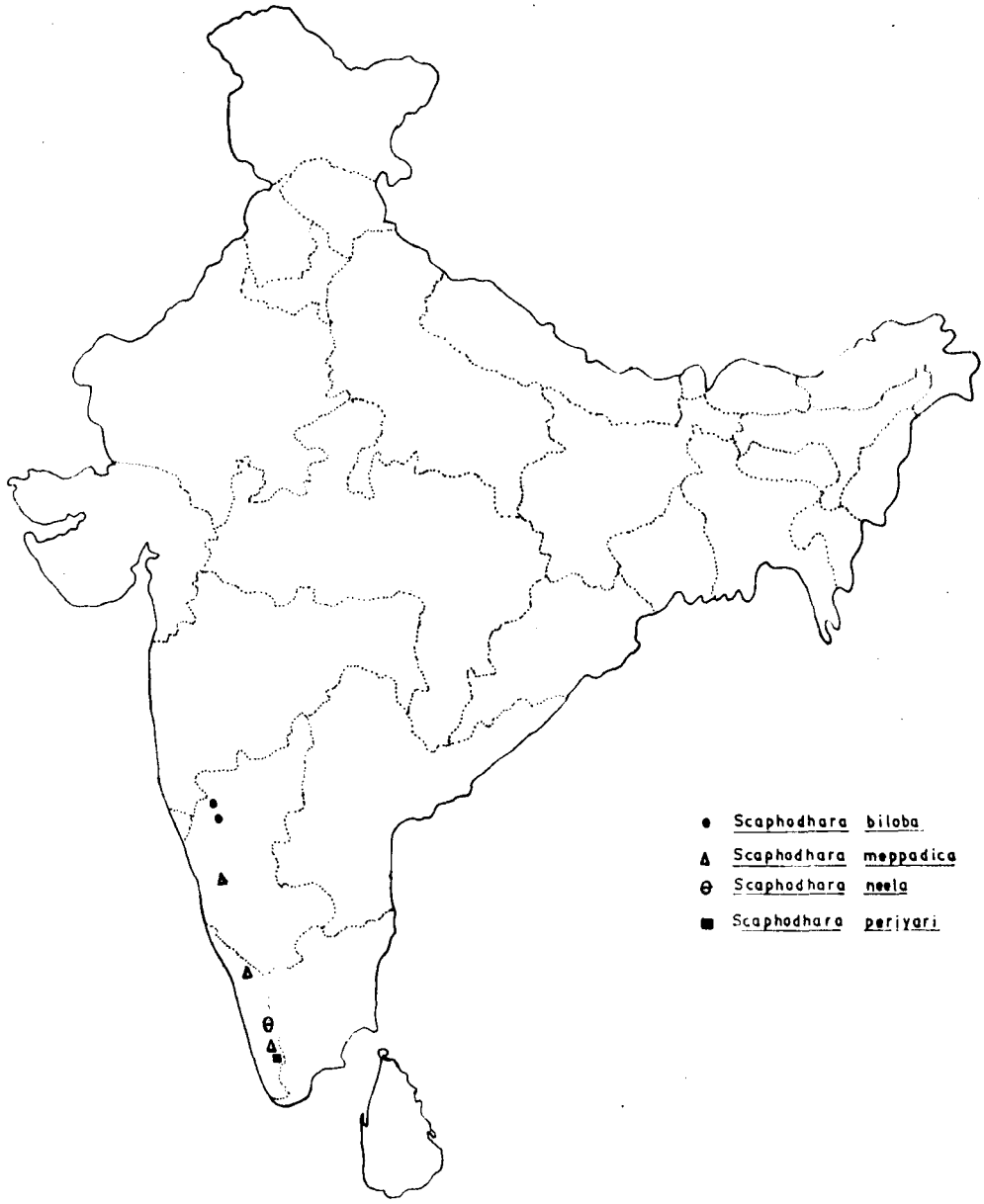
margin and with a median short apodeme. Male plate half as long as pygofer, elongated, broad in its basal 1/3 then narrowed to apex, with three basal long setae arranged in an oblique row and a number of hair-like marginal setae on the basal broad area. Style with well developed preapical lobe, apex of apophysis laterally curved, lateral angle attenuated and its ventral margin serrate. Connective Y-shaped, its arms half as long as the stem, fused with median plate. Aedeagus strongly compressed with apical gonopore and a pair of strongly recurved long apical processes, dorsal apodeme well developed, dorsal connective strongly developed with two to five finger-like sclerotized processes.

Morphometric ratios: Male: A: 4.5; B:1.35; C:0.46; D:3.78; E:1.0.

Measurements (in mm): Male: total length:4.5, length of vertex:0.5, length of pronotum: 0.5; length of scutellum: 0.6, length of face: 1.00; length of forewing: 3.6; length of clavus:2.3; length of hindtibia:2.0; width of head including eyes:1.0, width of vertex:0.37; width of pronotum:1.07, width of forewing: 0.95.

Specimens examined: Holotype ♂; INDIA: Kerala: Thekkadi, 27.iii.1977 (CAV)(UAS).

Map-III Distribution of species Scaphodhara gen.nov.


Scaphodhara biloba
Scaphodhara moppadica
Scaphodhara neela
Scaphodhara perjyari

Paratypes: 2 ♂ same data but collected by SV and BM (IARI,UAS).

Remarks: See under Scaphodhara meppadica sp.nov.

4.4. Scaphoideus Uhler

Head, pronotum and scutellum usually brown, yellowish brown with a median longitudinal yellowish or whitish stripe extending to folded forewings, rarely with colouration similar to Scaphotettix or with dark brown spots or bands on vertex pronotum and scutellum.

Head including eyes either as wide as or narrower than pronotum. Head bluntly pointed in front, vertex 1.02 times as long as its width between eyes. Face longer than wide, ratio between width of frontoclypeus between the bases of antennae to that at its apex ranging from 1:1.32 to 1:1.68. Pronotum 0.46 times as long as its width, shorter than scutellum. Forewing long with moderately developed appendix, two to three reflexed cross veins between outer anteapical cell and costal margin, outer anteapical cell 0.5 to 0.75 times as long as median anteapical cell, usually lying obliguely with respect to costal margin and usually acuminate distally; claval veins separate rarely approximated in the middle,

joining commissural margin at nearly a right angle. Front femora usually without short stout marginal setae but only with 10-15 hair-like setae on meso-apical area; middle femora with short stout setae of uniform length (except in S.curvatus).

Pygofer longer than its height, with or without a ventral process, usually with long setae arranged in one or two tufts. Male plate triangular, either simple or bilobed, from about half to equal in length of pygofer, its distal 2/3 usually narrowed, with hair-like and spine-like setae. Style variously shaped, its apophysis either short or long, with serrated ventral margin, apex usually sharply pointed. Connective anteriorly Y-shaped with fused or attached paraphyses which are variously shaped (but not crossing over each other in Indian species). Often asymmetrically twisted. Shaft of aedeagus, slender, elongate or short, stout or slender, often compressed with a pair of apical or subapical tooth-like or elongate or lamellate processes, dorsal apodeme well developed. Dorsal connective often well sclerotized with finger-like processes. Female pygofer long, narrowed to apex with tufts of long setae. Ovipositor extending beyond pygofer.

4.4.1. Key to species of Scaphoideus (males)

(S.brachycephalus, S.nutans and S.pallifrons are not included in the key as they are known only from females and were not studied except for their photographs)

1. Vertex of head with a solid unbroken transverse black fascia across eyes. .. .. S.baeticus (Distant)

- Colouration of vertex variable but not as above, if the transverse fascia black, it is broken into a number of longitudinal stripes 2

2. Vertex with a series of six short longitudinal connected spots across eyes 3

- Vertex either with a fewer spots or with a transverse band 4

3. Hind margin of 7th sternum sinuate with a concave median area .. .. S.stigmaticus Distant

- Hind margin of 7th sternum concave with a median notched lobe .. .. S.assamensis Distant

4. Male plate deeply bilobed (Fig.16G, 19G):apophysis of style slender, about half as long as total length or longer (Fig.16H, 19H) 5

- Male plate single lobed, apophysis of style stout usually less than half as long as its length (Fig.13H, 14H, 20H, 21H). .. 7

5. Pygofer without a ventral process. Face dark brown (Fig.19C,E).. .. S.jogensis sp.nov.

- Pygofer with a ventral process (Fig.16E). Face ochraceous with dark bands or markings, not entirely dark brown .. S.elegantulus Melichar..6

6. Lateral margin of the expanded area of paraphyses serrated (Fig.16b K).. S.elegatulus (Ceylonese population)

- Lateral margin of expanded area of paraphyses smooth (Fig.16a, K). .. S.elegantulus (Indian population)

7. Paraphyses sculptured (Fig.23a to 23b, K). .. S.sculptus sp.nov.

- Paraphyses not sculptured 8

8. Vertex, pronotum and scutellum with a median longitudinal yellowish or whitish stripe, extending on to the folded forewings (Fig.14A, 18A, 20A, 21A): Vertex without transverse band of any color between eyes (Fig.14A,18A,20A) 9

- Vertex with a transverse band between eyes, red, orange, black or brown; no longitudinal stripe extending from head to forewings (Fig.13A, 15A, 17A, 21A, 22A), pronotum either with two transverse red or brown bands, or with a series of 5 to 7 longitudinal short stripes (Fig.13A, 15A, 17A, 21A, 22A).. .. 11

9. Two longitudinal reddish or orange stripes on median stripe of pronotum continued on part of scutellum (Fig.18A, 20A) 10

- On median stripe of pronotum. A single median orange to reddish stripe (Fig.14A), lateral margin of broad stripe dark brown.
.. S.bifidus sp.nov.

10. Aedeagus slender, elongate, with a pair of apical, short processes (Fig.20M); paraphyses separated right from base (Fig.20K); apophysis of style 1/3 as long as its total length (Fig.20H). Small species (3.9-4.2 mm).
.. .. S.knapii Kitbamroong & Freytag

- Aedeagal shaft short, with a pair of lamellate processes on its ventral margin without apical processes (Fig.18M); paraphyses fused at their

basal 2/3 (Fig.18K): apophysis of style half as long as its total length (Fig.18H). Large species (6.4 mm). .. S.insignis (Distant)

11. Vertex with a round black spot on its apex, transverse band across eyes black and dark brown (Fig.22A), aedeagus slender tubular and strongly curved with a well developed dorsal apodeme (Fig.22N), paraphyses slender, elongate (Fig.22K). .. .. S.russus Distant

- Vertex without round black spot on its apex, transverse band across eyes on vertex brown, red or orange (Fig.13A, 15A,17A, 21A). Aedeagus short and stout (Fig.13M, 15MN); paraphyses of connective stouter (Figs.21J).. .. 12

12 Paraphyses forming a "horse-shoe" (Fig.21K); pronotum and scutellum with longitudinal brown stripes (Fig.21A).. .. S.morosus Melichar

- Paraphyses elongate may be twisted at their apex but not forming a "horse-shoe (Fig.13M, 15MN,17A); pronotum with transverse stripes (Fig.13A,15A, 17A). 13

13. Male plate with numerous long hair-like setae, their length as long as or longer than length of male plate (Fig.17G);paraphyses fused at their basal half(Fig.17K) .. S.hirsutus sp.nov.

- Male plate with shorter fewer hair-like setae; their length 1/5 to 1/10 as long as male plate (Fig.13G, 15G), paraphyses separated right from the base (Fig.13K, 15K). 14

14. Paraphyses parallel, sharpley pointed at apex and about 1/3 from apex expanded into a small triangular flag-like area on each side, aedeagus with an apical pair of short recurved spines .. .. S.ornatus Melichar

- Paraphyses neither parallel nor with triangular expanded area, asymmetrically curved, aedeagus without apical processes.. .. 15

15. Apophysis of style straight (Fig.15H)aedeagal shaft long compressed (Fig.15M); pygofer with a process on dorsal margin, caudo-ventral angle with a lobe-like margin (Fig.15N);

paraphyses narrowed towards apex, in apical 1/5 convoluted (Fig.15K) .. S.curvatus sp.nov.

- Apophysis of style curved (Fig.13H) aedeagal shaft, short, stout, with a pair of lateral median processes (Fig.13M); paraphyses broadest in middle asymmetrically curved (Fig.13K); pygofer with a rounded caudo-ventral margin without any dorsal process. .. S.asymmetricus sp.nov.

4.4.2. Scaphoideus asymmetricus sp.nov.(Fig.13,Plate 5a)

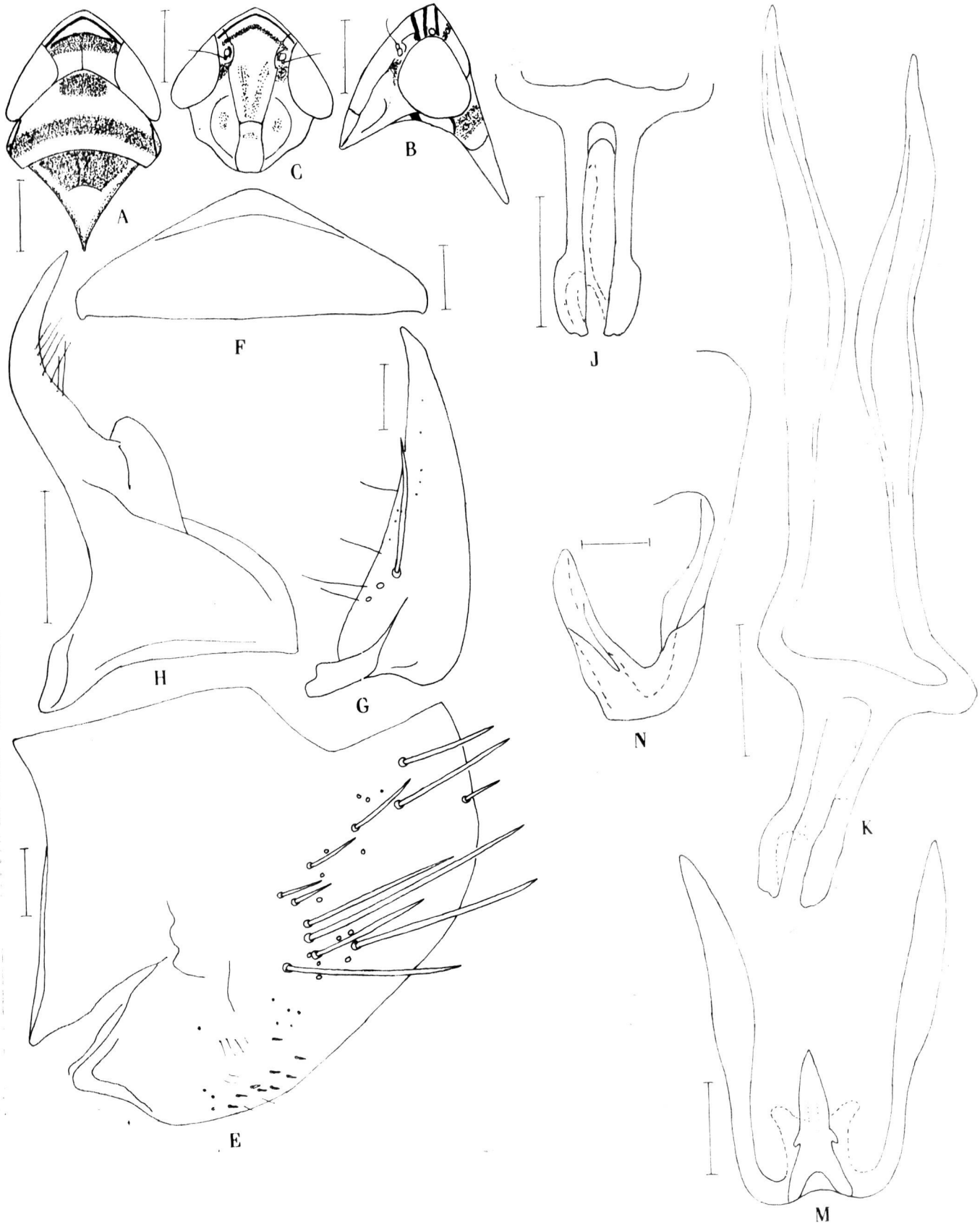
Head, pronotum and scutellum pale ochraceous. Head with three chocolate brown arcuate, anterior bands - two of which are below ocelli and one band above ocelli. A transverse fasciae between eyes on disk of vertex,sanguineous, its anterior margin narrowly chocolate brown. A short transverse spot below antenae and between lower angle of eye and frontal-sulcus chocolate brown. A spot on anterior margin of pronotum, an arcuate fascia on disk of pronotum, two spots at base of scutellum meeting on median line sanguineous, outer most margin of pronotum with two chocolate brown lines, proepimeron with an elongate chocolate brown band. Fore wing brownish with a number of large hyaline areas surrounded by dark brown, an oblique band connecting apex of inner claval vein and

outer claval vein, apex of clavus, a large spot on costal area near basal 1/3, the recurved veins to costa, a large spot on third apical cell, dark brown; entire area of apical cells darker. Legs pale ochraceous, middle tibiae with three chocolate brown spots; hind tibia with bases of spines and apex of tibia dark brown.

Vertex, pronotum and scutellum slightly polished. Median length of vertex shorter than width between eyes, obtusely rounded. Pronotum longer than vertex but shorter than scutellum, slightly more than twice as wide as long. Outer anteapical cell wider in middle and about 3/4 as long as median anteapical cell.

Male genitalia: Pygoter longer than its height, dorsal margin strongly sclerotized, caudo-dorsal area acutely angled, ventral margin smootherly curved. Valve triangular. Male plate triangular with narrowed, acute apex, three stout setae arising in an oblique line at basal 1/3. Style with well developed pre-apical lobe, apophysis stout at base almost straight apical half strongly laterally curved with pointed apex. Connective Y-shaped with short arm and stout stem, twice as long as arm, paraphyses fused with connective, wide apart,

Fig.13. Scaphoideus asymmetrius sp.nov.(♂)
Scale refers to 0.1 mm except in ABC where it is equal to 0.5 mm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asymmetrically twisted, broad in middle and apically narrowed. Aedeagus short, with well developed dorsal apodeme some what V-shaped, basal half of shaft stout apical half slender with a pair of lateral teeth near middle. Gonopore on ventral margin at mid length of shaft. Dorsal connective large wing-like.

Morphometric ratio: Male: A: 3.82; B:0.8; C:0.46; D:3.42; E.0.86.

Measurements (in mm): Male: total length : 4.4; length of vertex: 0.4; length of pronotum: 0.55;length of scutellum: 0.63; length of face: 1.00; length of forewing 3.6; length of clavus: 2.3; length of hind-tibia:1.9; width of head including eyes: 1.15; width of vertex:0.50; width of pronotum: 1.18; width of fore-wing:1.05.

Specimen examined: Holotype 1 ♂, INDIA: Karnataka: 27 km SE of Kollegal, 8.viii.1977 (CAV)(UAS).

Remarks: S.asymmetricus sp.nov., S.curvatus sp.nov. and S.sculptus sp.nov. have similar coloration but are not closely related. S.asymmetricus differs from Curvatus in having much slender, shorter aedeagus with lateral process, and paraphyses are very strongly asymmetrically curved.

4.4.3. Scaphoideus bifidus sp.nov. (Fig.14, Plate 5b)

Similar to that of Scaphoideus knapii. Vertex more angularly pointed than in S.knapii.

Male genitalia: Male pygofer similar to that of S.knapii with anterior apodemes, caudal lobe bluntly rounded with two subapical tufts of long setae in addition to scattered setae. Valve semi-circular. Male plate triangular, longer than in S.knapii with a single macro seta on basal 1/5 and with a few marginal hair-like setae. Style short, robust, pre-apical lobe well developed with a few setae, apophysis strongly laterally curved with acute apex, its ventral surface pustulate. Connective Y-shaped with arms about as long as its shaft. Paraphyses slightly divergent, of uniform length in their basal 4/5, apical 1/5 narrowed, apices acutely pointed. Aedeagus well developed, stout, dorsal apodeme bent caudally in its apical half, shaft directed caudally with a pair of anteriorly directed spine-like processes at its mid length. Gonopore apical.

Female genitalia: Seventh sternum twice as long as the sixth, broadly medially produced with a shallow notch in the middle.

Fig.14. Scaphoideus bifidus sp.nov. (♂)
Scale refers to 0.1 mm except in ABCD where it is equal to 0.5 mm


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Morphometric ratios: A: ♂ 4.08, ♀ 4.42; B: ♂ 0.95, ♀ 1.33; C: ♂ 0.48, ♀ 0.47; D: ♂ 3.76, ♀ 3.62; E: ♂ 0.91, ♀ 1.00.

Measurements (in mm): total length : ♂ 4.0, ♀ 4.6; length of vertex: ♂ 0.43, ♀ 0.56; length of pronotum: ♂ 0.48, ♀ 0.51; length of scutellum: ♂ 0.50, ♀ 0.59; length of face: ♂ 0.90, ♀ 1.05; length of forewing: ♂ 3.2, ♀ 3.7; length of clavus; ♂ 1.9, ♀ 2.3; length of hind tibia; ♂ 1.7, ♀ 2.1; width of head including eyes. ♂ 0.98, ♀ 1.04; width of vertex: ♂ 0.45, ♀ 0.42; width of pronotum: ♂ 1.00, ♀ 1.08; width of forewing: ♂ 0.85, ♀ 1.02.

Specimens examined

Holotype ♂, INDIA: Uttar Pradesh: Dehradun, 24.iv.1975 (CAV)(UAS). Paratypes: 4 ♂, 11 ♀, data as in holotype but 2 ♂ collected on 26.iv.1975 (CAV); 1 ♂, 2 ♀, INDIA: West Bengal, Calcutta, 11.xi.1981 (CAV); 1 ♀; INDIA; West Bengal; 10 km N Siliguri: 1.xi.1981 (CAV)(IARI, BMNH, UAS, USNM).

Remarks

Externally this species resembles S.knapii in coloration and structure. However, the vertex is more elongate and more acutely pointed, structure of adeagus is very characteristic in having a pair of median anteriorly directed processes.

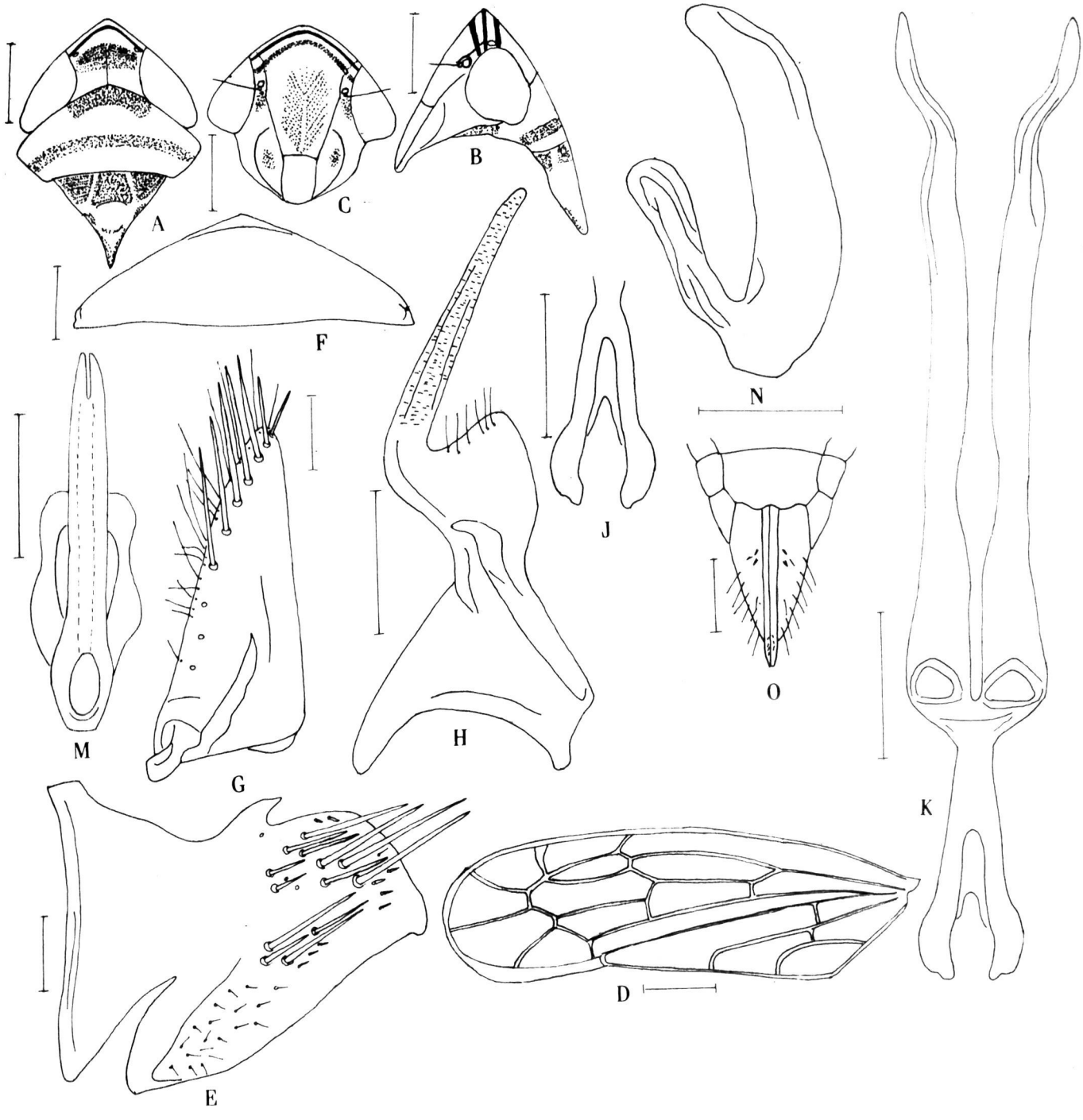
4.4.4. Scaphoideus curvatus sp.nov.(Fig.15, Plate.5C)

Similar to Scaphotettix freytagi but paler, face brownish, forewing pale brown, venation dark brown, a spot at apex of inner and outer claval vein, apex of clavus, two spots on costal margin (one near basal margin of outer anteapical cell and another at the apex of outer anteapical cell), broad margin to appex of forewing, veins dilimiting the anteapical cells apically dark-brown, a few scattered spots on forewing hyaline.

Median length of vertex shorter than its width between its eyes, obtusely rounded. Pronotum wider than long more than twice as wide as long but shorter than scutellum. Outer anteapical cell 3/4 as long as median anteapical cell.

Male genitalia: Dorsal margin of pygofer with a stout spine, caudal lobe ventrally produced into a short blunt process. Tenth segment sclerotized. Valve triangular. Male plate elongate, triangular with bluntly rounded apex, marginal stout setae long uniseriate. Style with well developed preapical lobe, apophysis slender, elongate, slightly curved laterally with its ventral area pustulate. Connective Y-shaped, stem short, slender, arms divergent. Paraphyses elongate, twisted and divergent at their caudal apex. Aedeagus compressed, V-shaped, dorsal

Fig.15. Scaphoideus curvatus sp.nov. (♂♀)
Scale refers to 0.1 mm except in ABCD & O
where it is equal to 0.5 mm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apodeme well developed, 4/5 as long as shaft; shaft broader at base, slightly narrowed at apex in lateral aspect. Gonopore sub-apical.

Female genitalia: Seventh sternum more than twice as long as sixth. Its caudal margin sinuate.

Morphometric ratios: A : ♂, 3.62, ♀ 3.75; B: ♂ 0.7, ♀ 0.69; C: ♂ 0.44, ♀ 0.47; D: ♂ 3.23, ♀ 3.09; E:♂ 0.86, ♀ 0.83.

Measurements (in mm): total length: ♂ 4.20, ♀ 4.5; length of vertex: ♂ 0.35, ♀ 0.38; length of pronotum: ♂ 0.50, ♀ 0.55; length of scutellum:♂ 0.60, ♀ 0.63; length of face: ♂ 1.00; ♀ 1.00; length of forewing: ♂ 3.4, ♀ 3.5; length of clavus: ♂ 2.3, ♀ 2.3; length of hind tibia:♂ 1.9, ♀ 2.1; width of head including eyes:♂ 1.15, ♀ 1.20; width of vertex: ♂ 0.50, ♀ 0.55; width of pronotum:♂ 1.13, ♀ 1.17; width of forewing: ♂ 1.05, ♀ 1.13.

Specimens examined

Holotype ♂, INDIA: Maharashtra; Matheran, 915 m, 23.xi.1977 (CAV)(UAS).

Paratypes: 1 ♀ data as in holotype; 1 ♂ INDIA: Karnataka: 25 km S. of Shimoga 26.xi.1982 (H.V.A.Murthy); 2 ♂, Jog Falls, 16.xi.1976 (BM); 1 ♂, Same data (CAV) (IARI, BMNH, UAS).

Plates:

5 a : Scaphoideus asymmetricus sp.nov. (♂)

5 a : Scaphoideus bifidus sp.nov. (♀)

5 c : Scaphoideus curvatus sp.nov. (♂)

Plate 5a

Plate 5b

Plate 5c

Remarks: S. curvatus sp.nov. resembles S. asymmetricus sp.nov. and S. sculptus sp.nov. in colouration. S. curvatus differs from asymmetricus in having much stouter, longer aedeagal shaft which lacks lateral process; its pygofer has a short finger-like process on its dorsal margin.

4.4.5. Scaphoideus elegantulus Melichar (Fig.16a,16b, Plate 6a,6b)

Colouration as described by Distant, however some specimens are much paler.

Vertex obtusely rounded, much shorter than the width between eyes, outer anteapical cell fusiform, half as long as inner anteapical cell, the latter constricted in middle.

Male genitalia: Pygofer caudally rounded with ventral margin expanded and with a spine-like process of variable length. Valve triangular with obtuse anterior angle. Male plate triangular apically deeply cleft. Outer lobe much longer than inner lobe, four stout sub-marginal setae in addition to hair-like setae. Style broad at base with well developed, preapical lobe, apophysis of style slender longer than half length of style, caudally attenuated with serrated ventral margin and with a prominent median tooth. Connective Y-shaped, stem stout,

Fig.16a. Scaphoideus elegantulus Melichar (♂♀) (Indian population) Scale refers to 0.1 mm except in ABCD, DA and O where it is equal to 0.5 mm


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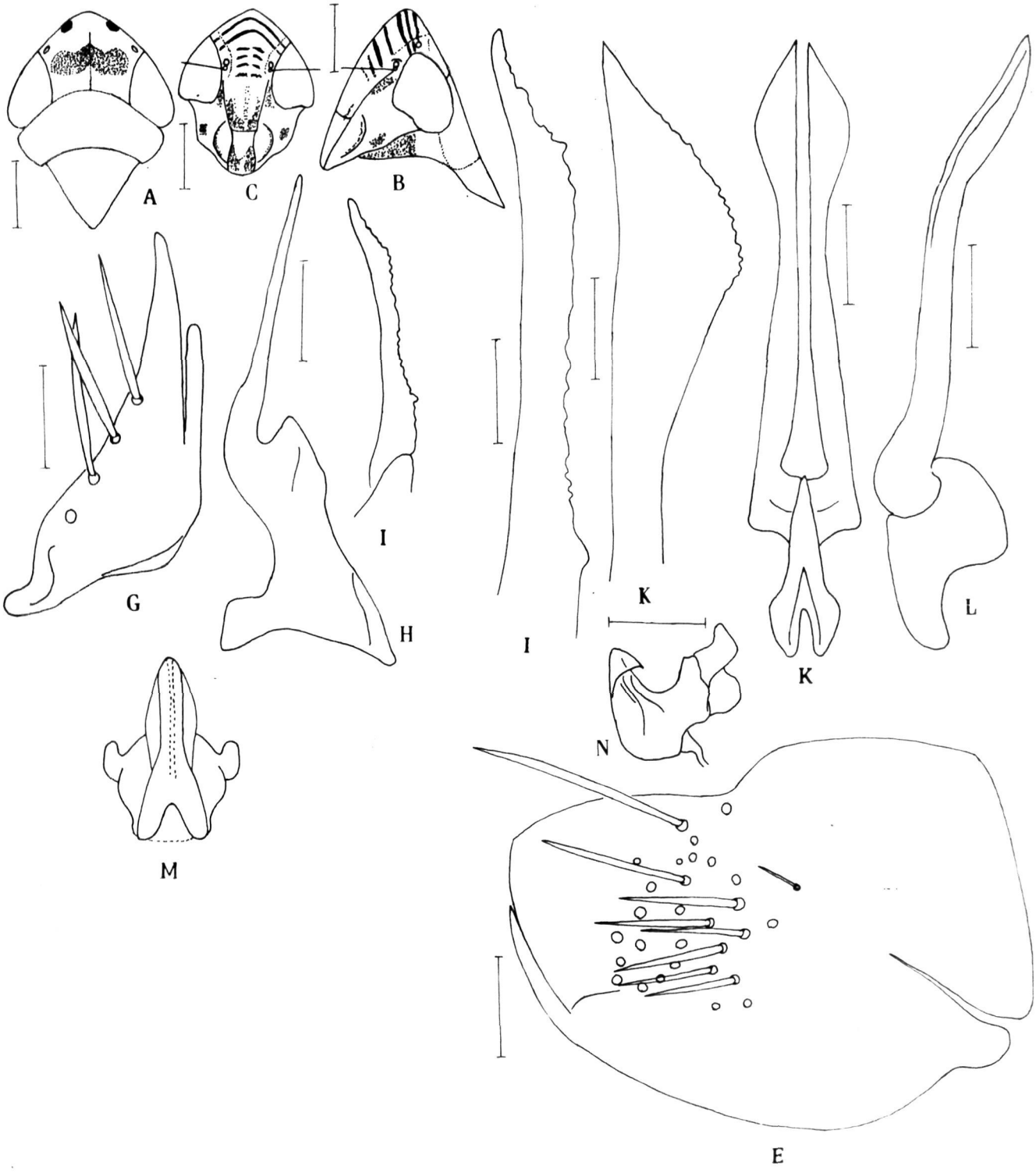
longer than arms. Paraphyses wide apart basally, in their apical 1/5 triangularly widened, then gradually narrowed to an acute apex, in a few specimens, the paraphyses have obtusely rounded apices. Aedeagus short, V-shaped, dorsal apodeme strongly developed, as long as shaft; shaft stout at base, narrowed distally with two lateral lamellate processes. Gonopore subapical.

Female genitalia: Seventh sternum three times longer than sixth, caudal margin broadly produced medially.

Morphometric ratios: A: ♂ 3.87, ♀ 3.89; B:♂ 0.82, ♀ 0.76; C:♂ 0.44, ♀ 0.45; D: ♂ 3.89, ♀ 3.90; E:♂ 1.02, ♀ 1.00.

Measurement (in mm): total length:♂ 4.3, ♀ 4.6; length of vertex:♂ 0.37, ♀ 0.38; length of pronotum: ♂ 0.51, ♀ 0.57; length of scutellum: ♂ 0.54, ♀ 0.61; length of face: ♂ 0.97, ♀ 1.05; length of forewing; ♂ 3.7, ♀ 4.1; length of clavus: ♂ 2.4, ♀ 2.6; length of hind tibia:♂ 2.1, ♀ 2.2; width of head including eyes; ♂ 1.11, ♀ 1.18; width of vertex:♂ 0.45, ♀ 0.50; width of pronotum:♂ 1.14, ♀ 1.25; width of forewing:♂ 0.95, ♀ 1.05.

Fig.16b. Scaphoideus elegantulus Melichar (♂) (Ceylonese population) Scale refers to 0.1 mm except in ABC where it is equal to 0.5 mm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Specimens examined

2 ♂, 2 ♀, INDIA: Kerala: Munnar 22.iii.1977 (CAV); 1 ♂, 1 ♀, same data but collected on 23.iii.1977 (CAV); 1 ♂, 1 ♀, INDIA:Tamil Nadu: Oothu, 36 km W. of Kodaikanal (ARJ)(UAS), 1 ♀, Kodaikanal (T.V.Chambell). 1 ♂, SRI LANKA: Maskeliya, 8.iii.1909 J.B.Fletcher; 1 ♀, Peradeniya, 3.x.1913 (BMNH); 1 ♀, Hanbantuta, 23.x.1907 (T.B.F.) (BMNH).

Remarks: The male specimen from Sri Lanka agrees closely with the description of Distant (1908). However, it differs from the specimens from south India in having slightly different colouration, but more prominently in the structure of aedeagus and dorsal connective. The specimen from Sri Lanka has the aedeagus slender and curved dorsally near tip, with a pointed apex. It lacks the two lateral sclerotized basal processes found in specimens from south India, instead dorsal connective has ventrally curved prong-like process which is probably an equivalent of basal process of aedeagus of specimens from south India. Paraphyses are more symmetrical with expanded apical 1/4 which has serrated lateral margin, however, in specimens from south India, paraphyses are asymmetrically curved; the lateral lamellate expansion to aedeagus are much longer and apophysis of style are more slender and

shorter. These variations are probably within the range of species variation and hence specimens from south India are treated as Indian population of S.elegantulus while those from Sri Lanka as Ceylonese population of S.elegantulus.

4.4.6. Scaphoideus hirsutus sp.nov.(Fig.17, Plate 6C)

Head, pronotum and scutellum ochraceous, a sub-marginal band on vertex and a series of three transverse stripes on face below ocelli chocolate brown. A transverse band across eyes castaneous, slightly produced medially and marked with chocolate brown. Median sulcus chocolate brown. Hind margin of transverse band with three concave excavations, one in the middle, one on either side of face, ochraceous. Pronotum with an anterior and sub-marginal faint castaneous transverse bands, extreme lateral margin fuscous. Basal triangles of scutellum castaneous, two spots on lateral margin fuscous, rest yellowish. Pleura and legs ochraceous with fuscous spots. Apices of fore tibia, first two tarsomeres of middle leg, bases of spines on hind tibia and apex of hind tibia, dark fuscous. Forewing with prominent dark brown venation, clavus with a fuscous spot at the apices of claval veins and the apex of clavus also with fuscous spot; apical area of forewing and a few patches in forewing fuscous.

Head narrower than pronotum, outer anteapical cell half as long as the median anteapical cell.

Male genitalia: Pygofer longer than its height with subapical row of tufts of setae. Tergum of pygofer well sclerotized. Valve more or less triangular with obtusely rounded caudal margin. Tenth segment with ventrally directed process which articulates with aedeagus. Male plate some what triangular with rounded apex and sub-marginal row of stout setae and long numerous hair-like setae arising from 2/3 apical margin and from apex, arising both on dorsal and ventral surface; their length as long as length of plate. Style elongate with well developed preapical lobe, apophysis stout with transverse striae, slightly directed laterally, apophysis behind pre-apical lobe 0.4 times as long as the total length. Connective Y-shaped, arms much shorter than stem. Paraphyses fused at base, apical 1/3 bifid, curved dorsally in lateral aspect and pointed near apex. Aedeagus simple with well developed dorsal apodeme, shaft in lateral aspect broadened near gonopore; with a sub-apical tooth like process. Gonopore large on caudal margin.

Fig.17. Scaphoideus hirsutus sp.nov.(♂)
Scale refers to 0.1 mm except in ABC
where it is equal to 0.5 mm


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Specimen examined

Holotype ♂, INDIA: West Bengal: Gopaldhara, B.W. Darjeeling, 4720 ft. 7.v.1917 (H.STEVENS)(BMNH).

Remarks: This species is unique in having numerous long hair-like setae on the male plate which are longer than the male plate and hence the specific name hirsutus.

4.4.7. Scaphoideus insignis (Distant)(Fig.18, Plate.6D)

Vertex, pronotum, scutellum and folded forewings, traversed by a broad median yellow stripe with brown lateral margin, a pair of orange lines one on either side of median line on the broad stripe from vertex to scutellum. Vertex with two apical spots connected by a marginal band, black; a spot on either side behind ocelli reddish brown; upper part of frontoclypeus with a series of arcuate fasciae dark chocolate brown; rest of face brownish ochraceous. Lateral areas of pronotum brownish, extreme lateral margin and a short longitudinal band behind compound eyes pale ochraceous. Basal triangles of scutellum, brown, apex black. Inner margin of clavus ochraceous, laterally margined by dark brown; remaining part of forewing pale brown, veins dark brown, inner anteapical cell, outer claval cell and median anteapical

Fig.18. Scaphoideus insignis (Distant) (♂)
Scale refers to 0.1 mm except in ABC
where it is equal to 0.5 mm


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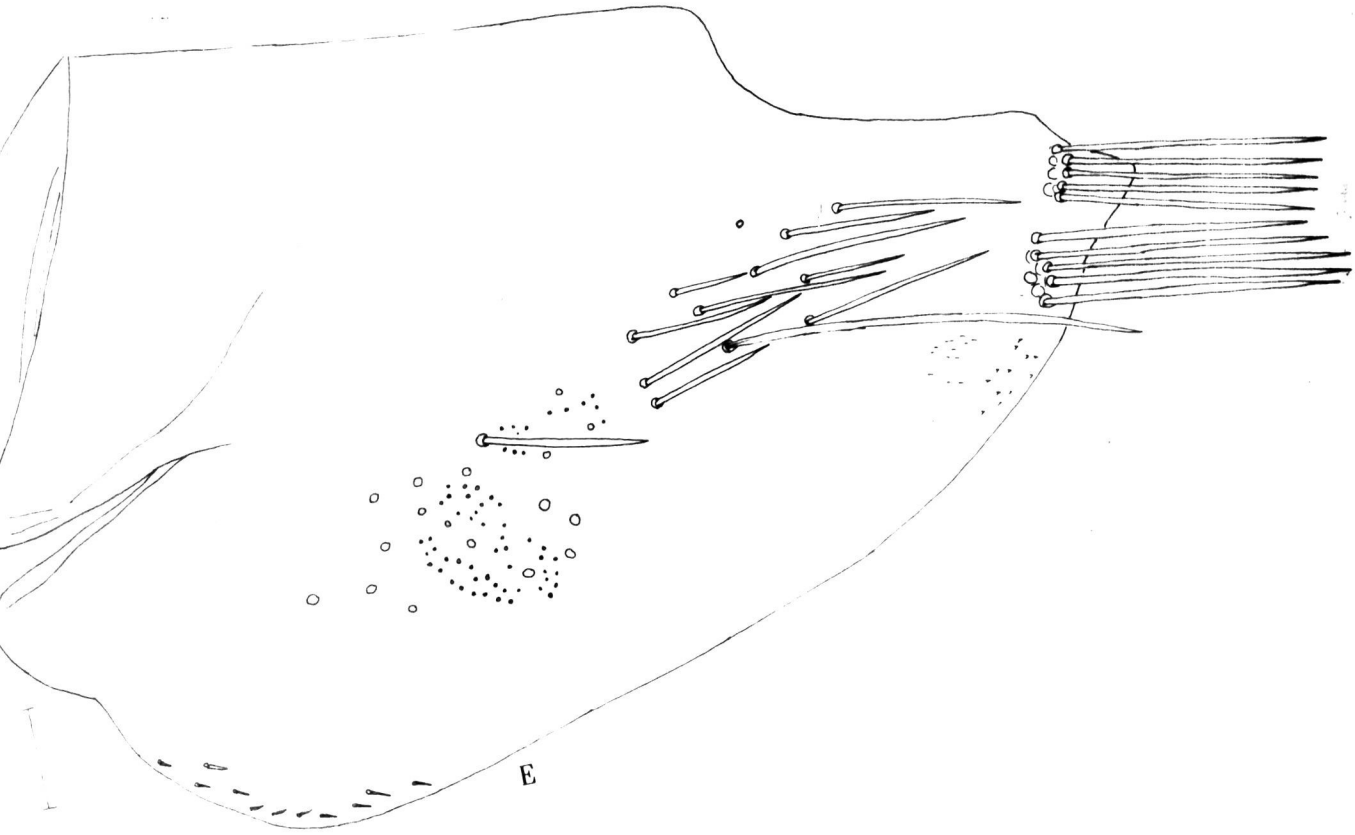
cell with brown fasciae in the middle; recurved veins to the costal margin and a spot among the apical cells chocolate brown, apex of forewing brown. Legs ochraceous, bases of hind tibial spines, and its apex black; apex of hind basitarsus and entire second tarsomere chocolate brown.

Vertex as long as wide between eyes. Pronotum slightly more than twice as wide as long but shorter than scutellum. Claval veins separate; median anteapical cell constricted in middle, outer anteapical cell 4/5 as long as the median.

Male genitalia: Pygofer longer than its height caudal area slightly angulate with two tufts of long setae. Valve strap-like with rounded caudal margin. Male plate triangular apically narrowed with an acute apex; oblique row of four stout setae in basal half. Style broad at base with well developed, preapical lobe; apophysis long, slender, slightly more than half as long as total length of style, with a short tooth on ventral margin and minutely pustulate along the ventral margin. Connective Y-shaped with arms almost approximating, stem short, fused with paraphyses, with strong basal apodeme. Paraphyses fused in their basal 2/3, slightly divergent in apical half and pointed apically.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Aedeagus V-shaped, dorsal apodeme well developed almost as long as shaft; shaft strongly laterally compressed, with two subapical tooth-like processes on the ventral margin and short triangular apical tooth on dorsal margin. Gonopore sub-apical on ventral margin, two well developed sclerites arising from tenth segment with curved, acutely pointed, dark pigmented distal process are in contact with dorsal apodeme.

Morphometric ratios: Male: A:4.63; B: 1.0; C:0.45; D:3.98; E:0.92.

Measurements (in mm): Male: total length:6.4; length of vertex: 0.55; length of pronotum:0.70;length of scutellum: 0.80; length of face: 1.28; length of forewing:5.3; length of clavus: 3.4; length of hind tibia: 3.0; width of head including eyes: 1.38; width of vertex: 0.55; width of pronotum:1.55; width of forewing: 1.33.

Specimen examined

1 ♂, INDIA: Tamil Nadu: Shambaganur, 30.x.1975 (CAV)(UAS).

Remarks: S.insignis is the largest species of the genus occuring in the subcontinent. It is unique in having its paraphyses fused to most of their length a character shared by Scaphoideus hirsutus. However, insignis has entirely different male genitalia and

Plates:

6 a : Scaphoideus elegantulus Melichar (♀)

6 b : Scaphoideus elegantulus Melichar (♀)

6 c : Scaphoideus hirsutus sp.nov. (♂)

6 d : Scaphoideus insignis (Distant) (♂)

Plate 6a

Plate 6b

Plate 6c

Plate 6d

male plate, have shorter hair-like setae.

4.4.8. Scaphoideus jogensis sp.nov.(Fig.19,Plate 7a,7b,7c)

Similar to that of Scaphoideus orientalis. Vertex, pronotum and scutellum yellowish brown, a small spot at the tip of vertex and two marginal short dots fuscous to darkbrown. A transverse slightly darker yellowish brown, band between eyes interrupted in the middle; a pair of faint median lines traversing from apex to base of vertex and fused beyond coronal sulcus. Face dark brown with sub-marginal inverted U-shaped band across eyes and area immediately below and above it yellowish brown, lateral area of clypellus, lorum and genae darker;scape, pedicel and basal 1/3 of antennae pale ochraceous. Pronotum with a pair of longitudinal yellowish brown stripes on either side of median line. In the female and paratype male a broad stripe narrowed anteriorly and obliquely touching caudal margin and a more lateral spot behind eyes fuscous. Scutellum with basal triangles and two lateral spots beyond median impressed line, fuscous; a median longitudinal stripe and two lateral arcuate spots on scutellum in few specimens fuscous. Thoracic pleura with fuscous area. Legs ochraceous three spots on middle tibia; first and second tarsomere of middle leg, bases of hind tibial spines, apex of hind tibia, apex of hind basitarsus and middle area of second tarsal segment except at its apex,

apex of third tarsomere, fuscous.

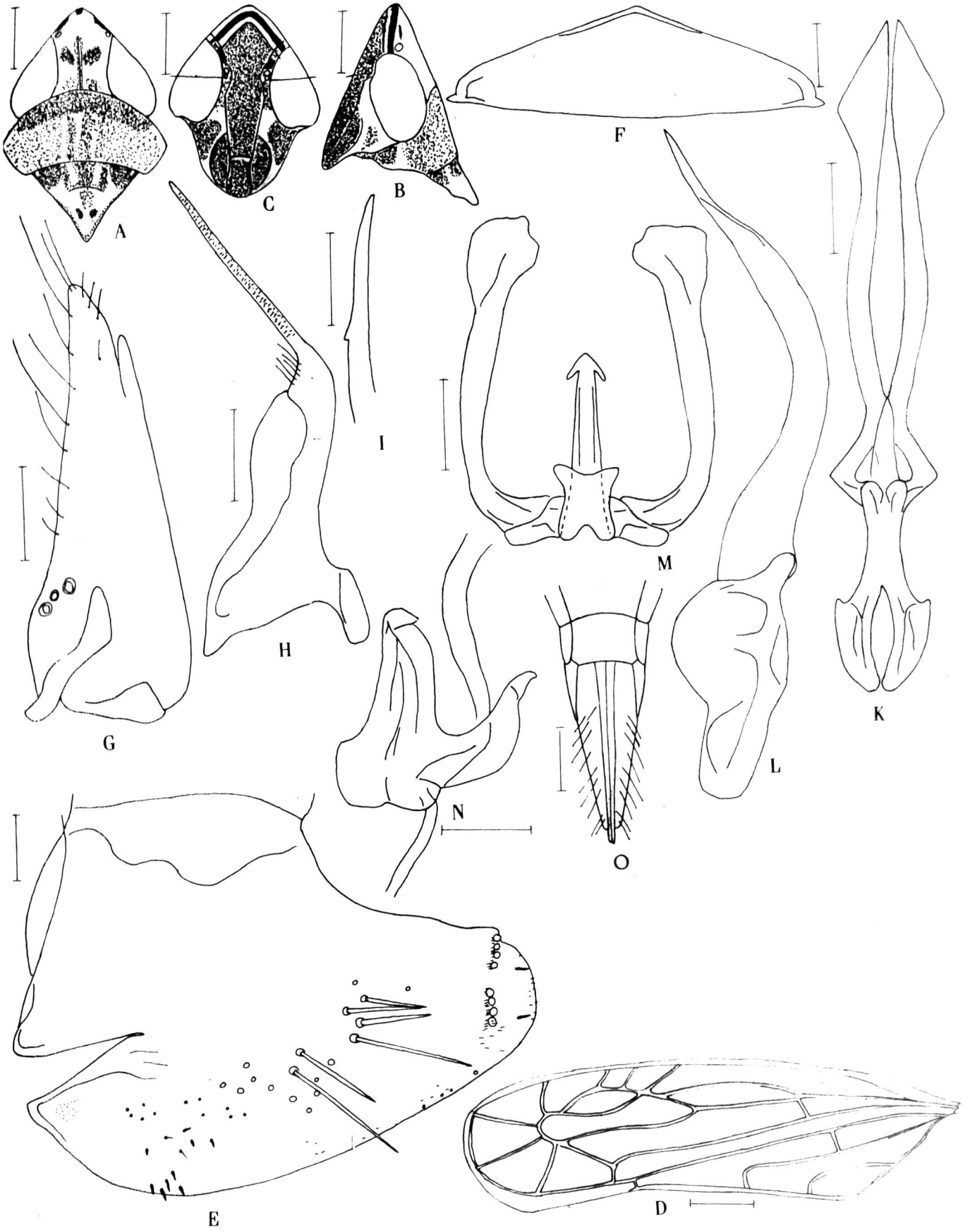
Wings streaked with dark brown, venation dark-brown, an oblique spot on clavus in basal half, a spot on costal margin in basal half, apex of forewing, oblique cross vein and costa more darker and prominent.

Head bluntly pointed at apex, distinctly narrower than pronotum (23:25). Vertex 1.3 times longer medially than width between eyes and slightly longer than pronotum. Pronotum 2.2 times as wide as long; shorter than scutellum. Outer anteapical cell half as long as median anteapical cell, the latter constricted at its apical 1/3.

Male genitalia: Pygofer longer than its height with two subapical tufts of setae in verticle row; caudal margin rounded. Valve broadly triangular. Male plate triangular with a mesal lobe at apical 1/3 and basal region with long setae arranged in an oblique row near base and a few long hair-like marginal setae.

Style slender, elongate its apophysis slender, straight and directed slightly laterally, half as long as total length of style; ventral margin with small tooth in its basal half. Connective Y-shaped

Fig.19. Scaphoideus jogensis sp.nov. (♂♀)
Scale refers to 0.1 mm except in ABCD & O
where it is equal to 0.5 mm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with arms as long as stem. Paraphyses arcuate, in their apical 1/5 strongly, dorso-ventrally flattened and triangularly expanded. Aedeagus compressed with well developed dorsal apodeme and short preatrium with a pair of lateral lamellate process near apex; which in ventral aspect appear as a pair of short tooth-like processes. Gonopore apical on ventral margin. Dorsal connective strongly sclerotized and fused with adeagus.

Female genitalia: Hind margin of seventh sternum more or less straight.

Morphometric ratios: A: ♂ 4.35, ♀ 4.11; B:♂ 1.41, ♀ 1.35; C: ♂ 0.44, ♀ 0.47; D:♂ 3.62, ♀ 3.71; E:♂ 0.92, ♀ 0.96.

Measurements (in mm): total length : ♂ 4.7, ♀ 4.9; length of vertex:♂ 0.55, ♀ 0.61; length of pronotum: ♂ 0.54, ♀ 0.59; length of scutellum: ♂ 0.59, ♀ 0.63; length of face:♂ 0.16, ♀ 1.15; length of forewing:♂ 3.7, ♀ 3.9; length of clavus:♂ 2.4, O 2.6; length of hind tibia:♂ 2.1, ♀ 2.3; width of head including eyes: ♂ 1.08, ♀ 1.19; width of vertex: ♂ 0.39, ♀ 0.45; width of pronotum: ♂ 1.21, ♀ 1.24; width of forewing: ♂ 1.02, ♀ 1.05.

Plates:

7 a : Scaphoideus jogensis sp.nov. (♀)

7 b : Scaphoideus jogensis sp.nov. (♀)

7 c : Scaphoideus jogensis sp.nov. (♀)

Plate 7a

Plate 7b

Plate 7c

Specimens examined

Holotype ♂, INDIA:Karnataka:Jog falls, 17.xi.1976 (CAV)(UAS).

Paratypes: 2 ♀, data as in holotype but collected on 18.xi.1976 (CAV); 1 ♂ INDIA: Kerala: Thekkadi, 27.iii.1977 (SV)(IARI, BMNH, UAS).

Remarks: This species is closely related to Scaphoideus literatus Distant described from Borneo, S.orientalis Kitbamroong and Freytag from Thailand in the shape of style, aedeagus, maleplate and paraphyses but differs in having more slender laterally compressed shaft, straight laterally directed apophysis of style and differently shaped paraphyses which obruptly expand near distal 1/5 into triangular lobes, the external colouration is very similar to that of S.orientalis.

4.4.9. Scaphoideus knapii Kitbamroong and Freytag (Fig.20 Plate 8a)

Similar to that described by Kitbamroong and Freytag (1978). Large spot behind each ocellus reddish brown, white area on head and thorax has a pair of orange longitudinal stripes, lateral brown marking adjacent to white transverse band, dark

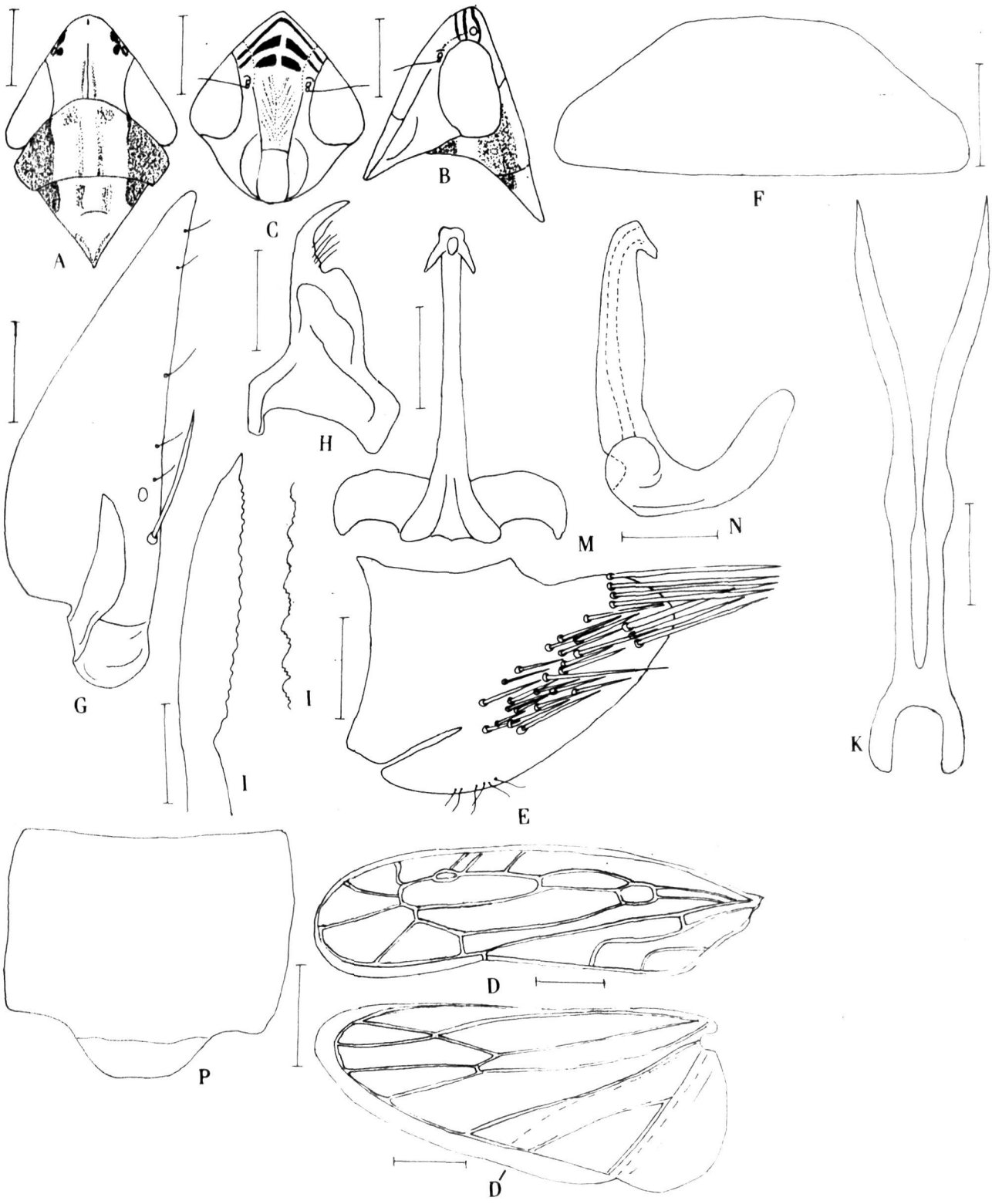
brown. Proepimeron with a transverse fuscous band. Legs ochraceous, three bands on middle tibia, bases of stout spines of hind tibia, apex of hind tibia, hind basitarsus and basal half of second tarsal segment dark fuscous.

Male genitalia: Pygofer longer than its height with two tufts of sub-apical setae in addition to scattered setae, half as long as pygofer. Valve quadrangular. Male plate triangular, apex pointed, two stout setae in basal 1/3. Style short, almost as long as connective, stout at base, apophysis slender sharply curved laterally, with an acute apex. Connective Y-shaped, with U-shaped arms. Paraphyses of uniform width near basal 1/3, in their caudal half divergent with acute apices. Aedeagus compressed with well developed dorsal apodeme which is 3/4 as long as shaft, dorsal margin of shaft with a narrow lamellate process on either side and its apex with a pair of short, tooth-like processes. Gonopore apical.

Female genitalia: Seventh sternum twice as long as the sixth and medially convexly produced.

Morphometric ratios: A: ♂ 4.3; ♀ 4.4; B: ♂ 1.11, ♀ 1.28; C: ♂ 0.46, ♀ 0.47; D: ♂ 3.5, ♀ 3.62; E: ♂ 1.08, ♀ 1.00.

Fig.20. Scaphoideus knapii Kitbamroong and Freytag(♂♀)
Scale refers to 0.1 mm except in ABCD Dh
where it is equal to 0.5 mm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Measurements (in mm): total length: ♂ 3.9; ♀ 4.6; length of vertex: ♂ 0.50, ♀ 0.54; length of pronotum: ♂ 0.43, ♀ 0.50; length of scutellum; ♂ 0.48, ♀ 0.55; length of face: ♂ 0.98; ♀ 1.04; length of forewing: ♂ 3.1; ♀ 3.7; length of clavus: ♂ 1.9, ♀ 2.3; length of hind tibia: ♂ 1.9, ♀ 2.1; width of head including eyes: ♂ 0.90, ♀ 1.04; width of vertex: ♂ 0.45, ♀ 0.42; width of pronotum: ♂ 0.93, ♀ 1.06; width of forewing: ♂ 0.88, ♀ 1.02.

Specimens examined: 2 ♂, INDIA: Karnataka: Mudigere, 3.vi.1978 (HSK); 1.♂, data same but collected on 7.iv.75 (CAV); 2 ♀, data same but collected on 2.vi.75 (CAV); 4 ♀ data same but collected on 7.vi.1978 (CAV); 1 ♂, INDIA: Karnataka: Thithimathy, 21.i.78 (CAV); 1 ♀ INDIA: Kerala: Thekkadi, 27.iii.77 (CAV). 1 ♀ INDIA: Kerala; Maraiyur 1066 m., 24.iii.77 (BM)(UAS).

4.4.10. Scaphoideus morosus Melichar (Fig.21, Plate 8b)

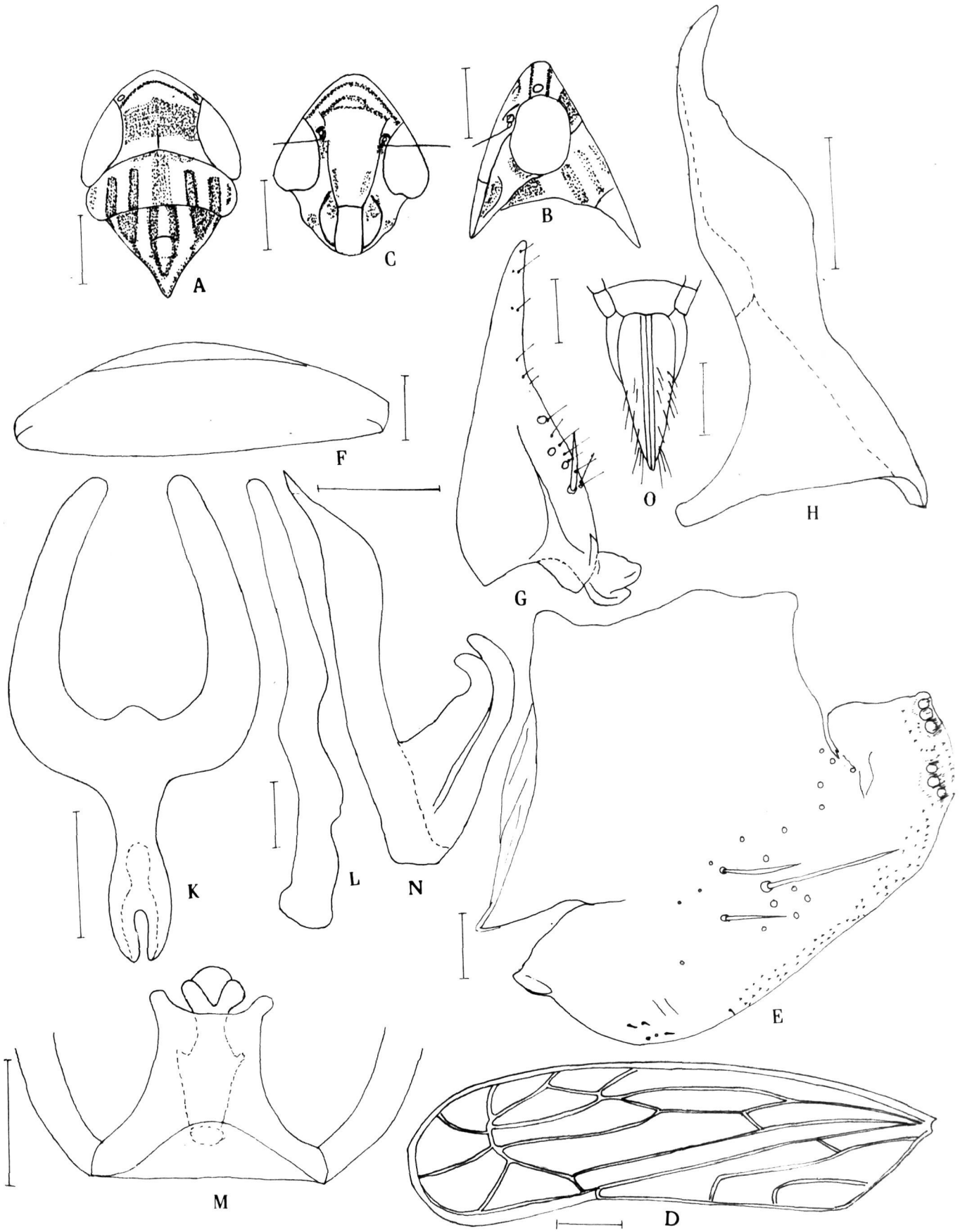
Coloration and structure similar to that described by Kitbamroong and Freytag (1978).

Morphometric ratios:

A: ♂ 3.63, ♀ 3.66; B: ♂ 1.0, ♀ 0.92, C: ♂ 0.45, ♀ 0.43; D: ♂ 3.47, ♀ 3.39; E: ♂ 0.98, ♀ 1.12.

Fig.21. Scaphoideus morosus Melichar (♂♀)

Scale refers to 0.1 mm except in ABCD & O
Where it is equal to 0.5 mm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Measurements (in mm): total length :♂ 4.0, ♀ 4.4; length of vertex:♂ 0.44, ♀ 0.50; length of pronotum:♂ 0.51, ♀ 0.52; length of scutellum:♂ 0.58, ♀ 0.51; length of face:♂ 1.08, ♀ 1.16; length of forewing:♂ 3.2, ♀ 3.5; length of clavus:♂ 2.0, ♀ 2.6;length of hind tibia:♂ 2.0, ♀ 2.1; width of head including eyes:♂ 1.1, ♀ 1.2; width of vertex:♂ 0.44, ♀ 0.54; width of pronotum:♂ 1.12, ♀ 1.19; width of forewing:♂ 0.92, ♀ 1.03.

Specimens examined

6 ♂ 8 ♀ INDIA:West Bengal: Calcutta; 17.iv.1975(CAV); 1 ♀ INDIA: Karnataka: AG.Coll. Dharwad, 9.vi.1972(CAV); 1 ♂ INDIA: Karnataka: 5 km N of ANEKAL, 10.viii.1975 (CAV); 1 ♀ : INDIA: UTTAR PRADESH: Dehradun, 26.vi.1975 (CAV) 1 ♀ : INDIA: Kerala:Thekkadi, 4.vi.1978 (SV); 2 ♀ 1 ♂ INDIA: Karnataka:Jog Falls, 17.xi.1976 (BM), (UAS).

4.4.11. Scaphoideus russus Distant (Fig.22,Plate.8C)
(Scaphoideus polymitus Distant,1908, syn.nov.

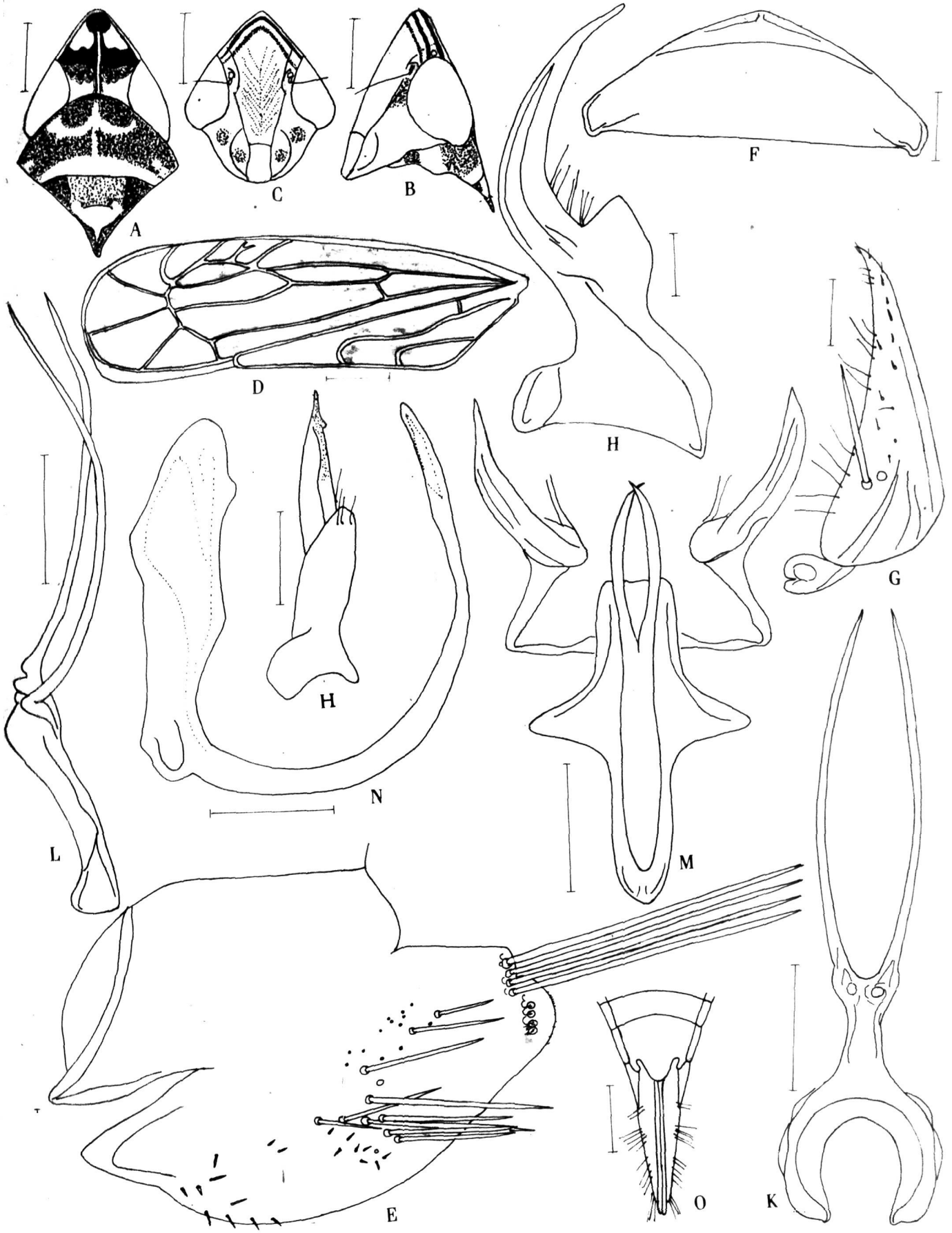
Similar to that described by Distant (1908) with following additional characters. Anterior margin of head, with three arcuate piceous lines one above, two below ocelli, apex of vertex with a round black spot, a transverse castaneous band connected with apical black spot and medially interrupted by an ochraceous line. Basal

triangle of scutellum, piceous area between them orange, posterior half bright-yellowish white with piceous marginal lateral spot near apex. Three spots to middle tibia, series of spots at base of spines of hind tibia, apex of hind tibia, first and second tarsomere except apex, dark fuscous.

Vertex bluntly pointed. Head about as wide as pronotum. Vertex longer than breadth between eyes. Pronotum twice as wide as long and shorter than scutellum. Claval vein medially approximated, outer anteapical cell about half as long as median anteapical cell.

Male genitalia: Pygofer longer than its height, with few tufts of apical long setae, caudal margin rounded. Valve triangular. Male plate triangular with acute apex, slightly curved laterally with two stout long setae at basal 1/3. Style with well developed preapical lobe, apophysis strongly laterally curved, about half as long as style, with subapical tooth and numerous microscopic dentations on its ventral surface, its apex acutely pointed. Connective Y-shaped with stem as long as arms, latter semicircular. Paraphyses slender and elongate. Aedeagus with stout dorsal apodeme which is cruciform in cephalic view, shaft slender strongly curved first caudally then dorsally with a pair of finger-like apical processes. Gonopore apical.

Fig.22. Scaphoideus russus Distant (♂♀)
Scale refers to 0.1 mm except in ABCD where it is equal to 0.5 mm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Female genitalia: Seventh sternum twice as long as sixth, medially angularly produced into a lobe-like structure with a notch in the middle .

Morphometric ratios: A: ♂ 4.16, ♀ 3.98; B:♂ 1.28, ♀ 1.20; C:♂ 0.50, ♀ 0.48; D:♂ 3.5, ♀ 3.3; E:♂ 0.92, ♀ 0.88.

Measurements (in mm): total length:♂ 4.5, ♀ 4.5; length of vertex:♂ 0.58, ♀ 0.58; length of pronotum: ♂ 0.55, ♀ 0.55; length of scutellum:0 0.60, ♀ 0.63; length of face: ♂ 1.00, ♀ 1.00; length of forewing:♂ 3.5, ♀ 3.5; length of clavus:♂ 2.3, ♀ 2.3; length of hind tibia: ♂ 2.2, ♀ 2.2; width of head including eyes:♂ 1.08,♀ 1.13; width of vertex:♂ 0.45, ♀ 0.48; width of pronotum:♂ 1.10, ♀ 1.13; width of forewing:♂ 1.00, ♀ 1.05.

Specimens examined

1 ♂, INDIA: MIZORAM: Lunglei, 20.xi.1981 (CSW); 1 ♀, INDIA: West Bengal:10 km N. of Siliguri, 1.xi.1981(CAV).

Remarks: S.russus is unique in having very slender paraphyses, slender, strongly curved aedeagal shaft with an apical pair of slender process.

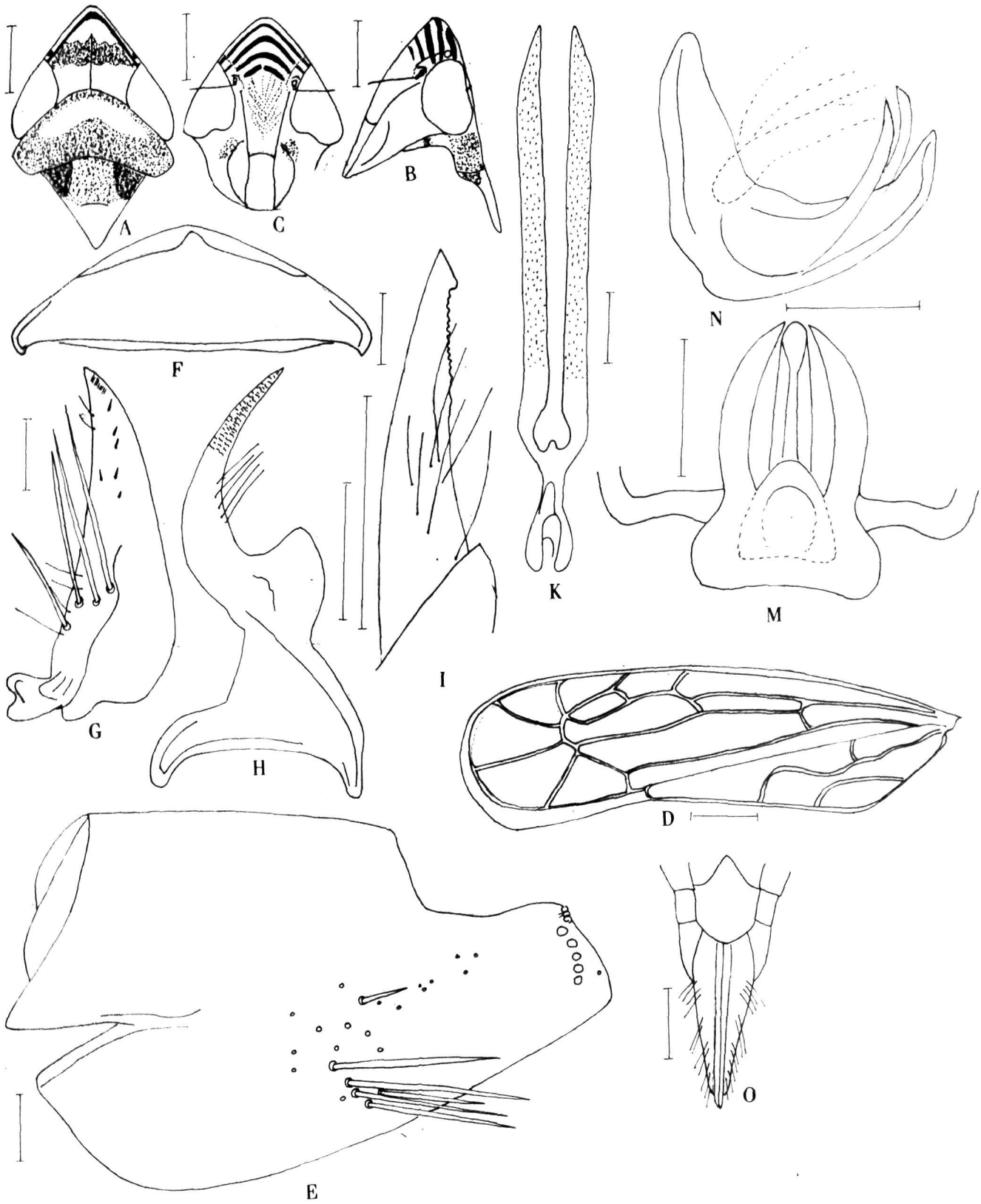
4.4.12. Scaphoideus sculptus sp.nov.(Fig.23a, 23b, Plate.8d)

Scaphoideus festivus sensu Distant, 1908.

Head ochraceous, disk of vertex with a marginal arcuate piceous line and transverse reddish brown band between anterior angles of eyes; posterior margins of vertex near eyes piceous, four transverse parallel piceous lines on the upper part of face. Pronotum with anterior and sub-marginal reddish brown transverse bands. Lateral areas of anterior band darker, basal angle of scutellum brown, area between them reddish brown, a transverse band behind impressed line ivory, area posterior to it dark brown. Mesopleura and metapleura with short oblique fuscous line. Middle tibia with three fuscous spots, first and second tarsomeres, median tibia, bases of hind tibial spines, apex of hind basitarsus and second tarsal segment of hind leg piceous. Forewing brown with contrasting hyaline area of which three on clavus along margin are prominent, veination brown, apical area of forewing dark brown.

Head narrower than pronotum, vertex bluntly rounded in front, 1.7 times longer medially than breadth between eyes, face longer than broad. Pronotum 2.2 times broader than long. Scutellum longer than pronotum. Claval veins approximated at their midlength but not fused. Outer

Fig.23a. Scaphoideus sculptus sp.nov. (♂♀)
Scale refers to 0.1 mm except in ABC where it is equal to 0.5 mm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anteapical cell about half as long as inner anteapical cell.

Male genitalia: Pygofer longer than its height, with caudal and obliquely curved and with tuft of long setae. Valve broadly triangular with a ventral short apodeme on its caudal angle. Male plate triangular with acute apex, an oblique row of four long setae near basal 1/3 of its length. Connective Y-shaped with stem slender long, slightly longer than arms. Paraphyses at base invariably curved with pointed apex, entire surface of paraphyses pustulated. Aedeagus with well developed dorsal apodemes, shaft cylindrical with apical gonopore directed caudally, a pair of recurved processes on either side of base of shaft and slightly longer than shaft.

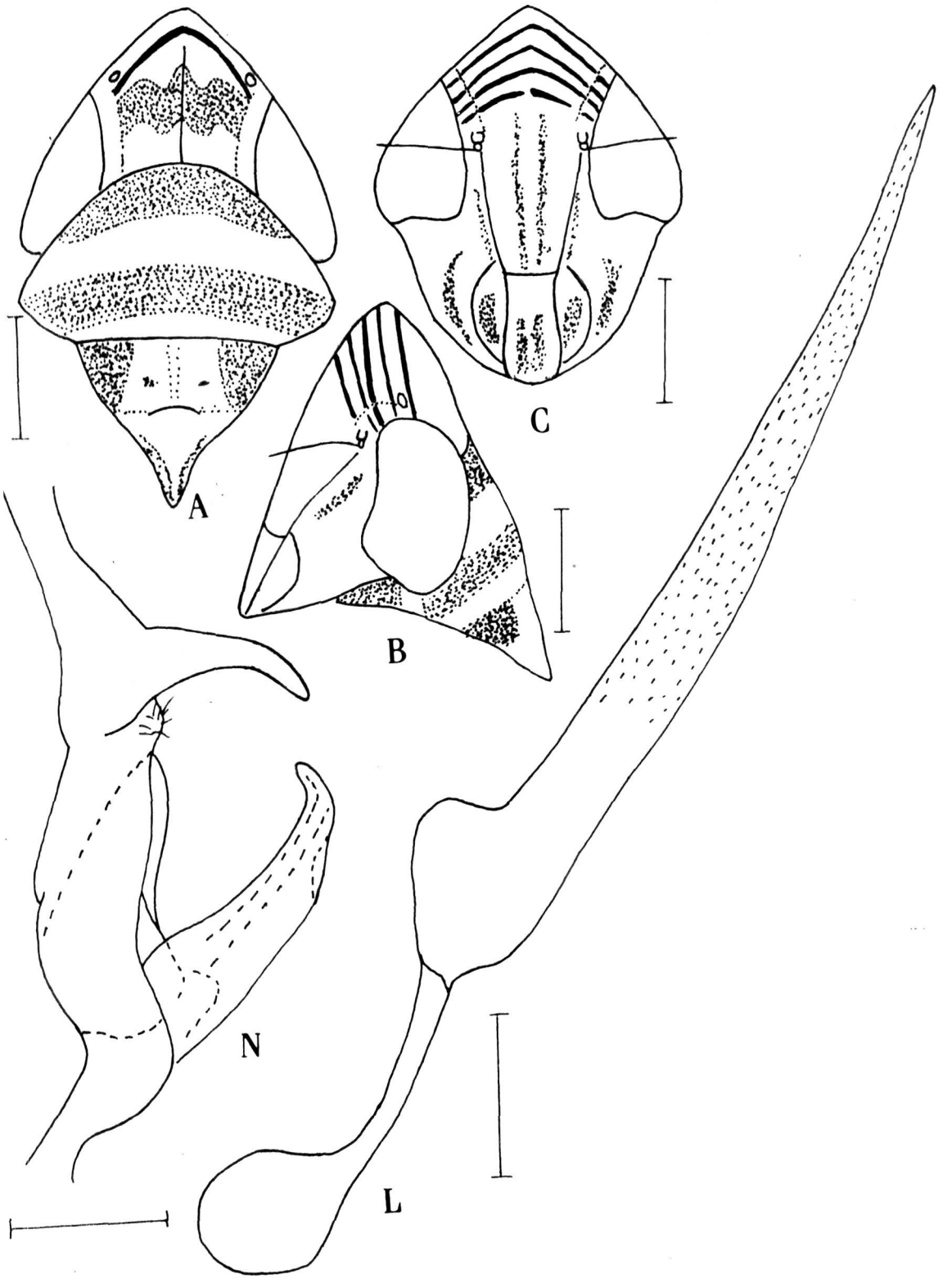
Female genitalia: Seventh sternum twice as long as sixth sternum and its caudal margin convexly produced medially.

Morphometri ratios: A: ♂ 4.28, ♀ 4.49; B:♂ 1.39, ♀ 1.52; C:♂ 0.49, ♀ 0.50; D:♂ 3.91, ♀ 3.47:E: ♂ 1.01,♀ 1.02.

Measurements (in mm): total length: ♂ 4.5, ♀ 4.7; length of vertex:♂ 0.50, ♀ 0.50; length of pronotum: ♂ 0.54, ♀ 0.64; length of scutellum: ♂ 0.60, ♀ 0.62; length

Fig.23b. Scphoideus sculptus sp.nov. (♂)

Scale refers NK : 0.1 mm
ABC : 0.5 mm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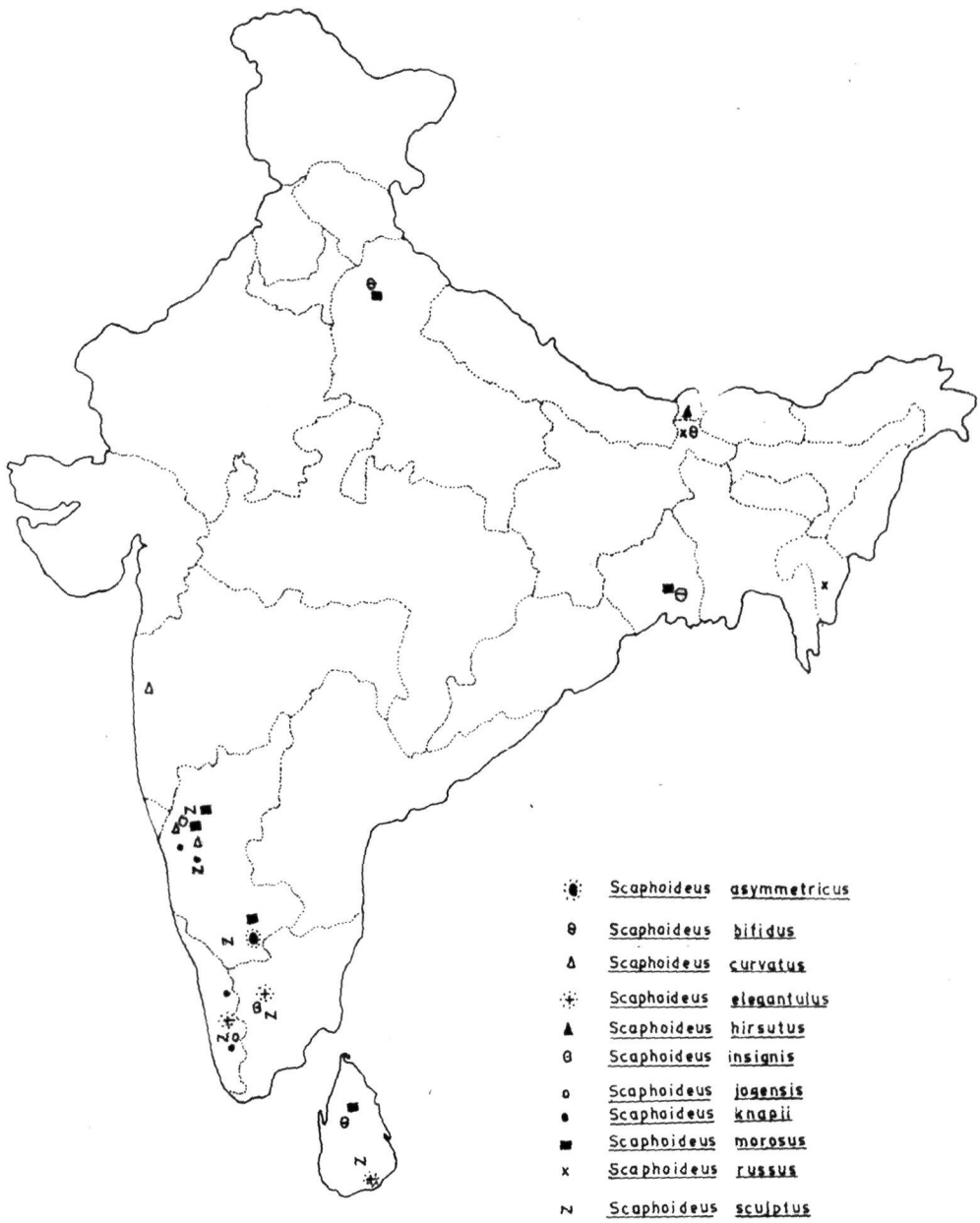
of face:♂ 1.10, ♀ 1.02; length of forewing: ♂ 3.6, ♀ 3.7; length of clavus:♂ 2.1, ♀ 2.4; length of hind tibia; ♂ 2.1, ♀ 2.2; width of head including eyes: ♂ 1.10, ♀ 1.19; width of vertex: ♂ 0.42, ♀ 0.44; width of pronotum:♂ 1.15, ♀ 1.23; width of forewing:♂ 1.05, ♀ 1.06.

Specimens examined

Holotype ♂ INDIA: Karnataka: Mudigere, 7.iv.1975 (CAV)(UAS). Paratypes: 1 ♂,5 ♀ data as in holotype collection 22.v.1976 (CAV), 1 ♀ same data but collected by (BM), 2 ♀ same data but collected on 26.iii.1977 (CAV). INDIA: Kerala:Thekkadi, 3 ♀ (CAV), 2 ♀ (SV), collected on 26.iii.77; 1 ♂, 1 ♀ data same but collected on 27.iii.1977 (CAV). INDIA: Karnataka: Nagarhole: 48 km N of Hunsur, 1 ♂, 1 ♀ on 17.i.78 (CAV); 1 ♀ Jog Falls (Kogur 36 km W of Jog Falls) 18.xi.1976 (BM); INDIA: Tamil Nadu; 1 ♀ Valparai 14.iv.81 (ARV)(IARI,BMNH,UAS,USNM). 1 ♂ SRI LANKA: Rakwana, 6.ii.1953, JWS Pringle; 1 ♂, Maskeliya, 8.iii.1909, TBF (TBF Flecher); 1 ♀. Peradeniya, 3.x.1913 (BMNH).

Remarks: This species externally resembles Scaphoideus festivus and very closely agrees with the description and illustration provided by Distant (1908), suggesting that what Distant had infront of him while describing S.festivus (Sensu Distant) was this species rather than S.festivus Matsumura.

Map-XV Distribution of species of Scaphoideus Uhler.


Scaphoideus asymmetricus
Scaphoideus bifidus
Scaphoideus curvatus
Scaphoideus elegantulus
Scaphoideus hirsutus
Scaphoideus insignis
Scaphoideus jogensis
Scaphoideus knapii
Scaphoideus morosus
Scaphoideus russus
Scaphoideus sculptus

S.sculptus is unique in having pustulated paraphysis. One male from Sri Lanka has the lateral process to aedeagus placed more dorsally compared to that in males from India, and appears like a dorsal connective.

4.5. Species not included in the study.

4.5.1. Species assigned to Scaphoideus

The following species were not encountered in this study. However, the photographs and/or male genitalia of type-specimens indicated that they belonged to Scaphoideus. Scaphoideus assamensis Distant; S.baeticus (Distant); S.brachycephalus Distant; S.nutans Distant; S.ornatus Melichar; S.stigmaticus Distant and S.pallifrons Distant.

4.5.2. Species transferred to Scaphotettix

The following species assigned to the genus Scaphoideus previously, are transferred to the genus Scaphotettix. Scaphotettix indicus (Distant) Comb.nov. Scaphotettix hieroglyphicus (Distant) Comb.nov., Scaphotettix consanguineus (Distant) Comb.nov.

4.5.3. Species removed from Scaphoideus

The following species assigned previously to Scaphoideus belong to Osbornellus Ball.

Plates:

8 a : Scaphoideus knapii Kitbamroong and Freytag (♂)

8 b : Scaphoideus morosus Melichar (♂)

8 c : Scaphoideus russus Distant (♂)

8 d : Scaphoideus sculptus sp.nov. (♂)

Plate 8a

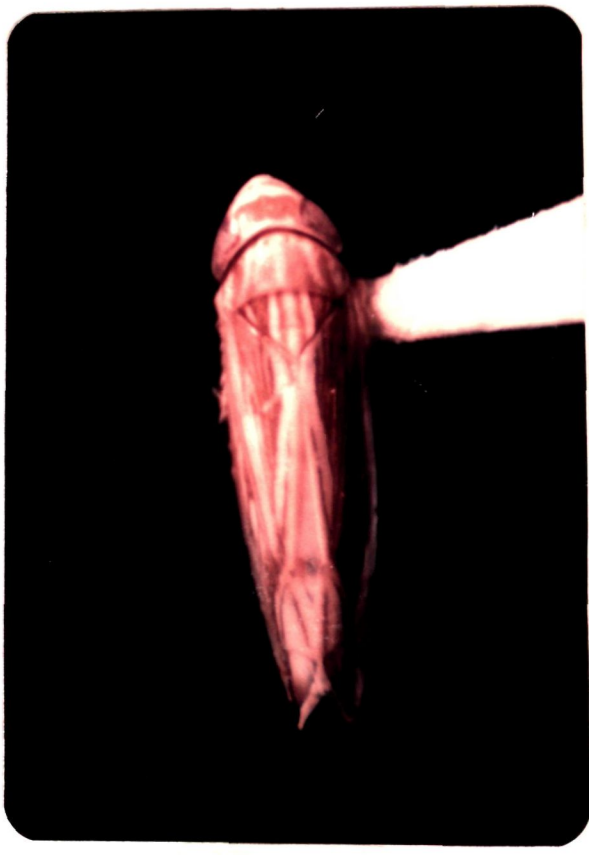


Plate 8b

Plate 8c

Plate 8d

Osbornellus fletcheri (Distant) Comb.nov.

Osbornellus notatus (Distant) Comb.nov.

Osbornellus punctulatus (Melichar) Comb.nov.

4.6. A check list of species of the genus Scaphoideus, Scaphodhara and Scophotettix of the Indian Sub-continent

Genus Scaphoideus Uhler

Scaphoideus assamensis Distant

Locality: INDIA: Assam

asymmetricus sp.nov.

Locality: INDIA: Karnataka: Kollegal

baeticus (Distant)

Locality: INDIA: Assam

bifidus sp.nov.

Locality: INDIA: Uttar Pradesh: Dehradun;
West Bengal:Calcutta, Siliguri

brachycephalus Distant

Locality: INDIA: West Bengal:Calcutta

curvatus sp.nov.

Locality: INDIA: Maharashtra:Matheran.
Karnataka;Shimoga, Jog Falls

elegantulus Melichar

Locality: INDIA: Kerala; Munnar; Tamil Nadu:
Oothu; SRI LANKA.

hirsutus sp.nov.

Locality: INDIA: West Bengal:Darjeeling

insignis (Distant)

Locality: INDIA: Tamil Nadu:Kodaikanal,Shambaganur

jogensis sp.nov.

Locality: INDIA: Karnataka:Jog Falls; Kerala:Thekkadi

knapii Kitbamroong & Freytag

Locality: INDIA: Karnataka:Mudigere,Thithimathy;
Kerala:Thekkadi, Maraiyar
Thailand:Thaphra, Khonkaen

morosus Melichar

Locality: INDIA: West Bengal:Calcutta; Karnataka:
Dharwad, Anekal, Jog Falls;Uttar Pradesh:
Dehradun; Kerala:Thekkadi. SRI LANKA,
JAVA, PHILIPPINES, ISLANDS, FORMOSA.

nutans Distant

Locality: INDIA: Tamil Nadu:Kodaikanal

ornatus Melichar

Locality: INDIA: N.Bengal, Katihar, Purnesh Distct.
SRI LANKA, Thailand, Formosa.

pallifrons Distant,

Locality:INDIA: Tamil Nadu: Kodaikanal

punctulatus (Melichar)

Locality: SRI LANKA

russus Distant

Locality: INDIA: Mezoram:Lunglei; West Bengal:
Siliguri, Tenasserim, Myitta; BURMA

sculptus sp.nov.

Locality: INDIA: Karnataka; Mudigere, Nagarahole,
Jog Falls, Kemmangundi; Kerala:Thekkadi;
Tamil Nadu:Valparai; SRI LANKA.

stigmaticus Distant

Locality: East Himalayan region

scaphodhara gen nov.

biloba sp.nov.

Locality: INDIA: Karnataka:Dharwad, Belgaum.

meppadica sp.nov.

Locality: INDIA: Kerala:Meppadi, Thekkadi;
Karnataka:Mudigere.

neela sp.nov.

Locality: INDIA: Kerala:Munnar, Thekkadi

periyari sp.nov.

Locality:INDIA: Kerala:Thekkadi, Maraiyur

Genus Scaphotettix Matsumura

agumbensis sp.nov.

Locality: INDIA:Karnataka:Agumbe

consanguineus (Distant)

Locality: INDIA:West Bengal: Calcutta

freytagi sp.nov.

Locality: INDIA: Uttar Pradesh:Dehra Dun;
West Bengal:Siliguri,Calcutta;Kerala:
Walayar; Karnataka:Bannerghatta.

hieroglyphicus (Distant)

Locality: INDIA: Nandidurg

indicus (Distant)

Locality: INDIA: Assam; BURMA:Tenasserim:JAVA

keralicus sp.nov.

Locality:INDIA:Kerala:Thekkadi,Karnataka:
Mudigere, Jog Falls

malnadicus sp.nov.

Locality:INDIA: Karnataka:Jog Falls

quadrifidus sp.nov.

Locality: INDIA: Kerala:Thekkadi

redundans (Distant)

Locality: INDIA: Tamil Nadu:Naduvattum,
Kodaikanal, Niligiri Hills.

DISCUSSION

V. DISCUSSION

During the present investigation 21 species belonging to 3 genera namely, Scaphoideus Uhler, Scaphodhara gen.nov. and Scaphotettix Matsumura were studied. Oman (1979) included the genus Scaphoideus in the tribe Deltocephalini. Metcalf (1967) included it in the tribe Scaphoideini, where as Hamilton (1975) proposed a classification in which he redefined the subfamily Aphrodinae to embrace both Deltocephalinae and Hecalinae and recognised 9 tribes. Under the tribe Deltocephalini he recognised 6 subtribes and relegated the genus Scaphoideus to the subtribe Platymetopiina. Since there is disagreement regarding the number of tribes to be recognised in Deltocephalinae, no attempts were made to examine the higher classification of the subfamily Deltocephalinae to place the three genera under investigation.

5.1. Relationships among the genera Scaphotettix, Scaphodhara and Scaphoideus

The genus Scaphotettix is only distantly related to Scaphoideus and Scaphodhara. Scaphotettix is here reported for the first time from the Indian subcontinent and outside Formosa. Some species of Scaphoideus have pattern of coloration similar to that in Scaphotettix.

however, Scaphotettix can be recognised by the much greater ratio between length and width of vertex, the width of frontoclypeus between bases of antennal pits to that from antennal pit to anterior tip of frontoclypeus, by the spinulation on anterior and middle femora and the characteristic male genitalia. The features that distinguish Scaphotettix from Scaphoideus and Scaphodhara are - (i) claval veins approximated and either fused or joined by a cross vein, (ii) front and middle femora compressed; front femora with a row of stout spines on mesal margin, middle femora with a row of long and short, stout spines on its mesal margin, (iii) fronto-clypeus and vertex broad (the ratio of vertex length to width is 1:0.72; frantoclypeus width between antennae to width at its apex varies from 1:0.9 to 1:1.25), (iv) male plates with rounded apices, and (v) connective neither with paraphyses nor with an intermediate sclerite before aedeagus.

Scaphoideus and Scaphodhara are very closely related and some species of both the genera have identical colouration and hence are difficult to separate without recourse to the examination of male genitalia. The species of Scaphodhara have colouration

similar to those of Scaphoideus albovittata Matsumura, S.knapii Kitbamroong and Freytag, S.harlani Kitbamroong & Freytag etc. In body proportions the species of Scaphodhara are intermediate between Scaphotettix and Scaphoideus. Scaphodhara can be characterised by - (i) the ratio between length and width of vertex being 1:1.19, (ii) the ratio of width of frontoclypeus between antennal pit to its width at apex varying from 1:1.48 to 1:1.68, (iii) an ivory stripe traversing head, pronotum, scutellum and fore wings, a reddish brown to reddish spot behind each ocellus on vertex and a single or paired median pink or red line on vertex and pronotum over the ivory stripe, and (iv) an intermediate sclerite being present between connective and aedeagus.

The species of Scaphoideus are variable in colour. In addition to having their own peculiar patterns they also have colour patterns similar to Scaphotettix and Scaphodhara. The characters which they share with Scaphodhara are the claval veins being separate and bent almost at right angles before reaching claval commissure, outer anteapical cell small, placed obliquely in relation to costal margin and with 3 to 4 reflexed cross veins reaching this cell from costal

margin. The most important distinguishing character of Scaphoideus from Scaphodhara is the presence of paraphyses.

5.2. Relationship among the species of the genus Scaphotettix Matsumura

So far the genus was known only by its type species Scaphotettix viridis Matsumura described from Formosa. The description and examination of photographs of type specimens of Scaphoideus consanguineus Distant (from Calcutta), Scaphoideus hieroglyphicus Distant (from Nandidurg), Scaphoideus indicus Distant (from Margherita, Myitta), and Scaphoideus redundans Distant (from Kodaikanal and Niligiri Hills) reveal that they belong to Scaphotettix (Freytag, personal communication). Except for S.redundans other species were not collected during the present study. Since the remaining three species are known only from females, their true relationship with other species of the genus is difficult to establish.

During the present study five new species of Scaphotettix were discovered in addition to S.redundans. These species may be grouped into two groups namely, those with ventro-caudal pygofer process (S.agumbensis, S.malnadicus, S.quadrifidus and S.redundans) and those

without caudo-ventral pygofer process (S.freytagi and S.keralicus). S.freytagi is unique in having an elongate aedeagal shaft lacking processes, outer and middle anteapical cells sub-divided. S.agumbensis, S.malnadicus, S.quadrifidus and S.redundans form a close knit group judging from the shape of the aedeagus and connective. S.keralicus is unique in having claval veins fused, apex of the male plate rather acutely rounded. S.quadrifidus is unique in having aedeagal two pairs of aedaegal processes where as the process of S.redundans has crenulate margin.

5.3. Relationship among the species of Scaphodhara

Four new species were discovered under this genus. Scaphodhara biloba is not only larger than the other three but also has bilobed male plate, stouter and straighter apophysis of style and slender strongly curved aedeagus. Externally it resembles Scaphoideus insignis. Scaphodhara neela, S.meppadica and S.periyari are very similar externally and resemble, Scaphoideus knapii and Scaphoideus bifidus. Scaphodhara neela appears not closely related to either S.meppadica or S.periyari. It has an elongate aedeagal shaft with apical pair of

short processes. S.meppadica and S.periyari are very closely related but differ in the relative size and curvature of the aedeagal processes and in the shape of the intermediate sclerite between aedeagus and connective.

5.4. The subgenera and relationship among the species of the genus Scaphoideus

Barnett (1977) while revising the genus Scaphoideus for the Nearctic region, recognised three subgenera namely, Scaphoideus (s.s.). Lonenus De Long and Latenus De Long and Knull and used the shape of aedeagal base to distinguish them. All the species found in the present study belong to the subgenus Scaphoideus.

Distant (1908, 1918) recorded 14 species of Scaphoideus and one species each under the genera Hussa Distant and Bolanus Distant in addition to four species of Scaphotettix alluded to earlier from the Indian subcontinent. The genera Bolanus and Hussa were suppressed as Junior synonyms of Scaphoideus by Evans (1947) and Barnett (1977), respectively. Thus transfering the type species of these genera namely, Bolanus baeticus Distant and Hussa insignis Distant to Scaphoideus. An examination of type specimens of Scaphoideus notatus Distant and

Scaphoidus fletcheri Distant by Freytag (Personal communication) indicated that they belong to the genus Osbornellus Ball and hence, were excluded from the study. Of the remaining 14 species recorded by Distant only four species namely, S.morosus, S.elegantulus, S.russus and S.insignis were encountered during the study. Since the male genitalia of the type specimen of russus is identical with male genitalia of the specimens collected during this study but agreeing with description and illustration provided by Distant (1908) for Scaphoideus polymitus Distant and further since the type specimen of the S.polymitus is missing (Freytag, personal communication), S.polymitus is here treated as a junior synonym of S.russus. Scaphoideus russus is unique in having very slender, elongate paraphyses and slender, strongly curved tubular aedeagus. Scaphoideus knapii Kitbamroong and Freytag is recorded for the first time from the Indian subcontinent. S.knapii, S.maai Kitbamroong and Freytag (from Thailand) and S.bifidus sp.nov. have a similar colouration and to some extent share this coloration with S.insignis Distant. They form a closely knit group judging from the shape of paraphyses, pygofer, general structure of aedeagus and processes of aedeagus. They can be confused with the species of Scaphodhara which they resemble in colouration.

The Indian population of S.knapii differs from the population from Thailand in having paraphyses more divergent right from the base where as those from Thailand have the paraphyses fused near the base. However, this difference appears to be within the limits of species variation as the structure of style, aedeagus and male plate are indentical with those of S.knapii. Scophoideus bifidus differs from S.knapii in having aedeagal processes arising at mid length of the shaft and the paraphyses of uniform width for most of their length. S.insignis is a large and robust species with paraphyses fused to almost 3/4 of their length. It is not related to S.knapii, S.maai and S.bifidus as it has the apophysis of style much longer and compressed aedeagus with ventral, almost vertical pair of lamellae. S.jogensis and S.elegantulus share the character of bilobed male plate. They also have an elongated narrow apophysis of style as in case of S.curvatus sp.nov. and S.insignis. Scaphoideus jogensis has apically triangularly expanded paraphyses, aedeagus with a pair of short apical processes and pygofer without a ventral process. S.elegantulus appears to be a variable species with respect to the length of pygofer process, serration on expanded area of paraphyses and lateral lamellate processes to the aedeagus. The Indian population of

elegantulus has an elongate ventral pygofer process, smooth asymmetrical expanded area of paraphyses where as the ceylonese population has a shorter pygofer process,apex of expanded area of paraphyses are symmetrical and laterally serrated. These two populations also differ in colouration. Indian population is much darker than ceylonese population. S.morosus, S.harlani Kitbamroong and Freytag and S.acanthus Kitbamroong & Freytag are closely related species judging from the external colouration and the shape of the paraphyses. Only S.morosus was found to occur in India. S.hirsutus, S.asymmetricus, S.sculptus and S.curvatus have coloration similar to that found in Scaphotettix. The sculptus is unique in having sculptured paraphyses and is also a variable species as far as the lateral processes of aedeagus are concerned. Distant misidentified this species as Scaphoideus festivus. The specimens of S.sculptus from Sri Lanka agree closely with the description and illustration of festivus given by Distant (1908). S.sculptus differs from festivus Matsumura in the structure of paraphyses and aedeagus. S.hirsutus can be easily recognised by the presence of numerous long hair-like setae on the male plate and by the basally fused paraphyses. S.hirsutus appear to be related to S.curvatus. S.asymmetricus and S.curvatus are

only distantly related. The apophysis of the style being straight, the paraphyses being close together at base and twisted in their apical 1/4 and aedeagus being long, compressed and without processes characterise S.curvatus. The apophysis of style being curved, the paraphyses highly asymmetrical and widely separated basally, short aedeagal shaft with a pair of median processes distinguish S.asymmetricus.

5.5. Zoo-geography of Indian species of Scaphotettix, Scaphodhara and Scaphoideus

Nine species of Saphotettix are found in India and one species each in Thailand (Scaphotettix freytagi Misidentified as Scaphoideus festivus by Ishihara (1961) and Formosa (Scaphotettix viridis Matsumura), This genus appears to be widely distributed in the Oriental region. All species of Scaphotettix encountered in this study barring S.freytagi, occur in south India (Karnataka, Kerala) the genus Scophodhara as known at present is restricted to the Indian subcontinent, however, it may also occur in other parts of the Oriental region. The known species of the genus come from south India (Karnataka, Kerala).

The species of Scaphoideus are found in all the zoo-geographical regions of the world. The species composition of Scaphoideus of the Indian subcontinent and Thailand (Kitbamroong and Freytag, 1978) is different. Only two species namely, Scaphoideus morosus and S.knapii occur in both the regions. All other species of Scaphoideus recorded in this study have rather restricted distribution. However, this may be due to lack of intensive collection of this group in the region. Scaphoideus festivus does not occur in the Indian subcontinent.

SUMMARY

VI. SUMMARY

Existence of a large number of undescribed species in the subfamily, Deltocephalinae and importance of the group as vectors of plant pathogens necessiated the present revisionary study which revealed the occurrence of 21 species belonging to three genera namely, Scaphotettix Matsumura, Scaphodhara gen. nov. and Scaphoideus Uhler.

The present study added five new species to the genus Scaphotettix in addition to S.redundans (Distant) namely, S.agumbensis, S.freytagi, S.keralicus, S.malnadicus and S.quadrifidus. Scaphotettix is here reported for the first time from Indian subcontinent. This genus is only distantly related to Scaphoideus and Scaphodhara. Some species of Scaphotettix have pattern of coloration similar to that in Scaphoideus. Totally nine species of Scaphotettix are found in India and this genus appears to be widely distributed in the Oriental region.

Genus Scaphodhara is described as new genus in this study, and four new species are discovered under this genus. These are S.biloba, S.mepradica, S.neela and S.periyari. Species of Scaphodhara are very closely related to Scaphoideus and are intermediate between Scaphotettix and Scaphoideus in body proportion. Some

species of Scaphodhara have identical colouration with the species of Scaphoideus. The most important distinguishing character of Scaphodhara is the presence of intermediate sclerite between aedeagus and connective. The genus Scaphodhara as known at present is restricted to the Indian subcontinent, however it may also occur in other parts of the oriental region.

Of the 14 species of Scaphoideus recorded by the Distant (1908, 1918) only four species namely, S.elegantulus, S.insignis, S.morosus and S.russus were encountered during the study. Six new species namely, S.asymmetricus, S.bifidus, S.curvatus, S.hirsutus, S.jogensis and S.sculptus are described in addition S.knapii Kitbamroong and Freytag is recorded for the first time from the Indian subcontinent. The Indian population of S.knapii differs from that of Thailand; however, these differences appear to be within the limit of species variation. S.polymitus is treated as junior synonym of S.russus. Two population namely Indian and Ceylonese of S.elongantulus are recognised as they differ in the structure of paraphyses and ventral pygofer process. S.sculptus is unique in having sculptured paraphyses and is alsoavariable species. Distant mis-identified this species as S.festivus. In

S.sculptus also two populations namely Indian and Ceylonese are recognised which differ slightly in the structure of paraphyses and aedeagus.

The species of Scaphoideus are found in all zoo-geographical regions of the world. All the species of Scaphoideus recorded in this study have rather restricted distribution except S.morosus and S.knapii which are found in both Indian sub-continent and Thailand. The species composition of Scaphoideus of the Indian sub-continent and Thailand (Kitbamroong & Freytagi, 1978) is different.

All the taxa treated here are described and illustrated including male genitalia. Keys are provided for recognition of the genera and species of the Indian sub-continent. A check list of the known species of the genera under study and distributional maps of the included species are also provided.

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*Original not seen.